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Teaching of Magnetism Unit Topics Via Active Learning Applications

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The aim of this study is to investigate the effect of active learning on students' achievement in the unit of magnetism. It is important to create proper teaching environments in order to ensure the active participation of students in learning processes. Many different methods and techniques may be used for active participation. Detailed information should be provided for the teachers on how these methods and techniques can be implemented. For this reason, an active learning environment was created in the present study by way of using worksheets accompanied by experiments, simulations, modelling, garden activity and games. It was explained how these activities are implemented for each of the acquisitions related with the magnetism unit topics. The study employed sequential explanatory mixed design. The subject of this study consisted of 98 eleventh grade students in a high school in Türkiye. The data were acquired via an open ended and multiple-choice conceptual achievement test, observation forms and interviews. The findings obtained illustrated that active learning applications increase academic achievements of students at a statistically significant level. In addition, it was concluded that active learning applications make a positive impact on the interest, attitude and motivations of the students towards the physics course. The results show that magnetism unit topics are effective in providing a conceptual change. It is suggested to use the applications shared in the present study for the teaching of abstract subjects such as magnetism. In this way, it may be possible to create learning environments that will enable instructors to reach the desired goals.

Introduction

Active learning method is the product of a continuously developing long chain dating back centuries. The theoretical foundations of active learning are based on constructivism and cognition as its counterpart in the field of learning (Açıkgöz, 2003; Meltzer & Thornton, 2012). According to the constructivist approach, individuals learn knowledge acquired from

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their environments by associating them with their already present knowledge. Active learning approach was based on the theories of mental psychology by Piaget, research by Bruner, social interaction by Johnson and Johnson, meaningful learning by Ausubel and conceptual change by Posner (Hand & Treagust, 1991). This approach is based on the individual's self-structuring of the knowledge in his/her mind. The learner is active during the process. The individual organizes knowledge based on his/her experiences and constructs the learning process (Canpolat et al., 2004; Dick, 1991; Fensham, 1992; Glasersfeld, 1989; Nakamura, 2012).

It is known based on previous studies that active learning methods and techniques play an effective role on the learning achievement of students as well as in the development of their learning motivations, attitudes towards the lesson and social skills. Freeman et al. (2014) carried out a comprehensive meta-analysis study which revealed the superiority of active learning over the traditional understanding in STEM (Science, Technology, Engineering and Mathematics) teaching. Sauricki (1989) put forth that students become an agent in active learning environments created through discussion and simulation applications. It was identified that the courses taught in such an environment are effective and that active learning activities increase the productivity of students. As pointed out by Nelson and Crow (2014) in their study, learning environments created using active learning strategy have positive impacts on the critical thinking skills of students. Accordingly, Avinç Akpınar (2010) asserted that students indicated an increase in their critical thinking and problem-solving skills during active learning process. Anlı Akyıldız (2008) reported that the lacked knowledge is revealed when students conduct discussions and interpret the subject in active learning environments. Thus, it was emphasized that the students are presented with an opportunity to overcome missing information and incorrect learning. Suwondo and Wulandari (2013) claimed that research based active learning applications affect the learning styles of students. They indicated that students are independent, original and disciplined in these environments. Theobald et al. published a study in 2020 in which they argue that the rearrangement of STEM courses via proof based active learning designs will reduce the achievement gaps while increasing permanence for insufficiently represented students.

It is observed that different strategies and methods coexist in active learning environments. Some of these are designs to which technology is integrated. It was shown as a result of a study by Fisher (2010) assessing technology supported active learning environments that both educators and students reacted very positively. Teachers stated during the conducted interviews that they enjoy teaching in such environments and indeed stated their sole concern as the inability to continue teaching in these new learning environments.

The use of technology in active learning environments is very beneficial and increases effectiveness. On the other hand, it is difficult and costly to transform technological advancements into teaching technology. Technology can change every year, however it requires a longer period of time to reflect these changes in teaching environments. Because the proper implementation of technology in schools and classrooms increases costs significantly. Moreover, it is not sufficient to equip teaching environments with technology in order to reach the desired goals. The integration of technology in teaching environments is limited with the related knowledge, skills and experiences of those who use them. It is a difficult and time-consuming process to ensure that information technologies are adapted, put into use and institutionalized by teachers (Oblinger, 2005; Seferoğlu, 2015).

It has been indicated in a study by Seferoğlu (2015) conducted as a general assessment on technology ownership and use at schools in Turkey that the ownership of information and communication technologies is at a considerably good level and that efforts are underway to overcome any shortcomings. However, the researchers set forth that the situation is not very good with regard to the effective use of information technologies. Studies reveal that the inclusion of technological tools to the education environment makes a very small impact on learning acquisitions. It has also been identified that the use of technology in education does not have a direct effect on student achievement (Fei & Hung 2016; Luckin et al., 2012; OECD 2015). It is important to integrate technology and teaching rather than incorporating technology into the education environment.

An active learning environment has been designed in the present study which effectively utilizes the already existing technological facilities in Ministry of Education schools. The subject of magnetism which includes abstract concepts, and which is one of the more difficult physics course subjects to grasp was selected in order to put forth this impact more clearly. The active learning activities geared towards the acquisitions related with the topics of the magnetism unit have been described in detail in the present study. In addition, the effectiveness of active learning applications was also examined. Thus, it was aimed to share with teachers the active learning activities that can easily be implemented in teaching environments.

Methods

Mixed method was used in the study in order to benefit from the strengths of qualitative and quantitative research methods. Sequential explanatory design was used as part of the mixed method which collects the qualitative data after the acquisition and analysis of quantitative data (Baki & Gökçek, 2012). Semi-experimental method with pretest-posttest control group was utilized during the quantitative section of the study. Whereas the phenomenology pattern was used in the qualitative section which examines the perceptions and experiences related with a phenomenon in order to illustrate how people name their experiences (Patton, 2014). Observations and interviews were conducted during the process. The findings acquired via qualitative and quantitative methods were taken into consideration in the interpretation and discussion sections in accordance with the sequential explanatory design.

The sample group of the study consisted of a total of 98 eleventh grade students continuing their education at an Anatolian High School in Turkey. The study group was selected from a total of four eleventh grades with two control and two experimental groups. The magnetism unit was taught for a period of six weeks for both groups. A teaching environment was created in the experiment group that incorporates active learning applications. The topics were taught using the traditional method by way of a blackboard and smart board in the control group during which the teacher taught the concepts related with the unit followed by the solving of a large number of questions on the subject. The teacher is the active lecturer in the traditional approach, whereas the student is the passive listener. The control group teacher used the smart board like a blackboard in addition to reflecting the textbook and the question bank. The smart board was not used activities such as video, simulation and animation.

A pilot application was conducted at the beginning of the study. Each stage of the active learning applications was evaluated during the three-month pilot study. Moreover, measurement tools were developed with the required validity and reliability.

Instrument

A three stage "Magnetism Conceptual Achievement Test" (MCAT) was developed and applied as a pretest and posttest in order to reveal any misconceptions. MCAT consists of a first section encompassing twenty multiple choice questions and a second section with four open ended questions. The items of the first section were prepared as a multiple-choice question in the first stage, an open-ended choice in the second section emphasizing the reasons for the response of the student and a three stage test in the final stage which questions whether the student is sure of the response. The reliability coefficient of MCAT was calculated as KR=0.697 during the pilot study conducted within the scope of the study.

The phenomenological approaches taken as basis in the qualitative section of the study focus on how people make sense of their experiences, how they transform these experiences into cognition and how they define the phenomena (Patton, 2014). This approach aims to provide a comprehensive description by identifying what these experiences mean for those who take part in them (Moustakas, 1994). In this regard, a semi-structured interview form was prepared in order to learn the opinions of the students on both their learning and the active learning application. The form was comprised of a total of ten open ended questions. The required changes were made when developing the form in line with the pilot application. 'What do you think about the physics course taught via active learning method? Did this learning environment change your opinions towards the physics course?' and 'Can you provide an assessment of the active learning environment with regard to interclass communication?' were among the interview questions. A total of twelve students who took part in active learning applications were selected based on the principle of voluntariness after which their opinions were taken. Each interview lasted for fifteen to 25 minutes. Approvals were taken for recording the interviews and short notes were taken. Approvals of the interviewees were taken in order to take notes during the interview process.

An observation form was developed for the assessment of the active learning environments by the specialist physics teachers monitoring the process. The observation form included questions on the active learning environment, the means with which students acquire knowledge, the roles of the teachers, interclass communication and the materials used. The specialist teacher who took part in the lessons as an observer was asked to fill in the form as well. The observation and interview forms were applied following the approvals of a Turkish Language specialist. Table 1 presents the order at which the data collection tools have been applied.

Table 1. Data Collection Chart

Prior to the Application	During the Applications	After the Applications
Magnetism Conceptual Achievement Test–PreTest	Semi-Structured Observation	Magnetism Conceptual Achievement Test–PostTest Semi-Structured Interview

Data Analysis

SPSS 16.0 package software was used for the analysis of quantitative data. The difference between the variables was examined using a statistically significance level of $p<.05$, the changes in the respective groups were examined by way of paired group t-test while the significance between the groups was examined using independent groups t-test and descriptive statistics. In addition, Hake (1998)'s group gain analysis was used for interpreting the difference between the pre-test and post-test averages.

Content analysis used for the analysis of written and visual data is generally used for qualitative studies. Data analysis in phenomenology studies aims to reveal the experiences and meanings (Patton, 2014). This type of content analysis strives to conceptualize the data and to put forth the themes that may define the phenomena. The data acquired from the interviews were classified into meaningful sections during the data coding stage of the study and the data with similar meanings were given the same codes at each stage. An inductive approach was used as the second stage of the study for thematic coding by identifying the common aspects between the codes. Afterwards, a system was developed for compiling the data followed by the identification of data. At this stage, the students were coded as Ö1, Ö2, … , Ö12 ("Ö" here stands for the first letter of the word "student" in Turkish language) and tables were prepared.

Application Process

The applications took place over a period of twenty-four course hours. An active learning environment was created for the magnetism unit subjects during the study by way of experiments, simulations, animations, videos, garden activities, modelling and games. All courses started with a discussion aiming to test the knowledge of the students on the related subject and to activate the related phenomena in the minds of the students. A separate activity was prepared for each subject. The activities were conducted after separating the students into different groups. Group discussion and classroom discussion were conducted at the end of each activity. Worksheets entitled "Activity Plan" were distributed to the students prior to the activities. The students were asked to fill out the worksheets both during the activity and at the end of group discussion stage. Classroom discussions generally focused on expressions involving misconceptions. The Conceptual Change Based Worksheet (CCBW) prepared by the researcher for eliminating the misconceptions of the students was applied at the end of the subjects. Table 2 presents the activities implemented for each subject of the magnetism unit.

Table 2. Table of Activities

SUBJECTS	Implemented Activities*							
	D	E	IE	GA	M	S	A	V
Magnetic Properties of Matter, Magnetic Poles	✓					✓		✓
Magnetic and Nonmagnetic Materials	✓		✓	✓				
Magnetic Field, Field Intensity and Field Lines	✓		✓		✓			
Magnetic Permeability	✓							✓
World's Magnetic Field	✓				✓			
Magnetic Effects of Electrical Current	✓	✓						
Force Acting on the Wire with Current in Magnetic Field	✓						✓	
Force Acting on a Charged Particle Moving in a Magnetic Field	✓		✓					✓
Magnetic Flux	✓				✓			
Faraday's Induction Law, Induction Current, Induced EMF	✓	✓				✓		
Direction of Induction Current and Self-Induction	✓					✓		

*Implemented Activities; D: Discussion; E: Experiment; IE: Illustrative Experiment; GA: Garden Activity; M: Modelling; S: Simulation; A: Animation; V: Video

Some of the active learning applications can be indicated as follows: the teaching of the magnetic and nonmagnetic materials subject was initiated when the teacher showed two pins to the students one of which is magnetic but the other is nonmagnetic after which the teacher asked, "Do you think a magnet may attract these pins?". After taking the guesses of the students, the teacher showed them that one of the pins is attracted to the magnet while the other is not. Students who wanted to try the experiment were given the pins and the magnet thus allowing them to try it out themselves. The students were asked about the difference between these two pins thus starting a discussion. A slide show was displayed which explains how the atomic structure of magnetic materials is affected from the magnet. The magnetic material activity prepared by the researcher was conducted outside. The activity was based on the attraction of iron (Fe) atoms by a magnetic material after being subject to a magnet thus pulling the iron atoms and the disruption of the magnetic effect of the material due to the heat impact. The students carried cardboards for the phenomena they represent during the activity. Afterwards, the students were asked to explain what they understood and to take notes. Figure 1 shows the implemented activity.

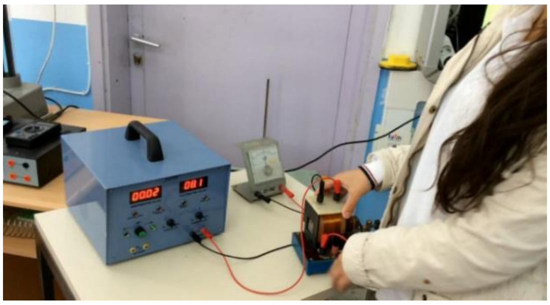

Figure 1. Activity on magnetic materials

Figure 2. Induction current experiment

In another application, the experimental setup prepared to view the formation of induction current along with the simulation experiment on the interactive board were prepared to enable the students to learn more on the subject. Activity plan worksheets were distributed to the students at the beginning of the lesson after which they were asked to head up to the experimental setups in pairs and make observations. The students took notes on the results of the experiments and later discussed the results in their groups. Figures 2 and 3 present the experiment and simulation photos. The definition of induction current was discussed in the form of a classroom debate. Following the debate, the following question was asked with regard to the need for potential difference at all times in order for the current to form: "What does the EMF (potential difference) generated as a result of a change in flux depend on?" The simulation experiment illustrating how the time interval at which the change in flux takes place makes an impact on EMF was displayed on the smartboard by the teacher. Photos related with the simulation experiment are presented in Figure 4. The students first developed the induction emf connections together with the student groups after which they controlled their answers based on the correct equation displayed by the teacher on the board. The (-) sign was emphasized in the equation set up for the induction EMF based on the change in flux over time. The formula for the EMF generated between the tips of the conductive rod moving inside the magnetic field was determined based on the rod velocity. The application was completed after providing related examples on the subject.


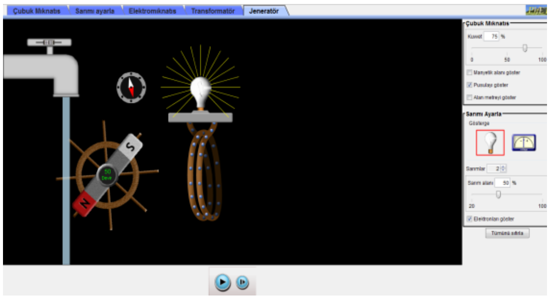

Figure 3. Induction current simulation Figure 4. Induction EMF generation simulation

Results

MCAT Data Analysis Results

The MCAT pre-test and post-test data for the experiment and control groups were subject to independent group t-test. The values of the MCAT pre-test results presented in Table 3 indicate that there are no statistically significant differences between the level of knowledge on the magnetism unit of the experiment and control groups prior to starting the study. Moreover, the values of the MCAT post-test results illustrate that there is a statistically significant difference between the magnetism unit achievements of the groups after the applications. The values for the group averages of the post-test results in the table put forth that the statistically significant difference in the post-test result is in favor of the experiment group.

Table 3. Experiment and Control Group MCAT Results

MCAT Pre-test	**N**	**$\bar{X}$**	**SD**	**p**	**t**	**F**
Experiment	52	15,67	9,233	0,253	-1,149	1,113
Control	46	17,67	7,829			
MCAT Post-test	**N**	**$\bar{X}$**	**SD**	**p**	**t**	**F**
Experiment	52	53,81	14,629	0,000	10,823	13,862
Control	46	28,30	6,828			

Table 4. Experiment Group MCAT Results

MCAT	**N**	**$\bar{X}$**	**Min**	**Max**	**SD**	**t**	**p**
Pre-test	52	15,67	0	36	9,233	-16,705	0,000
Post-test	52	53,81	27	92	14,629		

Experiment group MCAT pre-test and post-test data were analysed via paired group t-test. It can be observed when Table 4 is examined that there is a statistically significant difference between the MCAT pre-test and post-test results of the experiment group. The pre and post-test arithmetic means of the experiment group revealed a significant difference between the post-test and pre-test results. In addition, the pre-test, post-test mean values were subject to Hake (1998)'s group gain analysis in order to conduct a more sensitive assessment.

Hake (1998) expressed the average gain of the group acquired in the learning environment (G) with the following equality dependent on group averages;

G=(%Post-test classroom average-%Pre-test classroom average)/(100-%Pre-test classroom average)

The findings were classified into three groups based on the results obtained from Hake group gain (G) equality; G values of below 0,3 low gain; G values between 0,3-0,7 moderate gain; G values above 0,7 high gain.

The group gain based on the MCAT pre-test and post-test averages of the experiment group was calculated as ($G_{Experiment}$=0,45). This finding is in the moderate gain category based on Hake's classification. Even though the acquired data indicate a good result, it is set forth that there are still issues that require development.

Table 5. Control Group MCAT Results

MCAT	N	$\bar{X}$	Min	Max	SD	t	p
Pre-test	46	17,67	0	34	7,829	-6,755	0,000
Post-test	46	28,30	8	46	6,828		

MCAT pre-test and post-test data for the control group were analyzed via paired group t-test. As can be seen in Table 5 there is a statistically significant difference between the MCAT pre-test and post-test results of the control group. However, when the post-test class average is compared with the highest score of 100, it is observed that the control group average is at a much lower level compared with the experiment group.

The MCAT pre-test and post-test averages of the control group were subject to Hake's group gain (G) analysis in order to make a more accurate interpretation. Group gain was calculated as ($G_{Control}$ =0,13). Based on Hake's classification, this gain is in the low gain group.

Misconception Analysis by way of Conceptual Change Worksheets and MCAT Data

MCAT was prepared in three stages so as to provide data on the misconceptions of students. Conceptual Change Based Worksheet (CCBW) was developed in the study based on the misconceptions acquired from literature and MCAT pre-test data. CCBW was applied in the classroom for the experiment group after setting up a Socratic discussion environment. The students identified their own points of misconception and took notes on these misconceptions in their worksheets after which they found the right expression as a result of discussions conducted both in their groups and as a class. Afterwards, they prepared the conceptual change texts together with their groupmates.

The first section of CCBW that is described above is a study directly on concepts. Whereas the second section of CCBW focused on the solution of questions. In this way, the points at which students have some misconceptions were identified for the magnetism unit. It was ensured to overcome these misconceptions via peer teaching through group discussions.

Items with misconceptions in the MCAT pre-test results were identified for each student in the experiment and control groups. The responses of the same student to the MCAT post-test questions were controlled for these items. It was concluded that conceptual change took place for the items answered with certainty in the pre-test and the items answered correctly in the post-test and that the misconception was eliminated. Based on these analyses, it was identified that the classification of materials based on their magnetic characteristics; the concept of magnetic field forming the attraction and repulsion forces between the magnets and the variables related with the force; variables that have an impact on the magnetic field intensity that forms around the wire when a current passes through; reasons for the formation of self-induction current.

It was observed that while conceptual change took place at a significant level in the experiment group, conceptual change was limited in the control group for the subjects of; the characteristics of the world's magnetic field; reasons for the magnetic properties of magnets and the classification of materials based on their magnetic properties; induction EMF caused by magnetic flux change; induction current caused by magnetic flux change.

It was identified that the conceptual change took place at a significant level in the experiment group for the subjects of the intensity and direction of the magnetic field forming around the wire when a current passes through it; the movement of the wire frame with a current passing through it inside the magnetic field; variables that make an impact on the intensity of the magnetic field formed by the ring with a current passing through it; variables related with the direction of the force acting on a wire in the magnetic field; magnetic field intensity formed around the wire with a current passing through it. However, an improvement was not observed in the control group.

It was revealed that a limited conceptual change took place in the experiment group for the subject of magnetic flux and variables affecting magnetic flux but that there was no improvement in the control group.

While no change was observed in the misconceptions of the experiment group related with the subjects of the induction current caused by the magnetic flux change; reasons for the generation of the self-induction current and the direction of the self-induction current, a partial conceptual change was identified in the control group. Moreover, it was also observed that the misconceptions related with the direction and intensity of the force acting on the charge moving inside the magnetic and electrical field could not be eliminated in both groups.

It was illustrated when the results related with conceptual change were evaluated as a whole that the experiment group is more successful in eliminating misconceptions related with the magnetism unit subjects compared with the control group.

Findings Acquired from Interview Data Analysis

This section presents the analysis results for the semi-structured interviews conducted with twelve students after the active learning applications. The data acquired from the interviews were coded prior to starting the analyses and themes were identified. Afterwards, the codes and themes were arranged for ensuring that they are ready for the interpretation of the findings. Ö1, Ö2, … , Ö12 letters were used in the analysis to represent each student who took part in the interviews. The tables and graphs were supported with direct quotations from the participant interviews in order to ensure that the data are more intelligible.

The students were asked at the beginning of the interview whether they have any knowledge on active learning method or not. Nine of the students indicated that they have never heard of active learning before. Two of the students stated that they heard about the concept but do not have any knowledge about it, whereas one student indicated that he took part in an active learning application before.

The students were questioned regarding their opinions of the active learning-based physics course. Majority of the students indicated positive opinions by using expressions for active learning applications as 'beneficial, good, effective' adding that it is better to teach the magnetism unit in this way compared with the classical method. In addition, Ö5 from among the students stated that solving questions is more beneficial in physics course and that the lesson should involve more question solving rather than activity.

Within the framework of the second question, the students were also asked whether there were any changes in their interests and attitudes towards the physics course. The responses are presented in Table 6.

Table 6. Impact of Active Learning Applications on the Attitudes of the Students towards the Physics Course

Attitude Towards the Physics Course	**Frequency**	**Percentage**
There was a positive change in my attitude after the applications	6	%50
There was no change in my attitude after the applications	6	%50

Various responses to the question, “Did teaching the magnetism unit in an active learning environment cause any changes in your attitude towards the physics course?” have been provided below.

> *There is a difference. I think I understand better. Previously, I did not attend physics courses a lot but I did this time for the application. There is a difference with the previous physics lessons, we did not memorize anything I enjoyed it, physics is not boring anymore (Ö10).*

> *Yes, but the change was not towards the physics course but towards the magnetism unit. I had not understood magnetism at the private teaching institution I am attending, and I had thought it was quite difficult. This time it was better. I mean I understood it better in this environment. I think of it this way; I had been taught this subject at the private teaching institution, but I wasn’t able to solve the questions, now I am solving all the questions, there is certainly a difference (Ö8).*

> *There wasn’t much difference towards physics, I was able to do it anyway (Ö5).*

It can be observed from the expressions that some of the students relate their attitudes towards physics directly by understanding the subject or not being able to understand it.

The students were also asked during the interview about what they liked and disliked about the teaching environment based on active learning method. The students especially indicated that they liked active learning applications in general and considered them to be effective. It was observed that all students were of the same opinion especially with regard to remembering what is learned. Criticisms on the active learning environment were generally expressed as not solving enough tests in the classroom and the lack of discipline during group work. The acquired data were subject to content analysis and frequencies were obtained for these opinions. Table 7 presents the findings.

Table 7. Opinions of the Students on the Physics Course Taught via Active Learning Method

Theme	Opinions	Frequency
Benefits of the method	It was effective and easy to remember	12
	Different materials were used	12
	It made it easier for me to understand the subject	9
	It increased participation to and interest in the lesson	8
	We learned how to learn	8
	Communication between students increased, there was unity	7
	The teacher attended everyone individually	7
	Physics was more enjoyable	6
	Sincerity, comfort when asking questions	4
Limitations of the Method	There was sometimes a lack of discipline	5
	Not enough tests were solved	4
	It was sometimes quite fast, we had difficulty taking notes	2

Various students' opinions on active learning placing the student at the center and improving class participation are presented below.

> *Interclass communication was good. It was more focused on the student; the teacher did not explain things directly. The applications ensured that everyone took part in the class (Ö2).*

> *It was effective on permanence. We gained confidence since we got to do it ourselves which was effective (Ö6).*

> *I saw that physics is not limited to numbers. I think we gained some permanent knowledge. I was more active during the lessons, and it was more permanent (Ö9).*

The students stated that teaching the magnetism unit in this way made it easier for them to understand and that they grasped the subject better. Ö7 emphasized the importance of preparing different learning environments for individuals with different areas of learning stating his opinions as follows; *"Learning was easier for students since different materials were used. Everyone can have different interests, slides, experiments… seeing, listening, different ways of learning… learning also differs with regard to time, active learning was also effective in this regard."* (Ö7)

Some students emphasized visuality indicating that it is an important factor for learning, stating that the materials used in the active learning environment made significant contributions to learning. *"Teaching the lesson in this way was very good. Magnetism required visuality. The simulations were nice. I liked the applications with regard to visuality and permanence."* (Ö4)

Majority of the students emphasized permanent learning indicating also that they learned how to learn. *"The experiments and calculations are on our minds even if we forget some of the subjects. We learned how to learn."* (Ö1); *"One learns more effectively when he does it himself and finds his own learning method."* (Ö8)

Active learning environment was considered to be effective by the students with regard to interclass communication and it was indicated that there were positive results with regard to both communication between student-student as well as between student-teacher. Ö8 from among the students made the following speech with regard to the importance of peer learning through the impact of the students on their respective learning; *"In the classical method, a student has to receive data from one individual … But in group work students can ask their friends."* (Ö8)

Ö9 evaluated active learning with regard to interclass communication indicating that the communication between the students is strengthened by way of this environment which enables the teacher to get to know the students better. *"Previously, the teacher-student interaction was good because they only taught the lesson, but this is even better because now the teacher has gotten to learn more about the student through active learning. There is solidarity between the students…"* (Ö9)

Indicating that the worksheets used in group studies have made a positive impact on interaction between the students, Ö7 stated the following comments regarding the contribution of the applications to the social development of the students; *"Worksheets were effective during group work … These applications develop our social aspect thus increasing our capacity to understand … In this way, it was possible to reach out to each student."* (Ö7)

The students stated that active learning environment entertains them while providing means for effective learning.

> *I liked the sincerity in the environment. Comfort when asking questions. It was nice to use smart board, simulations, and experiments (Ö5).*
>
> *I have positive opinions on active learning environment. Physics is now more entertaining (Ö9).*
>
> *Physics is not boring anymore. We liked the applications, they were effective. I am planning to be an engineer and it was nice for that purpose, I think (Ö12).*

Some of the students stated, *"I liked all its aspects since it is a beneficial application for students"* (Ö7) indicating that they like almost all the applications, while others stated the following with regard to the shortcomings and negative aspects of physics courses taught in an active learning environment;

> *It was effective in the teaching and explaining of verbal sections. It would be better if we could solve more questions on paper for the quantitative sections. There are people who consider the experiments as a waste of time. This is due to the exam-centric education system (university exam). In the end, there is an examination that awaits us. This is very important for us (Ö4).*
>
> *Discipline was low. Activity worksheets could be more effective if there was no lack of discipline. We sometimes could not take part in the lessons at the back of the classroom save for the experiments. Students learn what they enjoy, but it is boring to put it all down on paper. Of course, it would be better if there are worksheets (Ö5).*
>
> *We solved a very small number of questions. We solved mostly easy questions. There are very difficult questions on the subject. We went a bit too fast; it was hard to take notes (Ö10).*

The students were asked how the shortcomings indicated with regard to the physics course taught in an active learning environment in the negative comments can be overcome. Some of the students stated that it is necessary to solve more tests in the classroom, while others said it would be better to give out tests as homework. *"I wish it was a bit more test-oriented … Because we will be on our own in the actual exam … When solving questions, we could have started as a group and then continue individually. Both are necessary."* (Ö3)

Regarding the suggestions for overcoming the issues of discipline during the lessons, some of the students suggested to scare with grades, act harshly, and give punishments while others stated that those who are not interested in the applications and the lesson in general should be left out. *"The teacher should give out grades to the students based on their performance which would scare the students."* (Ö4); *"Excluding those who are not interested, you can lead a horse to water, but you can't make it drink it."* (Ö6)

The 8th item of the interview form included a question on whether the materials used in active learning environments such as videos, simulations, experiment setups, worksheets were used during the physics lessons. Students who compared the traditional physics lessons with the active learning environment stated that there are significant differences. The opinions of various students on this issue have been provided below:

> *There was no experiment, there were no worksheets. As was the case in previous lessons, the slides, smart boards, and simulations were used to reinforce what is learned. We conducted experiments during these lessons prior to the teaching of the subject which made our learning more permanent (Ö1).*
>
> *We only used worksheets with test questions. There were no others (Ö2).*
>
> *Clearly no. Simulations were sometimes used previously in some other courses except physics. This was done to reinforce what we learned after teaching the subject. This application is better (Ö9).*
>
> *Smartboards were used but there were no experiments or worksheets (Ö10).*
>
> *There were not many experiments. We just performed simple experiments. Because we focused more on the examination (Ö5).*

In another item of the interview form, the students were asked their opinions on teaching of the other lessons via active learning method. The students generally agreed that active learning method can be used for science courses but that it would not be suitable for mathematics. In addition, it was observed that the students who want active learning for all lessons were in the minority.

It is observed when the responses of the students to the question in the interview form, "How could the magnetism unit be taught more effectively, what are your suggestions?" that they expressed their positive opinions on the active learning environment. Moreover, some of the students suggested that more problems can be solved. During the interview, the students indicated the materials and activities they considered effective in terms of both permanence and in-class communication. They stated that these applications were both enjoyable and increased their motivations towards the course. Frequencies of the materials and activities mentioned during the interviews were identified and the results were presented in Figure 3.

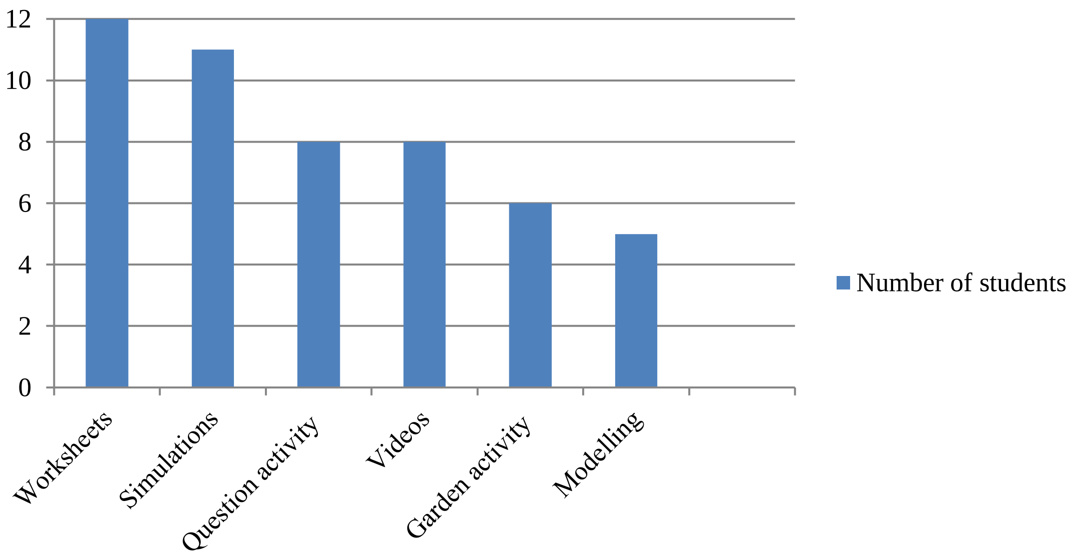

Figure 3. Graph for the applications preferred by the students

Based on Figure 3, experiments attract attention as the least preferred activity. The students indicated that previously they did not conduct many experiments, that the experiments conducted in active learning environment helped them learn and that they are important for permanence. In addition, they also stated that they increased class participation and that experiments are also beneficial for enabling active participation. Student expressions on this subject are as follows.

> *In previous courses, slides, smart board, and simulations were used for reinforcement after teaching the course. During these lessons, we made experiments before the subject was taught and thus, we learned more permanently by doing it ourselves (Ö1).*

> *It is more beneficial due to the visuality. I understood magnetism better, it was very difficult at first, but this environment made it easier. It made everyone participate. It's nice that there are materials (Ö2).*

> *Experiments aid in learning. Three-dimensional learning is more effective for magnetism. Everyone has a different method of understanding; some have to see things to understand and some have to listen. The applications actually benefited those who have to see things to understand. Those who think visually liked them more, they participated more in the classes. It was more beneficial for visual learners (Ö8).*

The students stated that experiments are beneficial for in-class communication as well as for enabling the teacher to focus more on the students while also enabling the students to learn from each other. *"It is better with the experiments since it is in the form of question-answer. In the normal classroom environment, the lesson was taught and we asked questions afterwards, but here, you can ask everything during the experiment at any time. Since we are altogether as a group, we can ask questions to one another and answer them which help us understand better."* (Ö3)

With regard to worksheets, the students stated that they find them beneficial for communication within the group. They indicated that they find activity plan worksheets beneficial with regard to scientific reasoning skills such as establishing hypothesis and drawing conclusions. It is also observed that the students have emphasized that the worksheets are effective and beneficial. In the meantime, they also stated that these applications have made it possible for the students to make an impact on each other's learning. In this case, it can be stated that peer learning takes place in active learning environments. Below are some quotations from student interviews on this subject.

> *First of all, we were doing the experiments and not the teacher and we were doing them as a group, other than that we put forth some hypotheses, the distributed worksheets, drawing conclusions, writing down the experiment etc. Group work was better. We filled the worksheets together which was also very effective (Ö6).*

> *We performed the experiments and then we went over the experiment results. Thanks to the worksheets, we discussed the subject among each other. It was great for permanence because we explained everything in our own words (Ö11).*

Below are expressions by Ö3 on the fact that conceptual change-based worksheets prepared for eliminating misconceptions helped the students discover their own misconceptions and eliminate them; *"Misconception worksheets were beneficial for eliminating misconceptions and discovering the points where we are faced with misconceptions."* (Ö3)

Students who stated that simulations and videos increased their interests and motivations towards the course put forth that the garden activity that took place at the beginning of the magnetism unit was a preparatory activity which was also very good. They emphasized that they enjoyed the visuality of the materials used in the active learning environment. They also stated that there was a nice competition among friends during the question activity in the classroom and they did not even realize how the time passed. They also indicated that the modelling applications helped them visualize abstract concepts in their minds. They put forth that all these applications and the different materials used encouraged the students to take part in the class. They said that active learning has many advantages compared with the classical method.

All students indicated that they think active learning environment is effective on scientific process skills. They especially indicated that the experiments and worksheets made a positive contribution in this regard. Ö3 said that the students observed the scientific process in active learning environment and stated the following with regard to the effectiveness of acquiring process skills; *"Process education... The student sees these and wants to make observations in the future. This of course makes an impact."* (Ö3)

Of the students, Ö2 compared the active learning environment with the traditional method as follows; *"Contribution to these skills… Yes, of course it will have contributions. Much better than the previous system. We can make observations."* (Ö2)

Ö1 considered the subject based on discipline indicating that he considers the lack of discipline in active learning environments that is present in traditional education environments as an advantage. Ö1 also said that active learning applications will be effective on scientific process skills. *"It will be effective. Discipline is more prevalent in traditional education. These applications will be more effective compared with the traditional method."* (Ö1)

Some of the students especially mentioned the experiment application with regard to the effects of active learning on scientific process skills. One of these was Ö6 who mentioned the applications in the activity plans used during the experiments. *"In the normal classroom we* *could just listen and go home, but here at least we can come up with questions, conduct an experiment and put forth a hypothesis which makes us think. That is why this information becomes permanent."* (Ö6)

Ö7 indicated that a strong communication in the classroom will prevent being unsociable. *"The applications we make help with overcoming being unsociable on the part of individuals compared with the classical education; it improves one's personality."* (Ö7)

Another student said that active learning environment stimulates one for research. He also indicated that these applications will be effective on scientific process skills. *"It made me want to research more rather than be content with only what I heard. It will be effective."* (Ö9)

Some students mentioned that the subjects are taught inductively throughout the process. They also stated that this was effective. One of these expressions was as follows; *"We went over the topics by dividing them into parts after which we combined them all which was very effective."* (Ö11)

Ö8 stated the following regarding the importance of the active presence of students in applications for the improvement of scientific process skills; *"The student can be more aware of his/her skills and abilities while trying to do something on his/her own. Because the students move from being passive to being active ..."* (Ö8)

Findings Based on the Analysis of Observation Data

The applications conducted throughout the study were observed by a specialist physics teacher. The results of the conducted observation were included in the observation form by the teacher. Thus, it was aimed to evaluate the physics courses taught via active learning method by a specialist from outside. The observation conducted evaluated the active learning environment, teacher (researcher) and students.

The observer summarized the process when answering the first item of the observation form which is the question, "What methods do students use in the classroom to acquire information?"

> *"The teacher makes the application through materials and experiment-observation relationship. In this way, he/she ensures that the student acquires the required information, guides them. The teacher also ensures that related problems on the subject are solved after teaching the theory."*

It was indicated in the notes related with the learning environment that the usage ratio of the teaching materials is quite high. It was also indicated to increase the comprehension ratios of the students. It was indicated that the teacher encourages students to participate in the lesson. The observer also indicated with regard to the ratio of participation of the students to the lesson that the applications ensure active participation of the students; *"Applications related with the subject make majority of the students more active."*

It was emphasized that in-class communication is established by way of active learning environment. It was stated that the students established positive communication inside the group and with other groups. It was specified that these relations contribute to the learning of the students. The related citations are provided below:

> *"The fact that students share their knowledge and experiences for reaching a conclusion leads to an increase in the knowledge of the individual. The groups share ideas among themselves during the applications and also on the results. The students compare the findings. This makes the findings and the subject more understandable."*

It was indicated that the teacher provided feedback during the applications. It was also stated that the teacher ensures that related problems are solved after teaching the subject which increases the mastery of the student related with the subject at hand. The observer gave the following response to the question in the interview form which was, "What is the impact of active learning on the problem solving of students?"; *"The student understands better when solving the problem. He/she grasps the logic behind what the question is trying to tell."*

In addition to filling out the observation form, interviews were also conducted with the observed during the lesson breaks. The observer stated during these interviews that the magnetism unit subjects that were taught in an abstract manner were concretized by way of active learning. The observed said that the students understood the subject better in this way and that they were able to conduct better reasoning.

Regarding the impact of active learning method in providing to the student solutions based on logic , the observed stated the following; *"The applications enable the student to grasp the connections between the topics better."*

With regard to the impact of active learning applications on the ability of the student to take responsibility, the observer said; *"The efforts of the student to find a correlation between the observations and the results make him/her more responsible. It also increases the motivation of the students."*

Based on the comments of the observer, it can be understood that a learning environment has been established which guides the students towards the right information. It has been specified in the observation form that student motivation is attained through the materials used and applications conducted in the learning environment in addition to increasing the interest and participation of the students. It is also emphasized in the form that the learning environment established also enables the students to restructure their own learning.

The active learning related components that stood out in interview and observation data were evaluated with regard to students, teachers and the environment after which they were presented in Figure 4.

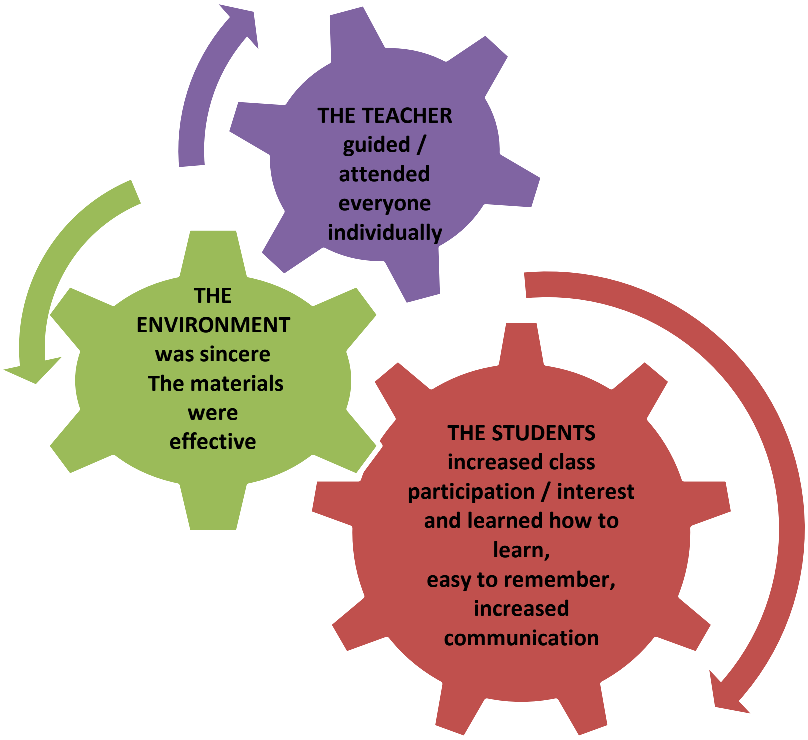

Figure 4. Expressions that stood out in observation and interview data

Discussion and Conclusion

The present study was conducted to examine the effectiveness of the active learning environment prepared for teaching the magnetism unit. In this regard, the data acquired from the tests applied prior to teaching the magnetism unit were compared with the data acquired from the tests applied after teaching the magnetism unit. The results were interpreted statistically. In the meantime, data acquired from the observations made during the process as well as the interviews conducted at the end of the applications were analyzed.

Magnetism unit was taught in an active learning environment in the experiment group. MCAT results indicate a statistically significant difference between the pre and post-test results of the experiment group. This difference puts forth that teaching in an active learning environment has made a positive impact on the academic achievement of students. Whereas magnetism unit has been taught using the traditional method in the control group. The MCAT results of the control group illustrated that there is a statistically significant difference before and after the process. This is an indication that traditional education also has a positive impact on the academic achievement of students.

A statistically significant difference was not observed as a result of the analysis of the MCAT pre-tests of the experiment and control groups. Accordingly, it was understood that the groups were quite equal with regard to academic achievement related with magnetism unit at the beginning of the study. While a statistically significant difference was identified when the MCAT post-tests of the groups were analyzed. It can be understood when the experiment and control group post-test averages were compared that there is a difference in favor of the experiment group. Moreover, the pre-test, post-test averages of the experiment and control groups were subject to Hake (1998)'s group gain analysis. Based on the results, experiment group gain was observed to be moderate while the control group gain was low.

In addition, the students stated during the interviews conducted after the applications that the applications made it easier for them to understand the subject and that a permanent and effective learning environment was set up through the use of different materials. They emphasized that there are significant differences between active learning and the traditional method.

It has been indicated as part of the observation data that the active learning method provides an opportunity to the students to structure their own knowledge on the subject of magnetism. It was emphasized that the environment provided enabled the students to establish the right connections between the acquired knowledge in the guidance of the teacher. Moreover, it was also stated that the students have had the opportunity to share their knowledge and skills during the lessons taught by active learning method. It has been set forth that such learning environments provide a positive support to the education of students.

Park and Choi (2014) suggested conducting studies which compare the education results of active learning environment and traditional classroom environments. It was observed when evaluated together with the findings of the study that active learning environment is more effective on the achievements of students related with the magnetism unit compared with the traditional method. It was determined as a result of studies conducted on the academic achievement of students in physics education that the active learning method is more effective compared with the traditional method (Demirci, 2000; Meltzer & Thornton, 2012; NRC; 2012; Parvin, 1989; Sökmen, 2000; Thornton et al., 2009; Uysal, 1996; Yılmaz, 1995). Hyun et al. (2017) indicated that active learning classes help increase student participation in addition to improving student performance. The findings of the present study support the aforementioned results.

MCAT was prepared in three stages for providing data on the already present misconceptions of the students. Conceptual Change Based Worksheet (CCBW) was prepared on the misconceptions acquired via literature and the MCAT data. CCBW was applied in a Socratic discussion environment established in the experiment group classroom. The students identified their own misconceptions and took notes after which they pointed out the right expression both within their groups and during classroom discussions. They then prepared conceptual change texts together with their group mates.

The first section of CCBW that has been described above is the part that is related directly with concepts. Whereas studies on solving questions were conducted during the second section of CCBW. Accordingly, misconceptions of students when solving magnetism related questions were identified. These misconceptions were eliminated via peer teaching by way of group discussions.

It can be observed that the misconceptions identified based on the MCAT pre-test results of the experiment group have been mostly eliminated in the post-test results. However, it was also observed based on the analysis of the MCAT pre-test and post-test results of the control group that the ratio of eliminating misconceptions is lower compared with the experiment group.

CCBW was utilized in the experiment group for helping the students to provide support related with filling the gap in their knowledge and to eliminate misconceptions. Students indicated in the interviews conducted that they became aware of their magnetism unit related misconceptions by way of CCBW applications. They stated that these applications have been effective in providing conceptual change related with the magnetism unit subjects. They put forth that CCBW is a helpful application that enables them to discover misconceptions related with solving questions. They asserted that conducting CCBW question activities while teaching the subjects will be more beneficial.

Based on the acquired findings, it was demonstrated that the active learning method is more successful compared with the traditional method in eliminating misconceptions related with the magnetism unit. Literature findings illustrate that active learning is a successful method in eliminating misconceptions (Acar, 2008; Aksu, 2010; Anlı Akyıldız, 2008; Avinç Akpınar, 2010; Naron, 2011). The findings of the present study were in accordance with the findings of previous studies. According to these data, it is possible to indicate that physics lessons taught in an active learning environment are effective in providing conceptual change.

The interviews conducted with the experiment group students after the applications revealed that positive opinions have developed related to the active learning method. The students put forth that teaching the lesson using experiments, simulations, videos, and worksheets have made a positive impact. They said that the method enabled them to understand the subject easily which increased their levels of achievement despite the fact that magnetism is one of the most difficult methods to understand in physics. MCAT post-test results were observed to support these statements. The students also pointed out that they had the opportunity to discover knowledge, discuss what they discovered and put it down in writing in the active learning environment which makes a positive impact with regard to the permanence of the acquired knowledge since they structure the knowledge themselves in their minds.

Students play an active role in the active learning method based on constructivism and learners structure their own knowledge in their minds (Canpolat et al., 2004; Dick, 1991; Fensham, 1992; Glasersfeld, 1989; Glasersfeld, 1995). The observation and interview data obtained as part of the present study verify that the active learning environment used for teaching the magnetism unit has met this requirement. It has been emphasized in the observation data that an environment has been established that enables the students to have access to this information and that majority of the applications encourage majority of the students to participate in the class. In addition, students have especially indicated the difference with the previous physics lessons and stated that the active learning environment has increased their in-class participation. The students said that they find the opportunity to develop their own methods while learning to learn.

Students have stated that they liked the materials used in the active environment in general. Visuality and permanence stood out as the most emphasized aspects related to the materials. Especially experiments, worksheets and simulations were identified as the favorite applications of students. It was indicated during the interviews that conducting these applications prior to teaching the lesson is more beneficial. In this way, students had the opportunity to acquire knowledge on their own in the guidance of their teacher. Meltzer and Thornton (2012) reported that the different methods used in active learning encourage the students with regard to learning, provided rapid feedback and guided the students in managing their processes of reasoning.

It was observed that conducting the experiments and worksheets in groups has led to positive outcomes regarding in-class communication. Observation and interview data illustrate that applications conducted as group work makes positive contributions to both student-student and teacher-student communication. The students stated that they were able to ask questions more comfortably thanks to the sincere environment. The teacher also had the chance to deal with a greater number of students more closely when they were classified into groups. In addition, students supported each other during group work by taking on responsibilities and they corrected each other's mistakes.

The students stated that the active learning environment has increased their self-confidence and supported their socialization. These findings are in accordance with the findings of previous studies. It has been reported in previous studies that the active learning method develops student achievement in addition to social skills, self-confidence as well as relationships with friends (Acar, 2008; Kalem & Fer, 2003; Naron, 2011; Suwondo & Wulandari, 2013).

The students were asked within the scope of the interview whether there have been any changes in their attitudes towards the physics course or not. Half of the students stated that they already liked physics course and thus there was no change in their attitudes. Whereas the other half indicated that they are prejudiced against physics class and magnetism unit. The students put forth that prior to the application process they considered that the magnetism unit subjects are very difficult to understand and that they found physics lessons boring. However, they also stated that the active learning environment eliminated these prejudices. They said that physics course taught via active learning method makes understanding easier and creates an entertaining environment. Findings of previous studies are in accordance with these results.

Studies show that a more social and entertaining environment is formed during the active learning process, increases the course participation and motivations of students in addition to shifting the attitudes of the students towards the course in a positive direction (Deslauriers et al., 2011; Ersoy & Dilber, 2016; Kalem & Fer, 2003). Schraw and Lehman (2001) assert that active participation is an important variable for grasping and sustaining attention. The results of present study support this assertion. Rotgans and Schmidt (2011) claimed that it will not be sufficient to use the situational level of interest declared by the students as an indication of performance. They stated that the interest of students towards the course should first transform into observable participation in the classroom in order to have any impact on performance. In this regard, it can be stated that active learning applications are effective in ensuring that the interest in the lessons is reflected in performance.

In addition, some of the students mentioned that more questions should be solved taking into consideration the importance of university entrance examination. They stated that teaching the course in this manner is good but that they do not think it has any validity in the current education system. The students put forth that in previous physics lessons the teacher taught the subject at the blackboard after which he/she distributed test papers to the students, that everyone solved the test and later asked the questions they could not solve. Students in 11th grade demand activities geared towards solving more questions due to the approaching deadline for the university examination. A large number of questions were solved in the control group lessons after the subject was taught. Even so, the final test success level of the control group was much lower compared with the experiment group. Based on this finding, it can be indicated that active learning is more effective than sparing time to solve questions for attaining academic achievement in the magnetism unit subjects. Moreover, higher academic achievement can be attained by increasing the number and quality of question solving activities that are included in active learning applications.

It was observed by both the researcher and the specialist teacher who took part in the lessons that students who are not accustomed to group work in traditional classroom environments at first found group work a bit strange. Even though the students were provided information as to how they will proceed with their group mates prior to the applications, they first passed through an adaptation period since they did not have prior experience. The observer specialist teacher indicated that the lack of experience of students related with similar applications in their previous education is a disadvantage for the present study. The observer put forth that the applications in active learning environments can be conducted more comfortably thus leading to better results if the students have prior experience in similar applications.

Students made some negative comments during the interviews stating that there was sometimes a lack of discipline in the classroom. It is considered that students who are accustomed to traditional classroom environment may sometimes find it disrupting that the classroom order is changed. The requirement for students in physics courses taught in active learning environments to structure their own learning and to take active part in the activities for this purpose in addition to the necessity of interacting with the other students during group work has made classroom management more difficult.

Some of the students complained that the lessons were sometimes taught very fast and that they had difficulty in taking notes. The active learning environments were designed so as to enable the students to discover the new knowledge to be acquired on their own. It was tried to ensure that the students take regular notes of their inferences on activity sheets. However, it is likely at this point that the students will make erroneous inferences leading to misconceptions. In order to avoid this, the researcher tried to collect the worksheets both during and after the class in order to conduct the required analyses. The researcher identified the misconceptions by talking to the students during the applications and by controlling the worksheets. The researcher prepared video, animation and simulation supported slides in order to overcome these misconceptions and to reinforce the newly acquired knowledge. It was ensured when providing an overview of the subject by way of these slides that the students took notes. A session for solving questions was always included after the teaching of the subject and it was aimed to ensure that the student encounters questions that require a different perspective. However, time management was not always easy for this process. The efforts to not lag behind the control group based on traditional method, the researcher sometimes had to teach the subject faster than usual. Even though the number of lessons taught like this was not high, this led some students to complain. It is considered that various active learning applications can be provided as homework in order to ensure efficient use of the allocated time. Students have virtual environment applications that will enable them to conduct active learning during off-school hours.

It can be stated when the study process was evaluated in general that the specialist teacher who observed the lessons and the students found the learning environment effective and that they were satisfied of the process.

Suggestions

Magnetism is mostly a unit that includes abstract physics concepts which are generally difficult to grasp for the students. It was observed during the present study that active learning applications were effective in teaching the magnetism unit subjects. It is considered that the physics teachers may create more effective learning environments by using the active learning method in teaching the magnetism unit subjects along with other physics subjects that students struggle with. In this regard, it is suggested that the active learning applications presented in the present study are used in teaching environments.

Simulations that are comprised of experiments designed both in a physical environment and in computer environments increase the interest and motivations of students. Applying the experiments and simulations in the present study by way of worksheets increased the interest and motivations of students while also enabling them to personally experience the scientific process. In addition, the experiments conducted as groups increased the cooperation between the students thus creating a social environment. It was put forth during the interviews conducted with the students that conducting experiments in active learning environment has many benefits. Conducting the experiments related with magnetism and other physics subjects in the classroom in groups accompanied by worksheets will support the different development aspects of the students. In this way, it can be possible to create educational environments that will ensure that the aimed goals are accomplished.

Creating a sincere and social classroom environment as part of active learning method has advantages as well as disadvantages. It may be difficult to control the classroom when implementing techniques and methods that require active participation on the parts of the students. Studies may be conducted on methods that will be effective in attaining discipline in classroom environments that place the student at their center.

The teacher controlled the worksheets during the active learning process and provided feedback. This is a very difficult, demanding and time consuming process. Accordingly, worksheets developed in an electronic environment may help in overcoming this difficulty. In addition, rapid and proper feedbacks will also be obtained. It can be indicated that the teachers may prefer using electronic worksheets in their teaching environments. Preparing easy to use electronic worksheets with the required validity and reliability for each physics subject and sharing them with the related individuals will be beneficial.

Misconception is another subject that researchers in education focus on. A conceptual change-based worksheet (CCBW) was prepared during the present study in order to eliminate the magnetism unit related misconceptions after which its effectiveness was identified. It is considered that preparing CCBWs for different subjects and implementing them will be beneficial for misconceptions identified for other physics subjects.

CCBW includes misconceptions that were identified for the magnetism unit as a whole. CCBW was applied after teaching the magnetism unit subjects. Separating the items of CCBW and implementing them step by step after teaching the related subjects may yield more effective results. Especially the test questions that make up the second section of CCBW can be classified into single question small worksheets and they may be applied after teaching the required magnetism related subject.

Active learning environments are open to development through the use of different materials. The active learning applications developed during the present study that are related with the magnetism unit subjects can be used by teachers either as is or by making certain additions or removals. As can be seen based on the study findings, the use of different materials enriches the teaching environment while also increasing its effectiveness.

The education environments are tried to be equipped with technological devices. These efforts are necessary but not sufficient on their own. Teachers who provided opinions on active learning indicated that they cannot find sufficient resources for each course. Materials that can be easily accessed by the teachers can be provided via the internet. Some websites have been developed to meet this demand; however, it is observed that such websites do not have data for all subjects. It is necessary to conduct studies that introduce materials with verified effectiveness for each course and subject in addition to explanations on their implementation. In the meantime, it will be beneficial for ensuring the functionality of constructivist and student centric applications to let teachers know of the related studies and materials and to encourage them for using these materials.

References

Acar, B. (2008). *"Acid and bases" in high school chemistry lesson*. (Unpublished doctoral dissertation). Dokuz Eylül University, İzmir.

Açıkgöz, K. Ü. (2003). Aktif öğrenme *[Active learning]*. İzmir: Eğitim Dünyası.

Aksu, Ş. (2010). *The effect of active learning method on preventing misconceptions in the subject of "mole" in Chemistry-1 Programme in high school.* (Unpublished doctoral dissertation). Dokuz Eylül University, İzmir.

Anlı Akyıldız, R. (2008). *Application of active learning methods in class management (in chemistry education).* (Unpublished master's thesis). Yeditepe University, İstanbul.

Avinç Akpınar, İ. (2010). *The preparation, implementation and evaluation of active learning activities based on constructivist approach in teaching solutions in chemistry course.* (Unpublished doctoral dissertation). Atatürk University, Erzurum.

Baki, A. and Gökçek, T. (2012). A general overview of mixed method researches. *Electronic Journal of Social Sciences, 11*(42), 1-21. https://dergipark.org.tr/en/download/article-file/70397

Canpolat, N., Pınarbaşı, T., Bayrakçeken, S. and Geban, Ö. (2004). Some common misconceptions in chemistry. *Journal of Gazi Faculty of Education, 24*(1), 135-146. http://www.gefad.gazi.edu.tr/en/download/article-file/77339

Demirci, C. (2000). Etkin öğrenme yaklaşımının ilköğretim 2. sınıf hayat bilgisi dersinde uygulanması [Application of active learning approach in primary school 2nd grade the social studies course]. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi, 18*(18). https://dergipark.org.tr/en/pub/hunefd/issue/7818/102729

Deslauriers, L., Schelew, E. and Wieman, C. (2011). Improved learning in a large-enrollment physics class. *Science,* 332, 862-864. https://www.science.org/doi/10.1126/science.1201783

Dick, W. (1991). An instructional designer's view of constructivism. *Educational Technology, 31*(5), 41-44.

Ersoy, F. N. B. and Dilber, R. (2016). The opinions of technical and vocational high school students and teachers about learning environment which are formed by active learning method. *Journal of National Education, 45*(212), 45-59. https://dergipark.org.tr/en/download/article-file/441230

Fei, V. L. and Hung, D. (2016). Teachers as learning designers: What technology has to do with learning: A view from Singapore. *Educational Technology,* 26-29. https://www.jstor.org/stable/44430473

Fensham, P. J. (1992). *Science and Technology.* In P. W. Jackson (Ed). Handbook of research on curriculum (pp. 789-829). New York: Macmillan Publishing Company.

Fisher, K. (2010). Technology-enabled active learning environments: An appraisal. Retrieved from https://dx.doi.org/10.1787/5kmbjxzrmc0p-en

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H. and Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Science, 111*(23), 8410–8415. https://www.pnas.org/content/pnas/early/2014/05/08/1319030111.full.pdf?utm_so

Glasersfeld, E. V. (1989). Constructivism in education. Oxford: Pergamon.

Glasersfeld, E. V. (1995). *A Constructivist Approach Teaching.* In L. P. Steffe and J. Gale (Ed.), Construtivism in education (pp. 3-15). Hillsdale, NJ: Lawrence Erlbaum Associates.

Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand student survey of mechanics teat data for introductory physics courses. *American Journal of Physics, 66*(1), 64-74. https://files.eric.ed.gov/fulltext/ED441679.pdf

Hand, B. and Treagust, D. F. (1991). Student achievement and science curriculum development using a constructivist framework. *School Science and Mathematics, 91*(4), 172-176. https://www.academia.edu/26222624/Student_Achievement_and_Science_Curriculum_Development_Using_a_Constructive_Framework?from=cover_page

Hyun, J., Ediger, R. and Lee, D. (2017). Students' satisfaction on their learning process in active learning and traditional classrooms. *International Journal of Teaching and Learning in Higher Education, 29*(1), 108-118. https://files.eric.ed.gov/fulltext/EJ1135821.pdf

Kalem, S. and Fer, S. (2003). The effects of active learning model on students' learning, teaching and communication. *Educational Sciences Theory & Practise, 3*(2), 433-461. https://web.a.ebscohost.com/ehost/pdfviewer/pdfviewer?vid=0&sid=0813439f-26a0-4796-b044-b1675718096b%40sdc-v-sessmgr02

Luckin, R., Bligh, B., Manches, A., Ainsworth, S., Crook, C. and Noss, R. (2012). Decoding learning: The proof, promise and potential of digital education. Retrieved from https://apo.org.au/node/32254

Meltzer, D. E. and Thornton, R. K. (2012). Resource letter ALIP–1: Active-learning instruction in physics citation. *American Journal of Physics*, 80, 478. http://physicseducation.net/docs/Meltzer_and_Thornton_2012.pdf

Moustakas, C. (1994). Phenomenological Research Methods. Sage Publications.

Nakamura, C. M. (2012). *The pathway active learning environment: An interactive web-based tool for physics education.* (Doctor of philosophy dissertation). Kansas State University, Manhattan.

Naron, C. (2011). *Active learning in the physics classroom.* (Doctor of philosophy dissertation). Walden University, Minneapolis.

National Research Council (NRC) (2012). Discipline-Based Education Research: Understanding and İmproving Learning in Undergraduate Science and Engineering. The National Academies Press. https://doi.org/10.17226/13362

Nelson, L. P. and Crow, M. L. (2014). Do active-learning strategies improve students' critical thinking? *Higher Education Studies, 4*(2), 77-90. https://files.eric.ed.gov/fulltext/EJ1076485.pdf

Oblinger, D. (2005). Leading the transition from classrooms to learning spaces. *Educause Quarterly, 1*(7-12). http://www.fisica.uniud.it/~stefanel/PerMarisa/InformalLearning/Articoli/Oblingereqm0512Oblinger.pdf

OECD (2015). Students, Computers and Learning. Making the Connection. Paris: OECD. Retrieved from http://dx.doi.org/10.1787/9789264239555-en

Park, E. L. and Choi, B. K. (2014). Transformation of classroom spaces: Traditional versus active learning classroom in colleges. *Higher Education, 68*(5), 749-771. https://link.springer.com/content/pdf/10.1007/s10734-014-9742-0.pdf

Parvin, F. N. (1989). Integration of communication skills with active learning techniques in science. *Dissertation Abstract International*, *45*(3).

Patton, M. Q. (2014). *Qualitative research & evaluation methods: Integrating theory and practice.* Sage publications.

Rotgans, J. I. and Schmidt, H. G. (2011). Situational interest and academic achievement in the active-learning classroom. *Learning and Instruction, 21*(1), 58-67. https://doi.org/10.1016/j.learninstruc.2009.11.001

Sauricki, J. L. (1989). *Shall women vote? An active-learning curriculum unit for college student.* (Doctoral dissertation, Dissertation Abstract International).

Schraw, G. and Lehman, S. (2001). Situational interest: A review of the literature and directions for future research. *Educational psychology review, 13*(1), 23-52. https://link.springer.com/content/pdf/10.1023/A:1009004801455.pdf

Seferoğlu, S. S. (2015). Okullarda teknoloji kullanımı ve uygulamalar: Gözlemler, sorunlar ve çözüm önerileri [Technology use and applications in schools: Observations, problems and solutions]. *Artı Eğitim, 123*, 90-91. http://www.egitimtercihi.com/okulgazetesi/17207-okullarda-teknoloji-kullan-m-ve-uygulamalar.html

Sökmen, N. (2000). Active education methods practiced in undergraduate chemistry courses. *Education and Science, 25*(117), 29-34. http://eb.ted.org.tr/index.php/EB/article/view/5288

Suwondo, S. and Wulandari, S. (2013). Inquiry-based active learning: the enhancement of attitude and understanding of the concept of experimental design in biostatics course. *Asian Social Science, 9*(12), 212-219. https://scholar.google.com.tr/citations?view_op=view_citation&hl=tr&user=jQCQ2PYAAAAJ&citation_for_view=jQCQ2PYAAAAJ:9yKSN-GCB0IC

Theobald, E. J., Hill, M. J., Tran, E., Agrawal, S., Arroyo, E. N., Behling, S., ... and Freeman, S. (2020). Active learning narrows achievement gaps for underrepresented students in undergraduate science, technology, engineering, and math. *Proceedings of the National Academy of Sciences, 117*(12), 6476-6483. https://www.pnas.org/lookup/suppl/doi:10.1073/pnas.1916903117/-/DCSupplemental.

Thornton, R. K., Kuhl, D., Cummings, K. and Marx, J. (2009). Comparing the force and motion conceptual evaluation and the force concept İnventory. *Physical Review ST Physics Education Research, 5*(1). https://journals.aps.org/prper/pdf/10.1103/PhysRevSTPER.5.010105

Uysal, Ö. F. (1996). *The effect of active student participation on learning outcomes in the learning process.* (Unpublished doctoral dissertation). Dokuz Eylül University, İzmir.

Yılmaz, A. (1995). *The effect of active method on student success in high school 2nd grade physics course.* (Unpublished master's thesis). Dokuz Eylül University, İzmir.