Activity-based Interactive Engagement in Science (Physics) Laboratory

An Approach to Stimulate Pre-Service Teachers' Conceptual Understanding

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Abstract

The purpose of this study was to investigate pre-service teachers' views with regard to the teaching approach used in the course of Science Laboratory and Its Applications based on activities and interactive engagement (Örnek, 2008; Orlik, 2005; Ornek, 2006) to stimulate their conceptual understanding of science concepts. Its aim was also to consider how physics may aid the teachers/instructors in bringing physics successfully to all levels. An open-ended exit survey was administered to 216 pre-service teachers, who were at Balikesir University in Turkey at the end of the fall 2007 semester and 210 pre-service teachers at the end of the spring 2008 semester and 140 pre-service teachers at Amasya University in Turkey at the end of the Fall 2008 semester to collect data in terms of students' conceptions about the course and the approach used. In addition, semi-structured interviews with 62 volunteer pre-service teachers from Balikesir University and 20 volunteer pre-service teachers from Amasya University were conducted. The findings of this study have potential in translating research insights into practical recommendations for teachers regarding with making science labs more effective and efficient and provide guidelines for teachers (Chin, 2007) to increase students' construction of knowledge in science and making connections to the real life and other fields such as health science.

Key words: Activity-based learning, interactive, physics lab, science lab

1. Introduction

Students' learning experiences, their experiences with the teacher, teaching approaches of the teacher, and the subject matter itself play a crucial role in formation of students' conceptions concerning the course. Students' conceptions affect their behavior, influencing what the learner selects from the class environment, how they will react to the teachers, the materials being used and their classmates (Shah, Riffat, & Reid, 2007). Science laboratories that are one of the class environments are broadly considered as a key component of science instruction since most science fields such as physics, chemistry, or biology are founded on activity-based investigations in the world even though observations, inferences, imagination, and creativity are parts of nature of science. A constructivist-inquiry approach can be used for effective teaching and learning science as a contemporary teaching approach that unfortunately teachers/instructors sometimes may not be able to manage properly to arrive at competent level of students' knowledge and skills (Orlik, 2005).

The usage of this approach is based on students' actively participation and emphasizes the cooperative and constructive nature of scientific activity. Therefore, students are expected to engage in explaining concepts with their peers and teacher/instructor (Akkus, Gunel, & Hand, 2007). Likewise, students are encouraged to make explicit and sound connections among questions, observations, and evidence (Akkus et al., 2007). This approach requires a high level of interaction among the students, the teacher/instructor, the area of study, and available resources (Aladejana & Aderibigbe, 2007). Traditional laboratory activities are already designed for students who follow instructions in their lab manual. Science teachers and science laboratory manuals in general emphasize procedures (Perkins-Gough, 2007). Teachers/instructors often prepare the questions and the tasks to be followed by students before starting the experiments. In other words, problem/questions and procedure/method are always provided to students. Solution can be either provided to students or constructed by students (Fay & Bretz, 2008). In general, the role of the teacher in the traditional lab classes is to transmit the knowledge to students. Students are also expected to receive or memorize the given information. This kind of classes likens teacher-centered instruction even though experiments are involved. Thus traditional teacher-centered instruction can have an absence of student-centered learning activities (Akkus et al., 2007).

According to the most research, it has been found that student achievement and skills improved when an activity-based interactive engagement curriculum was used to teach science (Aladejana & Aderibigbe, 2007; Turpin & Cage, 2004; Welch & Walberg, 1972; Fraser, 1986; Bredderman, 1983; Wong & Fraser, 1996). Students can recognize, design, and apply fundamental science concepts into practice (Akkus et al., 2007). Since students do have some difficulties in understanding the underlying scientific concepts, this activity-based teaching approach can have the potential to excite and enlighten students about the importance of science in their daily lives. It exposes teachers/instructors to classroom activities that combine excitement, cooperative learning, and participatory activities with real-world relevance" (Conlon, 2004). These approaches will motivate students to pursue careers in science, engineering, and technology if it is started to implement at the early level of schools such as primary and secondary schools.

2. Theoretical Underpinnings

The principal theoretical framework underlying this study is social constructivism that focuses on the environment in which the knowledge is formed and how this environment may influence the individual (Bodner, Klobuchar, & Geelen et al., 2001). Social constructivism would occur when a group of people collaborate to solve a problem or create and prepare an activity. Each person brings a little bit to the interaction, and together they can build knowledge that leads to a solution which each would have been unable to do alone. In this case teacher assists student performance by guiding the discourse among students to support student learning (Chin, 2007).

Meaningful learning in constructivist approach is a cognitive process that students make sense of the world with regard to the knowledge that they have already constructed (Wilson, 1996; Fosnot, 1996; Steffe & Gale, 1995). Some features of the constructivist classroom settings include carrying out some experiments or activities, engaging in meaningful problem-based work and working collaboratively with each other. In other words, students can construct knowledge and skills through their own experience (Windschitl, 2002) and they can construct an accurate representation of the real world (Doolittle & Camp, 1999). The science laboratory environment or setting is a major path for the students to be involved actively and to perform activities, construct new knowledge-sometimes modify the previous knowledge- onto their existing mental framework for meaningful learning to take place (Huitt, 2003; Sherman, 1995).

In addition, constructivism is used to describe a large number of different theories which fall under the general thought that knowledge is constructed (Philips, 1995). Rather than receiving knowledge as a transmission of knowledge that is already complete and ready to use, students build their knowledge on the foundation of what they have previously learned. Students approach a situation with prior knowledge influencing them (Hoover, 1996). For example, students in a physics class will apply what they already know about how objects react when they are sitting in a car going around a sharp turn (Churukian, 2002). The different theories of constructivism are often delineated by adjectives which describe their primary focus. There are different constructivism thoughts of which one is social constructivism is central for this study.

A Purpose of the Study

The purpose of this study was to investigate pre-service teachers' views with regard to the course of science laboratory and its applications. Its aim is also to consider how physics aid the teachers/instructors in bringing physics to all levels.

The focus of the study was: What are pre-service teachers' views and expectations of the role of activity-based approach in enhancing conceptual understanding of physics and constructing knowledge of physics by means of activity-based and interactive engagement?

B Structure of the Course and the Teaching Method

A course named "Science Laboratory and its Applications" for pre-service teachers was taught by using an activity-based interactive engagement approach in Turkey. This course was a two-semester course that the fall semester covers fluids, optics (light), energy, energy transfer and transformation, and sound and the spring semester covers electricity and magnetism. The teaching approach was the first time applied in the universities listed before.

In Science labs, the teacher should assist students in making sense of scientific ideas and support them in applying the ideas (Chin, 2007) and making connections to real life and other disciplines while teaching science. Whereas in traditional science labs, firstly content knowledge or theoretical information is provided by the teachers then students are asked to conduct experiments based on the lab manual which is a kind of cook book. For activity-based interactive engagement approach, students are asked to do activities and the teacher asks questions for brainstorming to explore students' views and gives importance on their views even though their ideas can be different from the scientific views. During continuing discussions, the teacher always asks conceptual questions to elicit students' ideas and facilitate productive thinking, gives constructive and encouraging feedback to students encourages multiple responses (Chin, 2007). These all help students construct knowledge of science by the constructivism- inquiry approach (Roth, 1996; Van Zee & Minstrell, 1997a).

The other advantageous of using this approach is that students are asked to make connections to the real life and other disciplines such as chemistry, biology, or health science. Before this contemporary teaching approach, the traditional teaching method as known, there are experiments that students are supposed to do and write reports after that, was employed to teach this course. Also, students were not able to do same experiments at the same course period due to the lack of materials so students had to do different experiments in each course period. In that approach, students memorized some information or were just taking measurements instead of construction knowledge.

The course had four sections and each section had about 40-55 students and was divided into 8 small groups. Each group had six or seven members and each one had to prepare and present one activity and manage the classroom in each class period as if he/she was a teacher. The students in each group presented in every week alternately. The purpose was to have students be actively involved and discuss the results. Each group presented the same topic in a class period such as density.

An example from the activities that was conducted is shown in Appendix A: Students do not have to do the same activity exactly shown in Appendix A. They need to do an activity about density though. The noteworthy thing about these activities students experienced are very easily duplicated with common, ordinary household items that can be probably found around your school or homes.

As seen in the activity in Appendix A, pre-service teachers should start with an interesting question to draw attention and make students engage in the activity. In other words, brainstorming should take place and is important before starting the activity which is called as pre-activity. During brainstorming a teacher or instructor can ask several questions and make students be curious about the phenomena. After that while the teacher is doing the activity, she/he asks students do it at the same time. In the time of performing activities which is called as during activity as well, you can ask some questions such as “what will happen now?” or “what did you observe?” So the teacher can involve students in the course actively.

In the subsequent section (What is happening?) called as post-activity as well, the teacher can ask students some questions such as what is happening and why this happened in science lab discourse to scaffold student’s thinking and assist students construction of scientific knowledge (Chin, 2006) to encourage them to explain the reasons of the phenomena. If their explanations and predictions are different from scientific knowledge, then ask more questions to make them to elaborate on their previous answers and ideas about the phenomena and assist them construct conceptual knowledge. Students may have some misconceptions or some knowledge that they bring from their previous learning or experience.

Thus, this teaching approach can provide a resource for students to clarify misconceptions regarding material covered in the other aspects of the course. For instance, some students may misuse the concepts of density and mass such as if one thing has more weight then it sinks first. Whereas it should be examined with respect to its density.

The other most important issue is that students do not have enough knowledge about the nature of science (NOS) because their teachers or instructors unfortunately are not in general aware of the importance of NOS in teaching science courses, so do students. One of the most important aspects of NOS is *tentativeness of scientific knowledge* that means all scientific knowledge is subject to change (Lederman et al, 2002; Akerson & Hanuscin, 2008; Abd-El-Khalick & Akerson, 2004; Akerson, Abd-El-Khalick, & Lederman, 2000). When new knowledge is found, the old one should be modified or omitted. This aspect of NOS is really crucial because if teachers, instructors, or prospective teachers do not know about that they can teach that scientific knowledge is durable and not easily changed. So, they learn and trust in old knowledge and they will not update their knowledge. For instance, when we did an activity concerning the concept of “static electric”, I asked students a question with regard to the real life. The question was “how can electric sparks occur in air?” An electric spark may be occasionally seen when you flip a switch, unplug a power cord, shake one’s hand, or open a door. All my students, approximately 200, answered this question incorrectly. Their responses were that during a spark, charge is transferred from one object to another object. In other words, during a spark electrons could simply jump from the negative object to the positive object. Whereas this knowledge is old knowledge and this is not a possible mechanism because a free electron can travel only about $5x10^{-7}$ meters before colliding with a gas molecule (air molecule or ion) and losing much of its energy (Chabay & Sherwood, 2002). The correct answer to the question is related to positive ions and electrons moving in ionized air. This ionized air model is significantly better explanation that jumping electrons model because no particle in the ionized air model travels farther than approximately $5x10^{-7}$ meters.

Therefore some activities can positively influence students' views of NOS. Smith, Maclin, Houghton, & Hennessey (2000) also found that appropriate science practices could positively influence students' views of NOS. The results of the study may provide evidence that activity-based instruction can be effective for developing students' NOS views.

Furthermore, in the activity, the section of "what to do" is the step three. That step has also other aspect of NOS that observations can be affected by the observers' anticipation, pre-knowledge, experience, background, and preconceptions (Chen, 2006). After students make careful observations, they will make some inferences based on their pre-knowledge and anticipation. So they will learn how to use available data to draw results.

3. Methodology

Settings and Participants

216 pre-service teachers in the fall 2007 and 210 pre-service teachers in the spring 2008 from Balikesir University and 140 pre-service teachers in the fall 2008 from Amasya University in Turkey were participated in this study. 62 pre-service teachers from Balikesir University and 20 from Amasya University also volunteered for interviewing in this study.

Data Collection and Analysis

An open-ended exit survey, which was adapted from Ornek's study (2006) and modified, to explore pre-service teachers' thoughts about the course and the manner it was taught in the course. This survey includes 10 open-ended questions and establishes students' views about the course. The questions are on what students liked and disliked about the course as well as what they would change in the course and how their activities provide them to understand physical phenomenon. The semi-structured interviews were conducted after the final exams since we were the instructor of the courses students may think their responses can affect their final grades. We used a qualitative approach to address our research question and analyze the data. The qualitative details from the semi-structured interviews were used not only to validate the survey results, but also to provide some plausible interpretations for the findings drawn from this study.

Each volunteer was interviewed in the offices or the science lab in personal. The interviewing time varied depending on students. Once we transcribed all the interviews, we created initial codes or concepts through the process of open coding by using transcripts from the interviews and the exit survey results. We coded them and analyzed them using inductive analysis with the help of a data-management software program called ATLAS.TI. Inductive analysis begins with specific observations and builds toward general patterns. Categories of analysis emerge from interviews and survey results as the researcher comes to understand patterns which are in the phenomenon being studied (Patton, 2002). This procedure involved grouping and regrouping the quotes until we developed the categories of descriptions. We interpreted and compared the meanings of the categories.

Theoretical Framework for Qualitative Study of Phenomenography

Since this study is concerned with student experience within a science laboratory course, the design of this qualitative study is best viewed within a phenomenographic framework. Phenomenography (Marton, 1986) is the study of the different ways in which people notice the world. In phenomenographic research, the researcher chooses to study how people experience a given phenomenon, not to study the phenomenon. Here we apply this idea to ascertain the ways of experiencing of a science laboratory and applications courses by students.

4. Results and Conclusions

The transcripts from the interviews and the informal conversations and quotations from the open-ended exit survey contain the following shorthand notation: [ ] represents comments about the interviews and the informal conservations with students and the survey results added after the fact, {…} indicates that unimportant words were omitted from the transcript, and unnecessary words or sentences that are not included.

Examining the data from the survey and the semi-structured interviews have given a deeper understanding of the students' conceptions about the course. First, all survey results and the interviews were examined and the results were supported by the quotations from the survey results. Second a researcher, who was not involved in this study, analyzed the same data independently and compared the findings. After that, we found that our results were compatible. Because of space constraints, a few quotes are chosen to support assertions. Quotes chosen from the survey results and interviews are representative of other students.

The data were analyzed into the following categories that emerged while reading and re-reading the transcripts and the survey results: *expectations; instructions; difficulties; understanding and learning; traditional science lab vs. activity-based lab; student-instructor interaction; assignments; interactions with students' group mates.*

Students enter a course with expectations of how it will be conducted, what will happen, and how they will interact in the class. In the case of these students, this activity-based teaching was a totally new environment for them. Also, the expectations concerning involvement of the instructor acting sometimes like a student and their interactions with the instructor were realized. The following quotes describe that students did not expect this kind of group work to be a part of the class and were not expecting involvement of the instructor that much.

> *S1: Um, I'm not sure. I know there's a lab but I don't know what we're doing in the lab. Actually I heard from students who already took this course before that it was going to be traditional science lab.*
>
> *S2: ... Um, I didn't expect you [the instructor] to be very involved. Like acting a student and being interested in students' any kind of problems.*
>
> *S3: ...And this course isn't like all the other class- or classes that I have. Like I have math and chemistry, and they're completely different from them.*
>
> *S4: The interesting thing for me is that I was very surprised at the beginning and did not like the way in which the course was taught because each group had to prepare and present an activity about the same topic. For example, each group did an activity about density in a class period and some of them did the same activities. It was not good for me because I felt that we were going to just repeat the same things; however what I saw was that each group presented in a different way and used different materials and made different connections to the real life and other majors. At the end of the class, I just said "wavvv" as being amazed [laugh].*
>
> *S : Honestly, this is the course I enjoy most in this semester and every week I was*

> *looking forward to doing my activity and seeing others' activities. To learn the reason of phenomenon that we come across in our life is very good. But at the beginning, I was very nervous while I was presenting my activity and acting like a teacher in the class. It was like the act of rehearsing before becoming a teacher [laugh]. On the other hand again frankly it was difficult to prepare the assignments because every week we have to prepare a new and different assignment. So I am not used to this kind of things.*

The students revealed strategies to help them learn and understand concepts being taught in the classes. In their comments, they stated about their own learning and understanding styles and whether those styles were or were not addressed. Students' natures vary and cannot be the same. They can learn through different styles. However, they learn by asking questions and discussing things with the instructor or some learn from people who are closer to their ages in general. In other words, some of students are comfortable to discuss things with their classmates. Students pointed out that they liked the fact that they could work, discuss, and share with their peers and learn from their peers. They had an opportunity to investigate and discuss the concepts with peers and the instructor as well. That's; this method can have the potential that students construct the knowledge and understand the science concepts by discussing concepts and questions, sharing idea, and getting help from the instructor and their peers. Here are several quotations that explore these ideas.

> *S4: First, I would like to thank you [the instructor] for employing this method because our teachers had tried to teach courses including science, mathematics, and others by using traditional methods that we had to memorize scientific truths and learn some concepts which are very abstract for us. As for science laboratory, the only purpose of school laboratory experiments was to help us memorize the scientific truth and take some measurements. I do not mean we did not learn, actually we learn for that moment but later we forget almost all knowledge that we learned because we did not make any connections to real life or other disciplines. Moreover, we forgot most of that knowledge. If we were taught our courses in that way, probably we would not forget almost all information and remember them. Also, I'd like to constitute activities with our group mates. That means we are not restricted to do same activity or experiment in the class. Also, we search, find, create, construct, and conduct the activities and the knowledge. So, it will be not easy to forget concepts. As a prospective teacher, when I become a teacher in the future I will definitely use the method, which you applied in the class, even though I will not teach science. So, I can adapt this method to mathematics.*

> *S5: It [the small group]'s helpful, because sometimes, well even more than sometimes, I'm wrong and it's good for other people to show me how I'm wrong. It's also good for me to explain to together people how they're wrong. If you work well together you can usually get most of the good activities and presentations. But if you don't work well together things don't always get done very well.*

> *S6: Small group work. Ok. It gives us a chance to like openly discuss, you know, the problem at hand and throwing out different ideas and seeing which ones work. Agreeing and disagreeing. Just working out the whole activity. Just, you know, that really helps develop the ability to prepare an activity.*

> *S7: Um, working in small groups for me has always been beneficial because I can talk to somebody, who knows what their*

talking about and learn from them. And if I know what I'm talking about or have a general idea and another person does not then I can teach what I know to them. This greatly helps me because I am rethinking what know and being `is this really right? Is- do I know this that well?' And I can find then that as I discuss these things and try to teach the concepts to somebody else it reinforces my own idea of the concepts. And also if, uh, nobody knows the answer, uh, then it does help to have many people, you know, looking in the book and searching their own notes for the answer. So, overall I think small groups are, uh, are very helpful. Um, in general the small group that I'm in right now we don't- nobody is really- had that firm a grasp, um, and so it's not as helpful as I would like it to be and that I can get more information from it- form my peers…(Fall 2004).

Some students complained that the method employed in the course, especially writing assignments, was difficult and made the course harder, but also they were aware that it provided a better understanding of physical phenomenon. They indicated this because they were not taught by using this teaching method so far. Also investigating and preparing the activities and writing assignments take a log time and the other problems are that we do not always have computer labs and internet access to be used by students for their search and libraries to search. Here are some comments from the study participants concerning their worries at the beginning and how their views are changed throughout the course.

S7: To be honest, at the beginning of the class, I was not that much happy because it [the teaching method] was new for me and I did not know how to do. So, I had some troubles in the beginning then I liked it. It is like exploring and discovering something. The most difficult part for me was to write and prepare assignments because the format of it is different from that of we had used so far. That's; we first start with activities then write or give theoretical information. Also, the best part for me is to make connections to everyday life. You know that it is good to know what is happening around us and how things work. Also, we made connections to the other disciplines. Moreover, we are asked to construct another activity that related to the topic. For example, if we prepare an activity on light, at the end of the assignment we need to write another activity that related to the light. Therefore, this makes us reinforce to comprehend the concepts. Writing the assignment in a different way provided our horizons expand. I really would like to thank you with regard to using this method and having us explore and investigate science concepts. Believe me that I will use your teaching style in the future.

Students think that this method is conceptually-oriented and made students understand physics concepts since some steps in activities are related to real life and other fields such as biology, chemistry etc. It assisted students figure out how things around the world work. Also, they stated how different this method is from the traditional science lab. Some quotes that illustrate these points from students follow:

S8: The teaching method is inquiry-based and student-centered so that it provided us to investigate the given topic and construct an activity that can be already created or used before. However, it requires us to digest all information and then to form the activity. Moreover, the best part of it is that we learned how to connect all things to our everyday life. To be honest, I hate physics and science before this course because everything was limited with the equations and some facts. I was always thinking that why we were learning this mass. I got to know that physics is not that much *difficult! How and where I am going to use all these junk information. In this course, I learned that the reasons of the phenomenon occurred around me or us. For instance, when I take a shower, now I know why a shower curtain gets sucked inwards when the water is turned on. The reason for this is Bernoulli principle. [The students explained the Bernoulli principle during the interview because I asked to make sure if they really learned or not] near the water stream flows into the lower pressure stream and is swept downward. Air pressure inside the curtain is reduced and the curtain is pushed inward. I can say that honestly I have not been aware of all physical principles that explain many phenomenon around us.*

S9: Frankly, there are too many things to do in this class. I do not like this. Maybe I am not used to doing this kind of things in my education life. We have not done too much so far. So, this much load makes me crazy. On the other hand, when I think what I have learned so far in this class is that I know how things work and I can make connections with real life and other majors such chemistry. Throughout the course, the class seems to be fun and enjoyable. Also, I enjoyed doing a project about how a magnetic field affects plants. It is wonderful to do this project because I can combine physics with biology. So I saw how physics are related to biology. But again there is too much to do. This is my problem maybe I am a lazy person [laugh].

S10: *...Of course, laboratory work makes me clear about the concepts presented in the teacher's lectures and textbooks.*

S11: The activities we did and presented in the class gave us some concrete experiences that help us to understand the scientific concepts.

S12: The activities are related to everyday life. We did some activities that explore some interesting life-related questions, and this is wonderful...For instance, in density activity, we answered a question about why fat people swim more easily in the sea than slim people. In other words, a fat person floats, as you've probably heard, while your bones and muscles, denser than fat, are not as willing to float.

S12: ... I really like the way in which the course has been taught because that is learning as doing, practicing, and living. For me it is good teaching. In other words, students investigate, prepare, and present the activities in the class and the most beautiful thing about that you do not need to buy expensive materials; you can probably have them in your home or around you. Or even if you need to buy some of them, they are very cheap materials. After students present their activities of course all students participate actively during that process, the instructor if she feels and sees the concepts are not fully understood or not complete, she makes explanations and clarifications. What I mean we do everything we act like a teacher, she only acts like a helper. That is very nice. If we had been taught in a traditional method, I am sure that we would not acquire of permanent knowledge or learn anything- just memorizing scientific facts and take measures and make calculations and write a report. The other thing that I think is very important is that if we did not learn this activity-based teaching method, we would not use in our classes in the future when we become teachers.

S13: As I know so far, the purpose of school laboratory exercises is to help me memorize the scientific truths, however ,in this course we constructed our knowledge *and learned the idea behind physical phenomena.*

S14: I liked the fact that it was very concept-oriented and very helpful in understanding Physics.

S15: I liked that we were taught and expected to know the underlying concepts of the

equations and principles. Like-learned how things work. The best thing I love about this course is that we learn different things that I do not know before. Also, even if several years pass, I believe that I remember that the activities and what I learned in the class.

S16: …to be honest, there was really too much to do in this course. It was tiring. But, we accomplished new things even if everything is already done before. On the other hand, we had to find the information, explore, digest them then we started to write our assignments. So, we learned and understand many topics for example now I know why I have a headache while talking on the cell phone even if we use headphones. The reason is that the headphones have magnets and they cause a magnetic field that affects our body.

Students declared that the instructor was really helpful because she knows the subject matter well and asks questions to make them think about the answer instead of showing the way to answer the questions or problems directly. Also, she/he [the instructor] helps in class, out of class, and in her/his office. She/he makes students be very comfortable during class period as well.

S16: During the courses of science laboratory and applications I and II, we had very enjoyable learning time. Being active [student-centered] in the class and making connections with everyday life makes our interest of science increase. In addition, regarding classroom environments, it is very flexible and enjoyable because when we present our activity like a teacher, the instructor acts like a student and ask questions to us- showing how a student should be also- so it makes us very comfortable. As a result, the instructor makes us be involved actively in the class, she acted like a facilitator. As for science concepts I believe that we learn some science concepts better…I want to add one more thing that I wish we will have the same format in the second semester [spring 2008]. The instructor is very helpful and has a good manner.

S17 : I am happy with my science lab, the method, and the instructor…the instructor changed the teaching method for traditional science lab to have gone on in certain way for a long time and she aimed students to construct and reach the knowledge by themselves instead of giving the knowledge. The other good thing is that I really love is that the instructor acts like students during class session and asks questions such as "why this happened?" This is really cool and makes us very comfortable during presentations.

Students stated how the course helped them have teaching experiences and social interactions with other students and other people.

S18: …by means of this course we learned how to teach and how to behave in the class and class management. Before that class, we feel embarrassed and our communication skills were not good. But now we are more comfortable during class presentations. By means of this class we can be more successful as a teacher in the future.

S19: We had experiences and we had social interactions with our group mates. It

> *is really good. The other thing we are enjoying during the class.*
>
> *S20: The course is very constructive. I plan to share what I learned from this course with my students in the future when I become a teacher.*

The exit survey results and the interview results are summarized. Students' interview results were basically consistent with their responses on the exit survey. For the most part, the students were positive about the course based on activities and interactive engagement. On this exit survey, the responses the students made to the "what did you like and dislike about the course and the instructor" questions tended to be about the structure and format of the course. Students liked the ability to get individual attention in a classroom setting, interactions and discussions they had with their peers in the form of small group, interactions and discussions with the instructor and their peers. Students liked to have activities that can be related to the real-life problems and understand the science concepts behind the complicated, confusing equations and concepts in science. The responses for what they disliked about the course or what they would change about the course focused on the operations of the course or on small details. For example, at the beginning and throughout the course, some students thought that assignments were hard to prepare because there were too much to do and the assignment structure was different from the one we used before. Here we had to construct everything while preparing our assignments and activities. On the other hand, when we deduced new things or investigated, combined and compiled all information related with the given topic we felt excellent because we achieved a success. Most of the students, however, indicated that there was nothing they would change about the course. The responses the students gave in the interviews corresponded closely with the exit survey results.

Consequently, students revealed the following thoughts about the course such as the way in which was taught and the instructor of the course which are retrieved from students' interviews and the exit survey results.

- The course based on activity and interactive engagement provided an application of the knowledge to real world situations-made to see how things work in the real world instead of just looking at equations or some scientific facts. In other words, the course helped students learn and understand physical phenomenon and their connections to the real life and other disciplines.
- The teaching method provided some opportunities to construct student activities and knowledge as they investigate, explore, and digest.
- It provided assistance in learning how to analyze the systems, and make connections to the real world and everyday life which make for students physical meaning and interpretation.
- The method provided an opportunity for self learning especially during small group work and investigating the topics or concepts. Thus the knowledge that they explored will not be temporary.

Discussions and Implications

The aim of this study was to investigate students' views about the course and the way in which it was taught. In addition, we were interested in applying a novel teaching approach in Turkey that can guide teachers/instructors to use in their classes instead of the traditional science laboratory course because the science laboratory course is an important defining aspect of the academic performance of the students in science.

The usage of this activity-based method is predicated on student participation and lets students pose appropriate questions, perform helpful activities (Aladejana & Aderibigbe, 2007; Aladejana, 2006; Adelson, 2004; Mayer, 2003). This method requires certain amount of interaction between the students and between the students and the teacher.

Major benefits of this activity-based learning are that it makes the subject matter more comprehensible because students discover and present after making searches about the subject matter. Also, all students in the class present same subject in each week, so they can see what they have not yet comprehended well and learn different perspectives of the same concept. The other important benefit, which is indeed crucial, is that it makes to minimize memorizing since students can acquire ability to transfer of knowledge to the real life and other disciplines. They can make connections with the real life and other disciplines too. Moreover, students do not have to make a given activity by a teacher or instructor. They have a chance to choose their activities on certain topics. Therefore, they can be creative. In other words, this method promotes student curiosity, rewards creativity, encourages reasonable questioning, avoids dogmatism, and promotes meaningful understanding. Thus, it strives to enable all motivated students to be successful (Aladejana & Aderibigbe, 2007).

It is found that students' achievement and skills can be improved when students are taught science in an activity-based curriculum (Turpin & Cage, 2004; Fraser, 1986; Bredderman, 1983) which provides constructivist students' learning is oriented to real understanding not just memorizing.

The science laboratory course is a major part of the setting for learning and most science activities designed for learning and understanding science. In addition, it encompasses different kinds of tools and information resources, the interactions, the relationships between and among students and teachers, as well as the expectations and norms for learning and behavior (Aladejana & Aderibigbe, 2007).

Furthermore, it can be surveyed students' current knowledge while using these activities and update their knowledge and inform them in terms of the nature of science and how new knowledge arises by refining old knowledge or remove it. Also they can learn how to draw conclusions when they make observations and inferences based on their observations.

Based on these findings, it can be recommended that the approach can improve science instruction, construction of scientific knowledge, and understanding of scientific concepts, understanding the nature of science (NOS), developing practical skills, developing teamwork abilities, and developing scientific reasoning. Thus, students' academic performance can be increased and the method can have great potential in school and university settings so that remarkable increases in interest of learning and understanding in science can be quite possible.

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References

Abd-El-Khalick, F.S., & Akerson, V.L. (2004). Learning about Nature of Science as conceptual change: Factors that mediate the development of preservice elementary teachers' views of nature of science. *Science Education*, *88*, 785–810.

Adelson, R. (2004) Instruction versus exploration in science learning. PsychNet, *American Psychological Association, 35*, 34–47.

Akerson, V. L. & Hanuscin, D. L. (2008). Teaching Nature of Science through Inquiry: Results of a 3-Year Professional Development

Program. *Journal of Research in Science Teaching*, *44*, 653-680.

Akerson, V.L., Abd-El-Khalick, F.S., & Lederman, N.G. (2000). Influence of a reflective explicit activity-based approach on elementary teachers' conceptions of nature of science. *Journal of Research in Science Teaching*, *37*, 295–317.

Akkus, R., Gunel, M., & Hand, B. (2007). Comparing an Inquiry-based Approach known as the Science Writing Heuristic to Traditional Science Teaching Practices: Are there differences? *International Journal of Science Education*, *29*, 1745-1765.

Aladejana, F. & Aderibigbe, O. (2007). Science Laboratory Environment and Academic Performance. *Journal of Science Education and Technology*, *16*, 500–506.

Aladejana, F. O. (2006). Concept of teaching. In Ehindero O. J., & Aladejana F. O. (eds) Introduction to the teaching profession. Literamed Publications Ltd, Lagos, pp 12–19

Bodner, G., Klobuchar, M., & Geelen, D. (2001). The many forms constructivism [Electronic version]. *Journal of Chemical Education*, 78, 1107.

Bredderman, T. (1983). The effects of activity-based elementary science programme on students' outcomes and classroom practices. *Review of Educational Research*, *53*, 499–518.

Chabay, R. W. & Sherwood, B. A. (2002). "Vol I: Matter and Interactions: Modern Mechanics", New York: John Wiley & Sons, Inc.

Chen, S. (2006). Development of an Instrument to Assess Views on Nature of Science and Attitudes toward teaching Science. *Science Education*, *90*, 803-819.

Chin, C. (2007). Teacher questioning in science classrooms: Approaches that stimulate productive thinking. *Journal of Research in Science Teaching*, *44*, 815-843.

Chin, C. (2006). Classroom interaction in science: teacher questioning and feedback to students' responses. *International Journal of Science Education*, *28*, 1315-1346.

Churukian, A. D. (2002). Interactive engagement in an introductory university physics course: Learning gains and perceptions (Doctoral dissertation, Kansas State University, 2002). *Dissertation Abstracts International*, *62*, 1685.

Conlon, J. (2004). Physics outreach for WYP. *The Physics Teacher*, *42*, 468-469.

Doolittle, P. E. & Camp, W. G. (1999). Constructivism: The career and technical education perspective. *Journal of Vocational and Technical Education*, 16.

Fay, M. E. & Bretz, S. L. (2008). Structuring the level of inquiry in: A rubric helps teachers compare experiments and plan inquiry. *The Science Teacher*, 38-42.

Fosnot, C. T. (1996). *Constructivism: Theory, perspective, and practice*. New York: Teachers College Press.

Fraser, B. J. (1986). *Classroom Environment*. Croom–Helm, London

Holbrook, J. & Rannikmae, M. (2006). The Nature of Science Education for Enhancing Scientific Literacy. *Science Education*, *90*, 803-819.

Hoover, W. A. (1996). The practice implications of constructivism. SEDLetter. Adapted from htpp://www.sedl.org/pubs/sedletter/v09n03/welcome.html.

Hsiao, W. D. L. (nd). CSCL theories. Retrieved May 8, 2008, from http://www.edb.utexas.edu/csclstudent/Dhsiao/theories.html

Huitt, W. (2003). Constructivism. Educational psychology interactive. Retrieved May 4, 2008, from Valdosta State University, Valdosta. http://chiron.valdosta.edu/whuitt/col/cogsys/construct.html

Lederman, N. G., Abd-El-Khalick, F., Bell, B. L., & Schwartz, R. S. (2002). Views of Nature of Science Questionnaire: Toward valid and meaningful assessment of learners' conceptions of nature of science. *Journal of Research in Science Teaching*, *39*, 497 – 521.

Martin et al. (1992). Displacement, velocity, and frames of reference: Phenomenographic studies of students' understanding and some implications for teaching and assessment [Electronic version]. *American Journal of Physics*, *60*, 262-269.

Marton, F. (1986). Phenomenography-A research approach investigating different understandings of reality. *Journal of Thought*, *21*, 28-49.

Mayer, R. E. (2003). Learning and instruction. Pearson Education, Inc, Upper Saddle River, pp 287–288

Orlik, Y. (2005). Using of active educational strategies and methods - the way to improve the quality of science education. *Journal of Science Education*, *6*, 44-46.

Örnek, F. (2008). *Örnek Aktivitelerle Fizik ve Günlük Yaşam*. Ankara: Pegema yayıncılık.

Ornek, F. (2006). Modeling-based interactive engagement in an introductory physics course: Students' conceptions and problem solving ability, *Dissertation Abstract International* DAI-A 68/02.

Perkins-Gough, D. (2007). The status of the science lab. *Educational Leadership*. *64*, 93-94.

Philipps, D. C. (1995). The good, the bad, and the ugly: The many faces of

constructivism. *Educational Researcher*. 24, 5-12.

Roth, W. M. (1996). Knowledge diffusion in a Grade 4–5 classroom during a unit of civil engineering: An analysis of a classroom community in terms of its changing resources and practices. *Cognition and Instruction*, *14*, 170–220.

Shah, I., Rıffat, Q., & Reid, N. (2007). Students perceptions of laboratory work in chemistry at school and college in Pakistan. *Journal of Science Education*, *2*, 75-79.

Sherman, L.W. (1995). A postmodern, constructivist and cooperative pedagogy for teaching educational psychology, assisted by computer mediated communications. The first international conference on Computer support for collaborative learning, USA, 308-311.

Smith, C., Maclin, D. , Houghton, C., & Hennessey, G. M., (2000). Sixth-grade students' epistemologies of science: The impact of school science experiences on epistemological development. *Cognition and Instruction* **18** (2000), pp. 349–422.

Steffe, L. P., & Gale, J. (Eds.) (1995). *Constructivism in education*. Hillsdale, NJ: Erlbaum.

Turpin T. & Cage B. N. (2004). The effects of an integrated activity-based science curriculum on student achievement, science process skills and science attitudes. *Electronic Journal of Literature Science*, *3*, 1–17.

Van Zee, E. H. & Minstrell, J. (1997a). Reflective discourse: Developing shared understandings in a high school physics classroom. International Journal of Science Education, 19, 209-228.

Wilson, B. G. (1996). Introduction: what is a constructivist learning environment? In: Wilson BG (ed). Constructivist learning environments. Case studies in instructional design. Educational Technology Publications, Englewood Cliffs, pp 3–8

Windschitl, M. (2002). Framing constructivism in practice as the negotiation of dilemmas: an analysis of the conceptual, pedagogical, cultural and political challenges facing teachers. *Review of Educational Research*, *72*, 131–175.

Appendix A

Case of the Sunken Ice Cube

Why does ice float in one liquid but not the other?

What is Needed?

- Two tall clear beakers or plastic containers, one filled with tap water, the second filled with isopropyl alcohol or ethanol
- Two ice cubes (you should have extras)

What to Do (procedure)

Step One: Begin by telling students: The most important tool a scientist has is his or her powers of observation. So today, we are going to stretch and build those powers. Reveal to the students two identical beakers, one containing about 200 ml of alcohol, the other containing the same amount of clear water.

Step Two: Show them the two ice cubes. Pose the question; "What will happen if the ice is placed in the beakers?" Ask for predictions and hypotheses. Point out that our next step is a test. The ice is placed in each liquid. It sinks in alcohol, and floats in water.

Step Three: What did you "observe"? Review the initial observations the students made. Point out the distinction between true observations, such as "There is clear liquid in each beaker" and statements such as "there is water in each beaker." The second statement is an inference, which means it is a judgment we have made, drawn from our observations. One of the things scientists do is to make inferences, but we need to check those inferences, which is one reason we do experiments.

(Note: Astute observers may pick up on some other details that are quite informative. For example, the ice in alcohol will, after a few minutes, begin to melt, and actually float up off the bottom on a layer of water. This layer will be colder than the alcohol above, so students may notice condensation on the bottom part of the beaker only. These observations may help the students later.)

What is Happening?

Density is the quantity of matter in a given unit of volume, stated as density = mass/volume, generally given in SI units of g/cm^3. Density is an *internal physical property* and thus is often used to identify a substance. Water has a density of 1.00 g/cm^3 at room temperature, 25 degrees Celsius, meaning that a mass of 1.00 g of water occupies a space of 1.00 cubic centimeters. Materials that are less dense than water (have a density less than 1.00 g/cm^3) will float in water, while substances more dense than water (have a density greater than 1.00 g/cm^3) will sink. The same is true of any liquid, such as ethyl alcohol with a density of 0.79 g/cm^3. Materials less dense than ethyl alcohol will float in it, while materials more dense will sink. Therefore, as observed in this demonstration, ice (with a density of 0.92 g/cm^3) will float in water but sink in ethyl alcohol.

When water solidifies to form ice, the solid ice phase is less dense (as observed) than liquid water. This can be attributed to the hydrogen bonding that occurs in water in both the liquid and the solid states. ***Hydrogen bonding*** is the strong intermolecular force between the hydrogen and oxygen atoms of neighboring water molecules (this explanation is purposefully simplified!!) When water freezes, hydrogen bonding holds the molecules rigidly in a three-dimensional crystal. There are holes, or empty spaces, within the ice crystal. As water freezes to form ice, it must expand (rather than contract) to form this open crystal. As a result, the density of ice is less than the density of liquid water, which explains why ice floats in water. This is a very unusual phenomenon. Most substances are denser in the solid state than in the liquid state because particles are usually closer together in the solid state. Water is the rare and unusual exception.

Relationships with Real Life

Winter pond temperatures can remain very cold for many months in northern climates. There's only so much water in a pond. There can only be so much oxygen in the water. If the ice caps over the pond, the fish, other animals, and any decaying organic material may eventually consume all the oxygen, the fish will suffocate.

This is referred to as "winter kill" and occurs commonly in natural ponds and our over-stocked backyard ponds are much more susceptible. It's easy to avoid this by simply keeping a small area of the pond ice-free for the exchange of gases with the atmosphere. Air bubblers and small pumps can be used to keep small areas ice free, but do not allow them to mix the lower 40 degree puddle of water with the colder top layers. They cost less to run than deicers, but do not work when the air temperature drops below the teens for extended periods of time. Any small air or water pump that creates a flow of water across the pond that disturbs the bottom puddle of warm water will eventually lead to a fish kill.

Interesting Relationships with other Sciences (chemistry, biology, earth science, medicine etc.)

Water is a unique substance. At about 40 degrees F. it is denser than water warmer or colder, so it settles to the bottom of the pond. It forms a puddle that if left undisturbed will not mix with the colder water above it. The ice floating on the top of the pond insulates the lower water from even colder air above it.

Other activities related to this activity

For instance, while you are making fermented pickles, you may need to use density if you do not want to deal with numbers or ratios. Even if you use ratios, sometimes your pickles can be spoiled, that's, you pickles become soft, slippery or slimy. As you know, you need some vegetables such as cucumber, green pepper or tomatoes and etc. to make fermented pickles. Also, water, salt, and vinegar are required. You need to add correct ratio salt to water. There is a very easy way to do that. The easy way to get the correct ratio: Take a cup filled water, start to add salt (unionized), and continue to add salt until an egg (can be raw or hard boiled) start to float in salt water. If the egg floats, that means salt is enough. You do not need to add more salt. As a result, here density plays a role. In other words, since density of salt water is more than egg, the egg floats. As you see, density is almost everywhere in our life.

Note: In above example, the sections can be broadened and more information can be added.