An effect of technology based inquiry approach on the learning of "Earth, Sun, & Moon" subject

Hakan TÜRKMEN

Assist. Prof. Dr. Ege University, Education Faculty, Elementary Department/Science Education

Email: hakan.turkmen@ege.edu.tr

Received 5 Mar., 2009
Revised 10 Jun., 2009

Contents

Abstract

The purpose of this study was to investigate what affect a technology based inquiry approach (TBIA) had 5th grade primary students' understanding of earth, sun, and moon concept in a science and technology course and how this changed their academic achievements. This study was carried out in a 5th grade elementary science and technology course with two groups of (a total of 97) students. Four hour a week course was conducted over a 3 week period of instruction. As a result of the analysis of data, there were statistically significant differences between experimental and control groups ($P<0.05$). According to results, the achievement level of the experimental group with TBIA was significantly higher than the control group with a traditional teaching method. TBIA is more effective and successful than traditional teaching methods in elementary science courses.

Keywords: Inquiry Approach, Technology Based Inquiry Approach

Introduction

Recent work by the OECD (2006) indicates that over the last decade in many countries, the number of young people entering universities is increasing, but students are choosing study fields other than science. The consequence is that the proportion of young people studying science is decreasing. The type of pedagogical approach students faced throughout their educational life in the numerous methods and the projects and actions that have been implemented in our science curriculums so far have impacted students. The oldest and most traditional approach, deductive reasoning, is still being used by teachers. The traditional approach focuses on the content of the subject matter organized by general concepts to particular concepts, with less emphasis on the development of skills. It is teacher-centered, which means that the teacher gives information about what has to be known, and students are note-takers and receivers of information.

Although inquiry-based science teaching seems to be a new teaching approach, it is as old as Socrates (Calhoun, 1996). John Dewey basically defined the inquiry of teaching which begins with the curiosity of the learner. For that process we use a spiral path of inquiry: *asking* questions, *investigating* solutions, *creating* new knowledge as we gather information, *discussing* our discoveries and experiences, and *reflecting* on our new-found knowledge (Germann, 1991). Each step in this process naturally leads to the next: inspiring new questions, investigations, and opportunities for authentic "teachable moments." Although inquiry-based science teaching has been employed and prevailed in classrooms since the US National Science Foundation curriculum-reform efforts in the late 1950s and early 1960s, according to many teachers, it has been very hard to proceed in introducing inquiry method in the classroom. Another difficulty is to precisely define the role of teacher in science lesson (Bonnstetter, 1998).

Over the last two decades, inquiry-based science teaching has been characterized in many ways and promoted from a variety of perspectives. DeBoer, in 1991, declared, "If a single word had to be chosen to describe the goals of science educators during the 30-year period that began in the late 1950s, it would have to be INQUIRY" (p. 206). In the 1990s', inquiry affected modern countries' education systems. Project 2061 (1990) and the National Science Education Standards (NSES) (1996), inquiry approach placed an emphasis on knowledge construction in science curriculums. For example, Project 2061 specifies features of scientific inquiry:

> Science explains and predicts. The duty of a scientist is to construct explanations of observations consistent with the currently accepted scientific theories that fit the observations and have predictive power on evidence. Scientists try to identify and avoid bias. Scientists must be aware of their biases. What kinds of evidence are necessary and how this evidence is interpreted are influenced by biases like nationality, sex, ethnic origin, age, political convictions. Science is not authoritarian. There is no scientist who is empowered to make decisions for other scientists (American Association for the Advancement of Science, 1990, p. 3-8).

In today's literature, some educators have emphasized that inquiry refers to activity-based instruction in which students are actively involve in hands-on learning. Others have defined inquiry as a means gaining knowledge and understanding common characteristics in science by using discovery approaches associated with the scientific method. Inquiry involves the active search for knowledge and/or understanding to satisfy a curiosity (Haury, 1993). Generally, inquiry-based teaching is opposite from traditional expository methods and refers to active learning through a constructivist model of learning. First model used as an inquiry based lesson planning, was the Learning Cycle model in the early 1970s. Many examples of inquiry based lesson models; such as 5E defined by Bybee (Ramsey, 1993) followed the Learning Cycle model. Colbum (2000) defined the inquiry based lesson plans into 3 categories: structured inquiry, guided inquiry and open inquiry.

Inquiry-based teaching has been closely associated with other teaching methods such as problem-solving, laboratory instruction, project-based learning, cooperative learning and discovery instruction. These methods are commonly referred to as the inquiry approach, which often emphasize extensive use of science-process skills and independent thought. Knowledge is constructed by learners who have to do many activities on their own in order to build new knowledge. This essential concept of the constructivist approach borrows from many other practices in the pursuit of its primary goal, helping students learn how to learn (Bodner, 1986; Bybee, 2000; Hancer, 2006; Türkmen & Pedersen, 2003). There is no authentic investigation or meaningful learning if there is no inquiring mind seeking an answer, solution, explanation or decision. Thus, inquiry is the process that utilizes scientific process skills to learn about some aspect of the world. Today, the definition of inquiry represents two points of emphasis in science teaching: decreasing emphasis on "science as exploration and experiment" (or hands-on activities), and increasing emphasis on "science as argument and explanation" (or minds-on activities) (Abell, Anderson, & Chezem, 2000; Kuhn, 1993; NRC, 1996, 2000). In general, the inquiry approach is the intentional process of diagnosing problems, critiquing experiments, and distinguishing alternatives, planning investigations, researching conjectures, searching for information, constructing models, debating with peers and forming coherent arguments (Aydın & Balım, 2005; Henson, 1986; Keys & Kennedy, 1999; Linn, Davis, & Bell, 2004).

The research has shown that inquiry-based teaching is effective in enhancing general student performance, in particular laboratory skills and skills of graphing and interpreting data, to fostering scientific literacy and understanding of science processes (Lindberg, 1990; Mao, Chang, & Barufaldi, 1998; Taasoobshirazi et al, 2006) and contributing to positive attitudes toward science and higher achievement on tests (Glasson, 1989; Kyle et al., 1985; Shymansky, Kyle, & Alport, 1983; Chiappetta & Russell, 1982; Ertepinar & Geban, 1996; Geban, Askar, & Ozkan, 1992; Muloop & Fowler, 1987; Basaga, Geban, & Tekkaya, 1994; Tobin & Capie, 1982; Welch et al., 1981). Germann also found the approach helpful in development at the cognitive level (1989).

In order for inquiry to be effective, a teacher must be a very active and set a rich environment in which students take on more responsibility in organizing and managing materials for their own learning, and develop a supportive social environment in which students can work collaboratively in small and large groups and learn to respect each other's ideas. During the inquiry process, the teacher walks around the room and interacts with groups of students. S/he listens to his or her students' questions and ideas and leads them to find the solutions to problems or questions, and if necessary, gives additional information through lectures, demonstrations, or discussions (Bybee, 2000; Chiappetta, 1997; Duschl & Hamilton, 1998;

Ergin & Kanlı, 2007; Genctürk & Türkmen, 2007; Hayes, 2002; Hogan & Berkowitz, 2000; Lott, 1983; Macaroglu Akgul, 2006; Von Secker, 2002; Welch, 1981).

While educators say that an inquiry approach is effective in science courses, it is still not widespread concept in classrooms and is often inappropriately used (Bencze et al., 2003; Lederman & Schwartz, 2001). The amount of classroom time, insufficient independent investigations, and insufficient incorporate abstract concepts with inquiry, lack of teacher expertise and experience and insufficient teacher science background has led to the ineffectiveness in the application of the inquiry approach. One of the solutions to this problem, especially regarding the difficulty of incorporating abstract concepts, is integrating educational technology into inquiry in science courses. New technologies, especially computer technology, are "interactive, it does away with the passivity associated with the traditional learning model in which the student is viewed as an empty vessel to be filled by the knowledge and expertise of the teacher" (Tapscott, 1996, p.144). Technology also gives new opportunities and more options for students to use materials to investigate the problems and to find solutions through a technology based inquiry approach (TBIA) (Krajcik et al. 2000). Use of interactive media and computerized databases in the inquiry approach make it easier for students to develop their own inquiry skills, such as proposing their own research focus; producing their own data and continuing their inquiry as new questions arise; and using theories that they define and develop themselves (Edelson, 2001; Flick & Bell, 2000; Litchfield & Mattson, 1989; Maor, 1991; Shimoda, White, & Frederiksen, 2002; Slotta, 2004; Taasoobshirazi, 2006). Moreover, computer technology facilitates the manipulation of variables in experiments and models. So in this TBIA, the teacher becomes better equipped to act as a guide and facilitator, allowing students to be engaged in a more realistic scientific inquiry experiences for abstract subjects. Hence, students can predict, observe and explore the effects of dependent variables in more complex experiments.

Simulated computer-based experiments allow teachers to demonstrate the effects of variables used in an experiment, to further the understanding of science subjects by facilitating the use of different methods to investigate the same issue, and to shift the emphasis to "thinking, conjecture and talk about scientific method, about the reasons, limitations and benefits of carrying out controlled experimentation, and about qualitative interpretation of evidence" (Miller, 2001, p. 194). When these methods yield conflicting results, it may "impel learners to think about how to reconcile the rival methods or how to decide which is more reliable" (Chinn & Malhotra, 2002, p.208).

In fact, some of these technologies can actually help transform science "from canned labs and the passive memorization of content to a dynamic, hands-on, authentic process of investigation and discovery" (Barstow, 2001, p. 41). Even, Hawkey (2001) says technology can now provide "a new opportunity to reconsider fundamental questions about what it means to be scientifically literate, about the nature of science and the relationship between practicing scientists, their work and the public" (p. 106).

TBIA is active learning and students in play a central role in mediating and controlling their learning. In this environment collaboration is important. Students collaboratively share their thoughts. Students feel free to ask questions on any part of lesson, and technology gives opportunity to students to manipulate variables, investigate data, and make connections to better understand and construct their own knowledge in a meaningful learning process.

The purpose of this study is to investigate the effect of TBIA on 5th grade primary students' understanding of phenomena associated with the "earth, sun, and moon" subject in a science and technology course, in addition to the shift of their academic achievements and attitudes towards science in a positive way. For this purpose, the integrated technology 5E method was used for this study. Many educators and philosophers agreed the 5E teaching method is one of inquiry methods, which involve learners in *generating investigable questions*, *planning and conducting investigations*, *gathering and analyzing data, explaining their findings*, and *sharing and justifying their findings with others.* The integrated technology 5E teaching method as TBIA consists of five phases:

> *Engage* - a teacher use an interactive Website or CDs as a warm-up activity, the purpose is to generate enough interest in the subject at hand to propel the student into the learning process, which follows with the remaining stages;
>
> *Explore* - students work through the problem and conduct experiments, discuss with friends, and collect data for analyzing. Teachers can ask directing questions, provide minimal consultation, and observe and listen to student interactions;
>
> *Explain* - students try to explain data they have collected and try to find correct terminology surrounding the subject. If they struggle to reach scientific concept, the teacher should encourage them to work with educational materials and participate in group work and class discussions. Next, the teacher should explain the concept and correct their misconceptions. Technology may be used to further clarify the concept and relevant vocabulary should be defined to fix misconceptions.
>
> *Elaborate* - in this stage, technology provides students with the opportunity to elaborate and build on their understanding of concepts by applying it to solve new problems related to scientific concepts. Teachers give new scenarios or problems and provide directive questions.
>
> *Evaluate* - The teachers' intent is to assign students technology based activities to evaluate what their students have learned. They ask questions or make observations that determine if students can discuss and apply the concepts covered. Alternatively, students assess their own progress via a self-evaluation.

This method is an effective way to deal with students' misconceptions about science concepts. The method allows students to place facts in a conceptual framework (which often includes recognizing or challenging the misconceptions), and to organize facts and ideas for retrieval and application (Bozdogan & Altuncekic, 2007; National Research Council 1999; Ozsevgenc, 2006).

Research Questions

1. What is the effect of TBIA on 5th grade primary students' understanding of phenomena associated with the "earth, sun, and moon" subject enrolled in a science and technology course?
2. What is the change of students' academic achievements, when TBIA applied?
3. What is the change of students' attitudes toward science?

Method

The research questions look at the effectiveness of the intervention developed in this study. For that reason, we need to employ a pre-post test research design. The quantitative data obtained from the sun, earth, and moon achievement test and the attitude toward science scale, analyzed by operating SPSS (Statistical Package for the Social Sciences) program. In order to support our results, we gathered some qualitative data from two open-ended questions about lesson and observation of students' performances.

Instrument

The achievement test (AT), developed by the researchers, includes a "concept map", which is graphical tools in order to summarize understandings acquired by students (Mintzes, Wandersee, & Novak, 2000); a "three-branched diagnostic tree", which can utilize much of the information content in quantitative measurements to make efficient and accurate diagnoses (Tong, Jolly, & Zalondek, 1989); a "semantic features analysis", helping students explore how a set of things are related to one another, and by analyzing the grid, students will be able to see connections, make predictions and master important concepts (Anders & Bos, 1986) and techniques (Appendix A). These techniques are very useful in the evaluation of students' understanding and their enjoyment. The achievement test items were analyzed for construct and content validity by two experts. In the test, the instructional objectives were developed for the three subunits based on different cognitive levels (knowledge and comprehension) that were stated by the researchers.

The two open-ended questions, were, "What do you think about the earth-sun-moon lesson?" and "What do you feel during the lesson?" in order to evaluate students' thoughts about TBIA.

The attitude scale toward science (ASTS) was developed Geban and his colleagues in 1994. This scale contains 15 likert type items (strongly agree, agree, undecided, disagree and strongly disagree). Cronbach alpha was found to be 0.83.

During the observation process, researchers used the observation sheet for instructors and students. The Constructivist Learning Environment Survey (CLES) teacher self-assessment sheet, adopted by Taylor, Fraser, & Fisher study (1997), was used as an observation sheet. Each section was evaluated with 5 likert type items (1-never…5-always) (Table 9).

***Table 1**: Qualitative and Quantitative instruments*

quantitative	*sun, earth, and moon achievement test (pre-post tests)*	*attitude toward science scale* *(pre-post tests)*
qualitative	*two open-ended questions (post test)*	*observation sheet of students performances (CLESTS) (post-test)*

Subjects

The research was conducted over three-weeks with 97 5th grade (10-11 years-old) primary school students. The two classrooms were randomly selected. The control consisted of 48 students and the experimental group consisted of 49 students (table 2). Each group had almost the same number of students, with approximately the same numbers of girls and boys. The experimental group was instructed using the technology integrated 5E method, whereas the control group was taught by traditional methods.

***Table 2**: Number of students*

	Female	Male	Total
Control group	26	22	48
Experimental group	26	23	49
Total	52	45	97

Design and Procedure

It is important to show the effects of TBIA in students' academic achievement for this study. Thus, a pre-test and post-test experiment control group design was used in this study. The instruction was for 4 hours a week and continued for 3 weeks. There were two instructors, one had 14 years experience teaching science and gave his lesson using traditional methods. The other instructor was a senior pre-service teacher and gave her lesson with using TBIA. In Turkey, the teacher education and training program is four-years, with the last year as a practice year in the classroom. This study was confined to the science and technology course consisting of 3 subunits, (a) "Sun, Earth, and Moon's shape and size," (b) "Earth's Motion," and (c) the "Moon's Motion"

During the beginning of the lesson in the experimental group, 49 students were randomly divided into 10 groups (one group had 4 students whereas the others had 5). According to Feletti (1993), inquiry-based lessons enhance observational skills, use simulations or experiences of professional practice, encourage student collaboration, foster student-directed learning, encourage independent study and foster reflection on the learning process. Thus, for the experimental group, the lesson process was not tightly structured. It is a more open-ended and adaptive process, not merely relying on questioning and thinking, but using deeper and higher levels of questioning. This perspective allows the use of many teaching strategies and links the educational technology with science concepts (Edelson, 2001; Flick & Bell, 2000; Friedrichsen, Munford, & Zembal-Saul, 2003). In Table 3, the structure of the instruction is briefly explained.

***Table 3**: TBIA Sample Lesson Plan - The Earth, Sun, and Moon Shapes and Sizes*

Engage	Students are given some materials (some cotton, one orange, one tangerine, one CD, circle of cheese, one ping-pong ball, one football, one tennis ball) then asked, "If you want to make a model for sky, what will you use?" Students are then given approximately 10 min. to complete the task.

	Example of Answers- Cotton for clouds; orange for sun; circle cheese for planet; small ball for moon. Assignment: Over the course of three weeks, observe the moon every night at the same time draw your observations of the moon.
Explore	Students are shown some pictures (moon earth sun) taken by NASA by using computer. And then asked what the photos look like. Example of answers: ball, watermelon, orange, bead, plum. Then students are asked, "if you think about their shapes, how do you match with your answers?" Example of Answers: watermelon (sun), orange (earth), plum (moon). Students watch movie about solar system and earth (from NASA) Drama activity: 6 students who are different weights and tall were selected. Teacher determined their roles; such as the tallest and fattest kid is sun, the smallest kid is moon. The teacher then asks the rest of class to match the students as the moon, sun, earth, star, and meteor. Each group discusses and makes a conclusion what you have learned so far. They will explore the earth, sun, moon shapes, and their sizes.
Explain	Each group has a spokesman to represent his/her group's ideas. After every spokesman talked about what they have learned, teachers briefly explained earth-sun-moon shapes are all spherical and explained their dimensions (400 moon =4 earth = sun). Also, historical information, especially Copernicus and Galileo' ideas, were explained. The teacher tried to explain why ancient people thought earth was flat and that by going to the edge of the world, you could fall off or be swallowed by monsters. The class discussed what would happen in their lives if this were true and what would change in day to day life.
Elaborate	The class is asked why we see the moon as bigger than a star even though they are almost the same size. And what is the difference between the moon and the sun, even though the sun is 400 times bigger than the moon. After getting some answers from students, the teacher shows a short animation movie and some pictures (taken from NASA) related to the question. (The teacher doesn't give the correct answers before showing the movie and pictures). Activity: One student holds a pencil in front of the blackboard and the other students tried to measure the length of pencil. Next, students compared the real size of pencil and to their results. Finally students reached the concept of

	perspective. Next, students did brain storming about the assignment. They talked about students pictures as a group then followed-up with a class discussion. The teacher explains perspective and then asks "Why do we always see the same face of the Moon?" Answer: As we know, the moon is 4 times smaller in diameter than the earth; the moon takes 27.3 days to go around (in oval orbit) the earth once, and this is exactly the same time that it takes for the moon to rotate once on its axis. Because these rates are equal, the same face of the moon always ends up pointing towards the earth. The teacher asks another question, "Does this mean that we never see the back of the Moon." Answer-From the earth we always see the same face of the moon. The back of the moon can only be observed from space.
Evaluate	While using computers, students try to answer, "How many times have moon and earth traveled around the Sun since you were born? How many times has moon rotated with around the earth? Answer- depends on students' ages. Next- Students try to make an earth-sun-moon model. Model criteria include the ratio of shape, distance and size. The subject is briefly summarized.

In the control group, the science lesson process was mostly a teacher-centered. The teacher gave the students information about just the shape, distance and sizes of the earth, sun, and moon, and reviewed these topics at the end of the lesson (traditional teaching approach). The key feature of this lesson was to provide students with clear and detailed instructions and explanations. The teacher did not use a computer to show any animation or movies related to the subject. Generally, the teacher talked and students listened, took notes, and occasionally asked questions.

Each instructional group used the same text and received the same amount of time on instruction (three weeks). A number of variables were held constant so that a statistical comparison between the experimental group and the control group could be made. The control variables were fifth-grade students, the same school administration, the very close group sizes (n=48 and 49) within each class, and the same instructional content and duration. The only independent variable was the type of instruction.

During the lessons, the researcher observed both groups and instructors. Before the treatment, a 15-item attitude scale toward science and achievement test was administrated to both groups as a pre-test because students' interest in science could be another possible variable. After the course, the attitude scale toward science test, achievement test, and 2 open-ended questions were implemented as post-test to both groups.

Analysis and Results

Quantitative Analysis

The pre-test score of ASTS showed that there was no significant difference between students in the control and the experimental group (pretest, t=.203: p>0.05). However, after the course, it was found that there was a statistically significant difference between the groups (post test, t= -3.279: p<0.05) (Table 4).

Table 4: *Mean scores of groups for attitude scale toward science test*

		N	Mean	SD	t	p
Pre-test	**Control group**	48	60.93	8.35	0.203	0.814
	Experimental group	49	60.44	9.02		
Post-test	**Control group**	48	61.38	6.82	-3.279	0.007
	Experimental group	49	65.71	6.21		

The AT scores of students were calculated, and comparisons were made between the control and the experimental groups by administering t-test. The average score of the AT in the experimental group taught in compliance with TBIA was higher than those of the control group (Table 5).

Table 5: *Mean scores of groups for achievement tests*

		N	Mean
Pre-test	Control group	48	40.13
	Experimental group	49	42.67
Post-test	Control group	48	64.08
	Experimental group	49	84.30

In order to determine the correlation between experimental group students' AT post-test scores and ASTS post-test scores, Pearson's Product Moment Correlation Coefficient (Pearson's r) was conducted (Table 6).

Table 6: *Pearson r score of experimental group*

		r	p
Experimental group	**Achievement**	0.557	0.000
	Attitude scale toward science		
Control group	**Achievement**	0.278	0.225
	Attitude scale toward science		

A positive coefficient indicates that the values of variable achievement vary in the same direction as variable ASTS for both groups. According to characterizations, Pearson r values greater than 0.50 indicate a strong correlation, *r* values around 0.30 indicate moderate correlation and *r* values less than 0.20 indicate a weak correlation. We can conclude that there is a strong positive relationship between AT score and ASTS ($r = .56$, $p = .000$), but for control group students, there is a weak positive relationship between AT score and ASTS ($r = .278$, $p = .023$). These finding pointed out the fact that TBIA positively affects the experimental group's attitude towards science and students' academic success because of the positive and significant correlation between the scores of the achievement and attitude post-test. Hence, TBIA based on an inquiry approach increased the students' success in the "sun, earth, and moon" unit in comparison to the traditional teaching methods.

Qualitative Analysis

Data from the qualitative section was analyzed to determine frequencies. The top five answers are given in Tables 7 and 8. For the first open-ended question, students who were in a control group described traditional science teaching in which the teacher talks more than the students, science activities are limited and most of students have difficulties in solving problems and/or understanding science concepts. On the other hand, students who were in experimental group described the perfect definition of TBIA, which gives students an opportunity to investigative science and to engage them in activities (doing drama, watching animations, seeing pictures, group/class discussion) in which they develop knowledge and understanding of scientific ideas.

Table 7: *Open-ended Question: What do you think about the earth-sun-moon lesson?*

Control group	%	Experimental group	%
Teacher talked too much	68	Teacher gave every student an opportunity to talk	81
The teacher did not give us opportunity to talk	66	It was very nice to see pictures and animations on the computer	76
We did not do any activities	64	We played games and had competitions	70
I could not solve the questions because they were very hard	45	It was nice to be able to discuss together when we had problems or misunderstandings	65
I did not understand the given examples	38	The teacher did repeat the concepts a few times when we did not understand	56

Table 8: *Open-ended Question: What did you feel during the lesson?*

Control group	%	Experimental group	%
I was bored in class	77	The lessons were very funny	90
The earth-moon-sun subject is hard	41	I have a good understanding	77
I am a little bit scared when my friend	35	I did not take many notes	45

could not solve the problem because of the teacher's behavior			
I was tired and had pain in my fingers	22	I felt I was a scientist	35

Additional very interesting outcomes were obtained from experimental group:

I wish the lesson was longer and you taught us more often as a real teacher (30%);

I wish you could teach our other lessons (22%);

You did not raise your voice when we could not give a true answer or could not understand (14%);

I will become a teacher and teach like you (10%).

Observation Classroom Analysis

In the observation process, the observation sheet (CLES Teacher self-assessment sheet) was used to analyze the classroom environment. According to the results, the mean score of TBIA is 4.3, whereas the regular class lecture is 2.0. The big difference between two classes is in the shared control section. In the control group, brain storming or discussions about subject were rarely used. Some students joined lesson actively, but most of the students just took notes and listened to their teacher. The connection between students' experiences and the science subjects was not taken into consideration, and technology and/or earth-sun-moon models was not used or used improperly. Another difference was between homework activities, which are very important for the earth-sun-moon subject. The teacher did not give tasks to students to observe the moon or sun or to make any organization of their findings. Both of these tasks were done in the experimental group.

In the experimental group at the beginning of the lecture, the teacher asks the class what they know and what they want to know about the earth-sun-moon subject. After getting students' thoughts, the teacher prepared lesson plans according to students' thoughts. The experimental group classroom environment was technology-based, and students were engaged in variety of interactions. The earth-sun-moon concepts were interpreted and constructed based on students' own experiences and interactions based movies and animations promoting exploration, experimentation, construction, collaboration and reflection of the subject.

Table 9: *CLES Teacher self-assessment sheet (1-never…5-always). Exp. group Cont.*

Personal Relevance	Connectedness of schoolwork with students' out of school experience.	4	3
	Students' opportunity to learn science subject in outside of school.	3	1
	Students' everyday experiences as meaningful.	4	2
	Students' opportunity to learn science with educational technology (especially computers).	5	2

Uncertainty	Opportunities: for inquiry, past experiences which make sense.	5	3
Critical Voice	Establishment of social climate: students able to ask questions.	5	3
	Question teacher pedagogy, concern about impediments to their learning.	4	2
Shared Control	Share control with the teacher. Include students in articulating their own learning goals.	5	1
	Design and management of their learning activities.	4	1
	Design and application of assessment criteria.	4	1
Students Negotiation	Students justify and explain their ideas to other students.	4	3
	Listening and reflection on other students’ ideas and critical self-reflection of their own ideas.	5	2
TOTAL		4.3	2.0

* Adopted from Taylor, Fraser, & Fisher, 1997.

Conclusions

Teachers have to decide on a method that is most productive for accomplishing their particular objectives in learning, such as developing conceptual understanding and experiencing what science is. Of course, hands-on activities, reading, brain storming, group discussion, teacher demonstrations, lab activities, using educational technologies (films, videos), inquiry investigations and so on are all important tools when used appropriately. Inquiry is the umbrella concept partnered with teaching and learning. It includes many teaching and learning methods and techniques to increase students’ motivation. This may reflect a greater emphasis at the school-level on the process of learning and the development of an understanding of science. Educational technology has opened new possibilities in science education. The use of computer technology benefits teachers during their valuable class time to create activities such as analysis and discussion about science. It helps teachers to shift from a transmission to a transformative approach that supports inquiry.

On the other hand, many teachers do not have enough backgrounds with TBIA in science (Pedersen and Yerrick, 2000). According to Williams, et al, (2004) “TBIA is complex and demanding for teachers, because it requires (a) understanding of the discipline or content well enough to allow students to ask ill-defined questions, (b) use of new representations of science content such as graphs, (c) new logistical practices such as managing small groups of students, and (d) understanding of technological and network related issues” (p. 190).

This study found that there were statistically significant differences between the two groups ($p<.05$), and that the achievement level of experimental group with TBIA was significantly higher than that of control group. The TBIA created a positive impact on 5th grade students' science achievement and attitudes toward science. Also, students in the experimental group declared the TBIA lessons were very funny and they enjoyed being part of the lessons. On the contrary, students who were in the control group said they were bored in traditional lessons and the earth-sun-moon topics were hard to learn.

It is very important to see these results, which are similar to previous literature on the subject in developing countries. Although there are many problems, such as a behaviorist approach in schools, lack of educational technology, improper physical contexts of schools and classrooms, lack of teachers' professional knowledge and skills and the improper use of laboratories, teachers solve these type of problems by demonstrating and implementing lab activities and using deduction in the classroom, as well as using traditional measurement and evaluation processes (for example, fill in the blank, multiple choice questions, etc.) (Kaya, Çepni & Küçük, 2004). These result showed that TBIA science teaching is effective and more successful than regular based teaching methods in elementary science courses because a TBIA helps students connect science with the scientific process skills.

References

Abell, S. K., Anderson, G., & Chezem, J. (2000). Science as argument and explanation: Exploring concepts of sound in third grade. In J. Minstrell & E. H. van Zee (Eds.), *Inquiry into inquiry learning and teaching in science* (p, 100-119). Washington: American Association for the Advancement of Science.

American Association for the Advancement of Science. (1990). *Science for all Americans*. Newyork, Oxford: Oxford University Press.

Anders, P.L., & Bos, C.S. (1986). Semantic feature analysis: An interactive strategy for vocabulary development and text comprehension. *Journal of Reading, 29*(7), 610-616.

Aydın, G. & Balım, A.G. (2005). An interdisciplinary application based on constructivist approach: Teaching of energy topics. *Ankara University, Journal of Faculty of Educational Sciences, year: 2005, 38(2), 145-166.*

Barstow, D. (Ed.). (2001). *Blueprint for change: Report from the national conference on the revolution in earth and space science education.* Cambridge, MA: TERC.

Basaga, H., Geban, O., & Tekkaya, C. (1994). The effect of the inquiry teaching method on biochemistry and science process skills achievements. *Biochemical Educatio*n, 22, 29-31. Bencze, J.L, Bowen, G.M., & Oostveen, R.V. (2003). *Web-mediated intellectual independence in science knowing*. Paper presented at the annual conference of the American Educational Research Association, Chicago, Illinois.

Bodner, G. M. (1986). Constructivism: A theory of knowledge. *Journal of Chemical Education*, 63, 873-878.

Bonnstetter, R.J. (1998). Inquiry: learning from the past with an eye to the future. *Electronic Journal of Science Education,* 3(1).

Bozdogan, A.E. & Altuncekic, A. (2007). The opinion of pre-service science teachers about the utility of 5E teaching model. *Kastamonu Eğitim Dergisi, 15(2), 579-590*

Bybee, R. W. (2000). Teaching science as inquiry. In J. Minstrell & E. H. Van Zee (Eds.), *Inquiry into inquiry learning and teaching in science* (pp. 20- 46). Washington: American Association for the Advancement of Science.

Calhoun, D. H. (1996). Which "Socratic method"? Models of education in Plato's dialogues. K. Lehrer, B. J. Lum, B. A. Slichta, and N. D. Smith (Eds). Knowledge, Teaching and Wisdom (pp. 49-70).Kluwer Academic Publishers, Dordrecht, The Netherlands.

Chiappetta, E. L. (1997). Inquiry-based science. *Science Teacher*, 64, 22-26.

Chiappetta, E.L., & Russell, J.M. (1982). The relationship among logical thinking, problem solving instruction, and knowledge and application of earth science subject matter. *Science Education*, 66, 85-93.

Chinn, C.A., & Malhotra, B.A. (2002). Epistemologically authentic inquiry in schools: a theoretical framework for evaluating inquiry tasks. *Science Education, 86*, 175-218.

Colburn, A. (2000). An inquiry primer. *Science Scope*, 42-44**.**

Duschl, R.A. & Hamilton, R.J. (1998). *Conceptual change in science and in the learning of science.* In B.J. Fraser & K.G. Tobin (Eds.), the International Handbook of Science Education. (pp. 1047-1065). Dordrecht, the Netherlands: Kluwer Academic Publishers.

DeBoer, G. E. (1991). *A History of Ideas in Science Education*. New York: Teachers College Press.

Edelson, D. C. (2001). Learning-for-use: A framework for the design of technology-supported inquiry activities. *Journal of Research in Science Teaching, 38*(3), 355-385.

Ergin, I., & Kanlı, U. (2007). To examine the effects of 5E model on the students' academic success in physics education. *GÜ, Gazi Eğitim Fakültesi Dergisi*, 27(2), 191-209.

Ertepinar, H., & Geban, O. (1996) Effect of instruction supplied with the investigative-oriented laboratory approach on achievement in a science course. Educational Research, 38, 333-341.

Feletti, G. I. (1993). Inquiry based and problem based learning: How similar are these approaches to nursing and medical education? *Higher Education Research and Development, 12* (2), 143-156.

Flick, L., & Bell, R. (2000). Preparing tomorrow's science teachers to use technology: Guidelines for science educators. *Contemporary Issues in Technology and Teacher Education*, 1(1), 39-60.

Friedrichsen, P., Munford, D., & Zembal-Saul, C. (2003). Using inquiry empowering technologies to support prospective teachers' scientific inquiry and science learning. *Contemporary Issues in Technology and Teacher Education*, *3*(2), 223-239.

Geban, O., Askar, P., & Ozkan, I. (1992). Effects of computer simulations and problem-solving approaches on high school students. *Journal of Educational Research*, 86, 5-10.

Geban, O., Ertepinar, H., Yilmaz, G., Altın, A., & Şahbaz, F. (1994). *Bilgisayar Destekli Eğitimin Öğrencilerin Fen Bilgisi Başarılarına ve Fen Bilgisi İlgilerine Etkisi.* I. Ulusal Fen Bilimleri Eğitimi Sempozyumu Bildiri Özetleri Kitabı: pp.I-2, 9. Dokuz Eylül Üniversity İzmir, Turkey, 1994.

Gencturk, H.A. & Türkmen, L. (2007). A Study of effectiveness and application of inquiry method in a 4th grade science course. *GÜ, Gazi Eğitim Fakültesi Dergisi, 27(1), 277-292.*

Germann, P. J. (1989). Directed-inquiry approach to learning science process skills: Treatment effects and aptitude-treatment interactions. *Journal of Research in Science Teaching*, 26(3), 237-50.

Germann, P. J. (1991). Developing science process skills through directed inquiry. *American Biology Teacher*, 53(4), 243-47.

Glasson, G. E. (1989). The effects of hands-on and teacher demonstration laboratory methods on science achievement in relation to reasoning ability and prior knowledge. *Journal of Research in Science Teaching, 26*(2), 121–131.

Hancer, A. H. (2006). Enhancing learning though constructivist approach in science education. *International Journal of Environmental and Science Education,* 1(2), 181-188.

Haury, D.L. (1993). Teaching science through inquiry. ERIC CSMEE Digest, March. (ED 359 048).

Hawkey, R. (2001). Science beyond school – representation or re-presentation? In A. Loveless & V. Ellis, (Eds), *ICT, Pedagogy and the Curriculum.* London: RoutledgeFalmer.

Hayes, M.T. (2002). Elementary pre-service teachers' struggles to define inquiry-based science teaching. *Journal of Science Teacher Education, 13*(2): 147-165

Henson, K. T. (1986). Inquiry learning: A new look. *Contemporary Education*, 57, 181-183.

Hogan, K., & Berkowitz, A.R. (2000). Teachers are inquiry learners. *Journal of Science Teacher Education*, 11(1), 1-25.

Kaya, A., Çepni, S., & Küçük, M. (2004). Fizik Öğretmenleri İçin Üniversite Destekli Bir Hizmet İçi Eğitim Model Önerisi. *The Turkish Online Journal of Educational Technology (TOJET)*, 3(1) Article 15.

Keys, C.W., & Kennedy, V. (1999). Understanding inquiry science teaching in context: A case study of elementary teachers. *Journal of Science Teacher Education*, 10(4), 315-333.

Krajcik, J., Marx, R. W., Blumenfeld, P., Soloway, E., & Fishman, B. (2000). *Inquiry based science supported by technology: Achievement among urban middle school students*. Paper presented at the American Educational Research Association, Anne Arbor, Michigan.

Kuhn, D. (1993). Science as argument: Implications for teaching and learning scientific thinking. *Science Education, 77*(3), 319-337.

Kyle, W. C., Jr., et al. (1985). What research says: Science through discovery: students love it. *Science and Children*, 23(2), 39-41.

Lederman, N. G., & Schwartz, R. S. (2001). Pre-service teachers' understanding and teaching of nature of science: an intervention study. *Canadian Journal of Science, Mathematics and Technology Education, 1* (2), 135-157.

Linn, M. C., Davis, E. A. and Bell, P. (2004). "Inquiry and Technology". In: Linn, M. C., Davis, E. A. and Bell, P. (Eds.), *Internet Environments for Science Education.* Mahwah, New Jersey, Lawrence Erlbaum Associates, 3 – 27.

Lindberg, D. H. (1990). What goes 'round comes 'round doing science. *Childhood Education*, 67(2), 79-81.

Litchfield, B. C., & Mattson, S. A. (1989). The interactive media science project: An inquiry-based multimedia science curriculum. *Journal of Computers in Mathematics and Science Teaching*, 9(1), 37-43.

Lott, G.W. (1983). The effect of inquiry teaching and advance organizers upon student outcomes in science education. *Journal of Research in Science Teaching*, 20(5), 437-451.

Macaroglu Akgul, E. (2006). Teaching science in an inquiry-based learning environment: What it means for pre-service elementary science teachers. *Eurasia Journal of Mathematics, Science and Technology Education*, 2(1), 71-81.

Mao, S-L., Chang, C-Y., & Barufaldi, J.P. (1998). Inquiry teaching and its effects on secondary-school students' learning of earth science concepts. *Journal of Geoscience Education,* 46, 363-368.

Maor, D. (1991). *Development of student inquiry skills: A constructivist approach in a computerized classroom environment*. Paper presented at the Annual Meeting of the National Association for Research in Science Teaching, Lake Geneva, WI.

Miller, K. (2001). ICT and science education. – New spaces for gender. In A. Loveless & V. Ellis (Eds.), *ICT, pedagogy and the curriculum*. London: RoutledgeFalmer.

Mintzes, J. J., Wandersee, J. H., & Novak, J. D. (2000). *Assessing science understanding: A human constructivist view*. San Diego: Academic Press

Mulopo, M.M., & Fowler, H.S. (1987). Effects of traditional and discovery instruction approaches on learning outcomes for learners of different intellectual development. A study of chemistry students in Zambia. *Journal of Research in Science Teaching*, 24, 217-227.

National Research Council. (1996). *National science education standards*. Washington: National Academy Press.

National Research Council. (1999). *How people learn: brain, mind, experience, and school*. Bransford J. D., Brown A. L., Cocking R. R., editors National Academies Press. Washington, D.C., USA.

National Research Council. (2000). *Inquiry and the National Science Standards: A guide for teaching and learning*. Washington: National Academy Press.

OECD. (2006). *Evolution of Student Interest in Science and Technology Studies – Policy Report; Global Science Forum*, OECD, May 2006

Ozsevgenc, T. (2006). Kuvvet ve Hareket Ünitesine Yönelik 5E Modeline Göre Geliştirilen Öğrenci Rehber Materyalinin Etkililiğinin Değerlendirilmesi. *Journal of Turkish Science Education,* 3(2), 36-48.

Pedersen, J. E., and Yerrick, R. K. (2000). Technology in science teacher education: Survey of current uses and desired knowledge among science educators. *Journal of Science Teacher Education* 11: 131–153.

Ramsey, J. (1993). Developing conceptual storylines with the learning cycle. *Journal of Elementary Science Education, 5*(2), 1-20.

Shimoda, T.A., White, B.Y. & Frederiksen, J.R. (2002). Students goal orientation in learning inquiry skills with modifiable software advisors. *International Science Education Journal, 88*, 244–263.

Shymansky, J.A., Kyle, W.C., & Alport, J.M. (1983). The effects of new science curricula on student performance. *Journal of Research in Science Teaching*, 20, 387-404.

Slotta, J. D. (2004). The web-based inquiry science environment (WISE): Scaffolding knowledge integration in the science classroom. In Linn,M.C., Davis,E. A., and Bell,P. (Eds.), *Internet Environments for Science Education*, Erlbaum, Mahwah, NJ.

Taasoobshirazi, G., Zuiker, SJ., Anderson, KT., Hickey, DT. (2006). Enhancing inquiry, understanding, and achievement in an astronomy multimedia learning environment. *Journal of Science Education and Technology*, 15(5), 383-395.

Tapscott, D. (1996). *Growing up digital*. New York: McGraw-Hill.

Taylor, P. C., Fraser, B. J., & Fisher, D. L. (1997). Monitoring constructivist classroom learning environments. *International Journal of Educational Research*, *27*(4), 293-302.

Tobin, K.G., & Capie, W. (1982). Relationship between formal reasoning ability. Locus of control. Academic engagement and integrated process skills achievement. *Journal of Research in Science Teaching*, 19, 113-112.

Tong, Jolly, & Zalondek, (1989). Multi-Branched Diagnostic Trees. *IEEE*, 92-98. Retrieved november 12, 2008. http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=00071258

Türkmen, H., & Pedersen, J. (2003). Learning environments in our science classrooms: The view of international students. Science Education International (SEI), 14(3), 21-29.

Von Secker, C. (2002). Effects of inquiry-based teacher practices on science excellence and equity. *The Journal of Educational Research*, 95(3), 151-160.

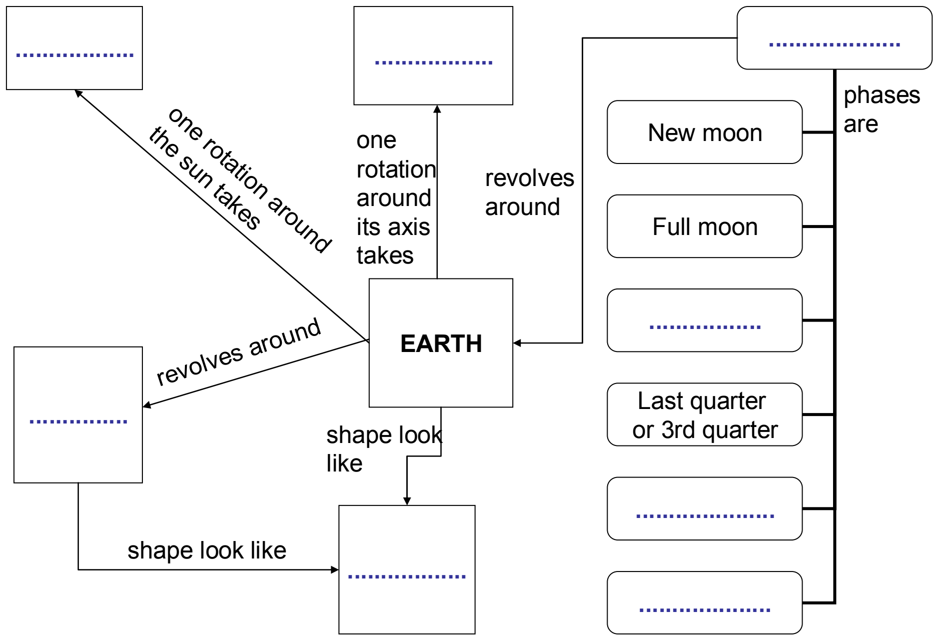
Williams, M, Linn, M.C., Ammon, P., & Gearhart, M. (2004). Learning to teach inquiry science in a technology-based environment: A Case Study. *Journal of Science Education and Technology,* 13(2), 189-206

Welch, W.W., Klopfer, L.E., Aikenhead, G.S., & Robinson, J.T. (1981). The role of inquiry in science education: Analysis and recommendations. *Science Education*, 65, 33-50.

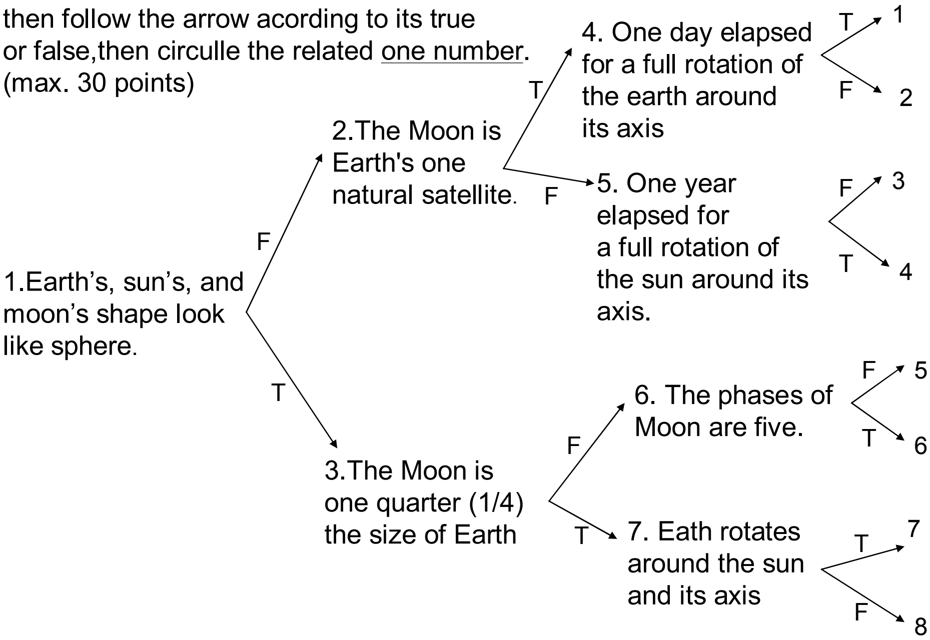
Appendix A:

Achievement Test

Question 1: Fill in the 8 blanks with apprapriate concepts.
Each blanks is 6.25, total is 50 points.



Question 2: Read the first sentence, then follow the arrow acording to its true or false,then circulle the related one number. (max. 30 points)



Question 3. In semantic features analysis table, read the situation and answer the objects are seen wheather bigger or smaller via one check for each rows. (20 points)

Object	appear of objects according to distance	
	SEEN MUCH BİGGER	SEEN MUCH SMALLER
Becoming away Ship		
Kite in air		
Landing Plane		
Stars are far away from sun		
Student sitting in front acording to student sitting on back		