EXPLORING THE EFFECTS OF SCIENCE WRITING HEURISTIC (SWH) APPROACH ON THE EIGHT GRADE STUDENTS' ACHIEVEMENT, METACOGNITION AND EPISTEMOLOGICAL BELIEFS

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ABSTRACT

INVESTIGATING THE EFFECTS OF SCIENCE WRITING HEURISTIC APPROACH ON EIGHT GRADE STUDENTS' ACHIEVEMENT, METACOGNITION AND EPISTEMOLOGICAL BELIEFS

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The aim of this study was investigating the effects of Science Writing Heuristic (SWH) approach on 8th grade students' science achievement, metacognition and scientific epistemological beliefs when compared to traditional instruction. For this purpose, a non-equivalent control group post-test only design was employed. Two 8th grade classes from a public elementary school were selected for the study. One class was assigned as experimental group and the other class was assigned as the comparison group. Students in the experimental group were instructed with the SWH approach, while those in comparison group were instructed with traditional science instruction during 13 weeks. Science Achievement Test for Eight Graders (SATEG), Metacognitive Awareness Inventory (MAI) and Epistemological Belief Questionnaire (EBQ) were administered as pre-test and post-test to collect data. The data were analyzed by using t-test and MANOVA. Pre-test results indicated that there was no statistically significant mean difference between the two groups regarding MAI, EBQ and SATEG scores before the treatment. Post-test results revealed that there was a statistically significant mean difference between the experimental and the comparison group, in favor of the experimental group.

Keywords: Argument Based Inquiry, Science Writing Heuristic, Metacognition, Epistemological Beliefs

ÖZ

ARGÜMANTASYON TABANLI BİLİM ÖĞRENME YAKLAŞIMININ
8. SINIF ÖĞRENCİLERİNİN FEN BAŞARILARINA, ÜST BİLİŞLERİNE
VE EPİSTEMOLOJİK İNANÇLARINA ETKİSİ

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Bu çalışma, Argümantasyon Tabanlı Bilim Öğrenme (ATBÖ) yaklaşımının 8. sınıf öğrencilerinin fen başarılarına, üst bilişlerine ve epistemolojik inançlarına etkisini araştırmak amacıyla yapılmıştır. Nicel çalışma yöntemlerinden yarı–deneysel çalışma yöntemi kullanılmıştır. Bir ilköğretim okulunda aynı öğretmenin girdiği 2 adet 8. sınıf araştırmanın örneklemini oluşturmaktadır. Bir sınıf rastgele deney grubu olarak diğeri ise karşılaştırma grubu olarak atanmıştır. Deney grubundaki öğrenciler konularını 13 hafta boyunca ATBÖ yaklaşımı ile işlerlerken, aynı konular karşılaştırma grubunda geleneksel yöntemler kullanılarak anlatılmıştır. Çalışmanın verileri, 8. Sınıflar için Fen Başarı Testi, Üst Bilişsel Farkındalık Ölçeği ve Epistemolojik İnançlar Ölçeği aracılığıyla toplanmıştır. Ön-test sonuçlarına gore gruplar arasında anlamlı istatistiksel bir fark çıkmazken, son-test sonuçları incelendiğinde deney grubu lehinde anlamlı istatistiksel farklar bulunmuştur.

Anahtar Sözcükler: Argümantasyon Tabanlı Bilim Öğrenme Yaklaşımı, Üst Biliş, Epistemolojik İnançlar

To my family

Who have always shown their trust in me

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LIST OF ABBREVIATIONS

ABI	Argument Based Inquiry
CFA	Confirmatory Factor Analysis
CG	Comparison Group
EBQ	Epistemological Beliefs Questionnaire
EG	Experimental Group
MAI	Metacognitive Awareness Inventory
MANOVA	Multivariate Analysis of Variance
MONE	Ministry of National Education
NGSS	Next Generation Science Standards
NRC	National Research Council
NSF	National Science Foundation
PISA	Programme for International Student Assessment
SATEG	Science Achievement Test for Eight Graders
SWH	Science Writing Heuristic
TI	Traditional Instruction
TIMSS	Trends in International Mathematics and Science Study

CHAPTER I

INTRODUCTION

…The aim (of education) must be training of independently acting and thinking individuals…

-Albert Einstein

Students need to be nurtured to completely develop their abilities to become independent thinkers. They need to puzzle through problems, observe multiple ways of finding solutions, gather and analyze evidences, test scientific ideas and apply the ideas during problem solving. In other words, they need opportunities to experience the joy of making science and developing science related skills such as inventiveness, curiosity, risk taking and perseverance (NSF, 2000). The practices of inquiry prepare students to everyday world and assist them to become independently acting and thinking individuals. National Science Education Standards (1996) expressed inquiry as:

> "A multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results. Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations (p. 23)."

Described activities are very different from the activities done in traditional science classrooms. The National Research Council (NRC, 1996) emphasized inquiry as central to science teaching and learning. Inquiry based science classrooms should provide students not only hands-on laboratory works, but also minds-on activities such as reading, writing and oral discourse as parts of the procedures of doing science (Wallace,Hand,&Prain,2004). Besides, the NRC stated the significance of inquiry in the Framework for K-12 Science Education as: "…students cannot fully understand scientific and engineering ideas without engaging in the practices of inquiry and the discourses by which such ideas are developed and refined" (NRC Framework, 2012, p. 218).

Since 1980, numerous studies have confirmed that different inquiry-based instruction models have positive impacts on teachers and students with various findings (White & Frederiksen, 1998; Lederman, 2006; Anderson, 2007; Kaynar, 2007; Gornally, Brickman, Hallar & Armstrong, 2009; Minner, Levy, & Century, 2010). Engaging in an inquiry classroom develops students' creativity and science process, reasoning and critical thinking skills, and also helps students construct better understanding of scientific concepts (Choi, 2008; Chanlen, 2013), metacognition (Sandi-Urena et al., 2012; Kipnis & Hofstein, 2008) and epistemological beliefs (Conley, Pintrich, Vekiri & Harrison, 2004; Kaynar, Tekkaya & Çakıroğlu, 2009) .

Various inquiry-based instructional models have been introduced within the science education community. NRC Framework (2000) stated five attributes that are supposed to support inquiry in the classroom: 1) familiarize students with scientifically based questions, 2) students prioritize to evidence during stating and assessing explanations, 3) students benefit from evidences during constructing explanations, 4) students consider alternative explanations when evaluating their own explanation 5) students declare and defend their explanations. Argument-based inquiry is one of the three main inquiry-based instructional models. According to Pinney (2014) argument-based inquiry let students compete during justification of explanations or claims which are obtained from experimental data. The difference between other inquiry-based approaches and argument-based inquiry occurred because of the explicit focus on using alternative claims. Meaning-making negotiation was arisen between peers during justification of explanations in argument-based inquiry approaches. Conversely, other inquiry-based approaches provide environment in which peer interaction occurs during hands on activities and no opportunity for peer negotiation is supplied.

Argument-based inquiry focuses the importance of the application of language in science through argumentation. Argumentation is an important aspect of science education. According to NGSS, student engagement in scientific argumentation leads to students to comprehend the scientific culture and effects the application of science and engineering on the benefit of society. The Framework for K-12 Science Education underlined the vital role of argumentation as follow:

> “The study of science and engineering should produce a sense of the process of argument necessary for advancing and defending a new idea or an explanation of a phenomenon and the norms for conducting such arguments. In that spirit, students should argue for the explanations they construct, defend their interpretations of the associated data, and advocate for the designs they propose”. (NRC Framework, 2012, p. 73)

Similar to abovementioned reform movements, Turkish Ministry of National Education (MONE) highlighted the importance of argumentation as an integral part of scientific inquiry. According to MONE (2013), inquiry process should be thought not only a process of “exploration and experimentation” but also a practice of “explanation and argumentation” and the teachers should create nonthreatening learning environments in which students express their claims with different evidences.

There are different kinds of approaches and techniques for teaching science within argument-based inquiry. Cavagnetto (2010) analyzed the characteristics of argument-based interventions in the research literature and proposed three main instructional approaches in argument-based inquiry which were immersion, structure, and socio-scientific approach. The Science Writing Heuristic (SWH) approach was classified as an immersion argument-based inquiry approach. According to Cavagnetto (2010), the immersion-oriented interventions depicted argument as a tool not only for the production and comprehension of scientific principles but also cultural applications of science. Interventions in this orientation were structured to insert argumentation to student investigations of scientific principles. Explicitly, argumentation was not viewed something that was made to end up the inquiry, however, was found in each steps of inquiry such as during question generation, experimentation, interpretation of data, and construction of claims based on students' evidences. SWH classrooms encourage students to develop arguments comprised of three components: question, claims, and evidence (Hand, 2008) providing a learning environment in which students are required to conduct inquiry investigations by posing their own questions about the topic under review, collect data, construct claims derived from evidence, make peer discussion, search what experts say about the topic, and reflect upon the their arguments to see how their ideas have changed.

SWH contains a teacher template and a student template. The teacher template involves a series of activities to help teachers design their classroom environment based on the SWH approach. The recommended activities in teacher template are: 1) exploration of pre-instruction understanding, 2) pre-laboratory activities, 3) participating laboratory activities, 4) negotiation – make personal meanings from the data, 5) negotiation – make peer discussion about interpretations of data, 6) negotiation – compare the ideas with the books or experts, 7) negotiation – individual SWH reports, 8) post-interaction discussion. As can be seen, learning arises through the negotiation of ideas in the SWH approach. Besides, student template consists of the argumentation structure involving three components: question, claims, and evidence. This template also provides reflective writing opportunities for students. It comprises seven reflective questions: 1) "What are my questions?" 2) "What do I do?" 3) "What can I see?" 4) "What can I claim?" 5) "How do I know? Why am I making these claims? 6) "How do my ideas compare with other ideas?" 7) "How have my ideas changed?" By answering these questions students are being aware of and keep under control of his/her knowledge and the choices to develop it. In this type of instruction students have lots of opportunities to control their own learning process such as using time efficiently, planning and modifying their research settings, revising their research questions or claims and thinking about what they learned during the process. In other words, student template works as prompter of students' awareness. White (1986) defined metacognition as inner awareness. From this perspective, the SWH approach provides lots of opportunities for metacognitive activities.

Students are not only metacognitively but also cognitively active during SWH process because they are responsible from their own learning. Student template provides students to understand scientific concept during report writing by relating claims to evidence (Hand & Keys, 1999). Their construction of meanings is also affected by social context. Peer negotiation plays a critical role in students' zone of proximal development (Pinney, 2014). Therefore SWH approach also positively influences students' science achievement (Hand et al.,2004; Rivard, 2004; Günel, 2006; Hohenshell & Hand, 2006; Akkuş, Günel & Hand, 2007; Poock, Burke, Greenbowe & Hand, 2007; Caukin, 2010; Hasançebi & Günel, 2013).

Moreover, students construct their ideas via experimentation, observation and negotiation in SWH approach. This may lead students to realize that answers of questions do not have to be generated by authorities. Also such an instruction may affect students' awareness about development and modification of scientific ideas. Since students generate authentic data and results that are unique to that exploration, SWH approach may lead less reliance on the certainty of knowledge.

As it was indicated above, SWH approach can affect students' achievement metacognition and epistemological beliefs. Therefore, the present study aimed to investigate the effects of SWH approach on the 8th grade students' achievement metacognition and epistemological beliefs.

1.1 Research Questions

The specific research questions addressed in this study were:

1. What is the effect of Science Writing Heuristic (SWH) approach on 8th grade students' science achievement when compared to traditional instruction?

1.a Is there a significant difference between the groups' pretest results with respect to students' science achievement?

1.b Is there a significant difference between the groups' posttest results with respect to students' science achievement?

2. What is the effect of Science Writing Heuristic (SWH) approach on 8th grade students' metacognition when compared to traditional instruction?

2.a Is there a significant difference between the groups' pretest results with respect to students' metacognition?

2.b Is there a significant difference between the groups' posttest results with respect to students' metacognition?

3. What is the effect of Science Writing Heuristic (SWH) approach on 8th grade students' scientific epistemological beliefs when compared to traditional instruction?

3.a Is there a significant difference between the groups' pretest results with respect to students' scientific epistemological beliefs?

3.b Is there a significant difference between the groups' posttest results with respect to students' scientific epistemological beliefs?

1.2 Definition of Important Terms

Science Writing Heuristic: It is an approach used in science classrooms, consolidates inquiry with reading and writing to learn strategies and classroom discourse (Hand, Norton-Meier, Staker & Bintz, 2009).

Science Achievement: It is an indicator of students' science learning level. In the present study science achievement of students is identified by SATEG scores ranging from 0 to 30.

Metacognition: Students' knowledge about their own cognitive processes and control and awareness of his/her learning processes (Schraw & Moshman, 1995).

Epistemological Beliefs: Students' beliefs about the nature of knowledge and knowing (Hofer & Pintrich, 1997).

Traditional Instruction: It is a textbook-driven teacher centered direct instruction in which the concepts are taught by the teacher with didactic methods and traditional laboratory applications.

Traditional Laboratory Application: It consists of hands on experiments followed by students with step by step procedures that are explained in their textbooks.

1.3 Significance of the Study

As defined by the NRC, the fundamental goal of science education is that "students [need to] learn scientific knowledge with understanding" (NRC, 1996, p.21). The goal of science learning has shifted from replicating scientific terminology or learning without understanding to construction and communication of an in-depth scientific understanding through argumentation processes (Chanlen, 2013). International and national organizations have emphasized argumentation a great attention (MONE, 2013; NRC, 20012; OECD, 2003). Although its' importance and the increased attention in the research literature over the past two decades, argument-based inquiry is not a common implementation in science classrooms (Cavagnetto, 2010).

To make argument-based inquiry approaches -in the case science writing heuristic approach- a part of science classrooms, its' effects on teaching-learning process and

students should be investigated in different dimensions and situations. Its' positive effects should be highlighted with the sample implementations. Demonstrating the practicality of this approach minimize the chance of its' remaining just a theoretical knowledge and increase the chance of implementation in science class. On the other hand, indicating the limitations and difficulties of this approach leads regulations and increase the effectiveness of the approach. The result of this study will provide useful information regarding the implementation of SWH in elementary science class.
To avoid rote learning, students should construct their own knowledge. In this sense, development of metacognition is inevitably important for meaningful science learning (White, 1998; Georghiades, 2004; Thomas, 2012). According to Gunstone (1994) metacognition is a key element of constructivist learning environments in which students have to manage their cognitive processes. Similarly, Pintrich, Smith, Garcia, and McKeachie (1993) described metacognitive strategies as deeper processing strategies consisting of planning, monitoring, and regulating which assist students in the control and regulation of the cognition. For example, students read textbooks to obtain conceptual understanding; they solve problems through reasoning and applying formula; they design, plan and perform laboratory experiments and write reports or papers during a constructivist science course (Veenman, 2012). In the literature there are some studies indicated the relations between metacognition and science achievement. For example Akyol, Sungur and Tekkaya (2010), found the metacognitive self-regulation strategy use as a main predictor of students' science achievement. Similarly, Topçu and Yılmaz-Tüzün (2009) found that metacognition influenced 4^{th} to 8^{th} grade students' science achievement.

Veenman, Van Hout-Wolters and Afflerbach (2006) emphasized that "metacognition need not be studied in splendid isolation" (p.10). According to them, there are complicated connections between metacognitive experiences, metacognitive knowledge, self-regulation and epistemological beliefs. Introduction the notion of metacognition to the process of epistemological development was firstly done by Kuhn in 1991. According to her, thinking about thinking was important to making any improvements or positive changes in one's epistemic thinking (Wyre, 2007).

Kuhn (2001) also explained that “To fully understand processes of knowing and knowledge acquisition, it is necessary to examine people’s understanding of their own knowledge” (p. 1). Then a question why does maturate epistemological beliefs or fully understand knowing and knowledge important in science learning was brought to the light by Hand, Lawrance and Yore (1999). According to them learning science requires an awareness of epistemological beliefs. Besides, epistemological beliefs influence students’ academic performance (Kızılgüneş et al., 2009; Tsai, 1998). All these studies bring the significance of epistemological beliefs on science learning.

As can be understood there can be a relationship between epistemological beliefs, metacognition and science achievement. Although the present study did not investigate this relationship due to its nature the SWH approach may affect these three interrelated variables. For that reason, investigating its effects may also contribute to the literature.

In the accessible literature there is not much study about the effects of SWH approach on students’ metacognition (Van Opstal, 2014). Moreover, no study was investigated the effects of SWH approach on students’ epistemological beliefs. Kıngır (2011) recommended further studies about the effects of SWH approach on students’ epistemological beliefs. Findings of this study also expected to contribute science education literature by completing the gaps.

CHAPTER II

LITERATURE REVIEW

The purpose of this study is exploring the effects of science writing heuristic (SWH) tasks on the 8th grade students' achievement, metacognition and epistemological beliefs. This chapter presents a review of related literature that provides the essential background to guide this study. The review of the literature consists of three sections. The first section gives brief review of argument based inquiry approach under this section evolving process of science writing heuristic approach, from a writing-to-learn strategy is presented in a detailed historical review. The second section focuses on the construct of metacognition. The third section concentrates on the epistemological beliefs concept.

2.1 Argument-based Inquiry Approach

Biological Science Curriculum Study (BSCS) 5E model, model-based inquiry, and argument-based inquiry approaches are the three main inquiry-based approaches (Cavagnetto, 2010). Argument-based inquiry focuses the value of language usage in science through argumentation. The argumentation concept is building on Vygostky's (1978) learning theory and the idea that without language comprising text, modes of representation and talk, science is impossible (Lemke, 2004). Language is a fundamental part of science as inquiry as it leads the epistemic nature of science and catches the scientific culture; both enlighten understanding and knowledge construction (Ford, 2008). According to Chanlen (2013), students can learn in more meaningful ways via engaging students with argumentation in the science classroom. Moreover, by engaging students with argumentation their communication skills, reasoning skills, and scientific literacy are developed and their understandings of scientific culture and practice are improved. According to Cavagnetto (2010), there are three major argument intervention approaches used within science: an immersion for learning scientific argument (immersion approach), teaching the structure of argument (structure approach), and emphasizing the reciprocal influence of science and society (socio-scientific approach). He added that the immersion-oriented interventions depicted argument as a tool not only for the structure and interpretation of scientific principles but also cultural applications of science. Interventions in this direction were structured for embedding argument within student investigations of scientific principles. The Science Writing Heuristic (SWH) approach is considered as an immersion argument-based inquiry approach. Before expressing the SWH approach, its' roots writing-to-learn strategy was expressed in the following part.

2.1.1 Writing-to-learn Strategy

Although writing to learn has been one of the popular concepts in the last decade in science education, it has been a part of education literature for a long time. Writing for learning grounds on Vygotsky, mentioned writing as a conceptual change tool in his book, *Thought and Language* (1962). Similarly Emig (1977) perceived writing as a conceptual change tool moreover defined writing as a more assertive way, 'unique mode of learning' (p.122). According to her, writing provides learning incomparably since writing as process-and-product acquires a bunch of elements that equal incomparably to certain influential learning strategies. Learning needs active, personal and self-regulated production of organized conceptual associations, enriched by feedback processes. The same requirements characterize writing. The externalization of personal understandings in symbolic form lets self-reflection and revision by making the understandings available for feedback.

Hayes and Flower (1980) stated that writing requires planning, translating and reviewing which constitute the central features of metacognitive strategies. In some other sources, writing-to-learn is defined as a useful tool for building, clarifying, and conceptualizing knowledge in a content area (Rivard, 1994; Hand & Prain, 1996 & 2001; Hohenshell & Hand, 2006; Caukin, 2010). Rivard (1994) denoted that "the process of writing is important, not only for learning about something or acquiring knowledge, but generating a personal response to something, for clarifying ideas, and for constructing knowledge" (p. 970). Hand and Prain (2001) expressed that "writing enhances students' conceptual knowledge, develops scientific literacy, familiarizes students with the expectations, conventions, and reasoning skills required of scientific writing, and also engenders positive attitudes towards being a writer on scientific issues" (p. 737). Caukin (2010) claimed that writing enables students to be "expressive, proceed at their own rate, and use their own language and experiences". This process supports personal engagement in learning and 'combats passivity' (p.32). Langer and Applebee (1987) defend that meaningful writing in the content areas provides complex thinking and learning.

In the review of *Language and Science Learning,* Carlsen (2007) explained Vygotsky's belief that writing is linguistically different and more demanding than speech. The developmental path of writing is more abstract and less likely to obtain feedback from others (p.59). Similarly, Klein (2000) made a research with 70 children in grades 4, 6 and 8. In the research, students had done two experiments about buoyancy and balance beam. Students' explanations about the concepts before experimenting, immediately after experimenting and after writing were analyzed and categorized to six ordinal levels. Students who indicated one level of explanation before writing and a higher level of explanation after writing had thought to indicate explanatory benefits through writing. He found that only writing cannot contribute to explanatory gains. According to him, unless combined with other strategies, writing is not sufficient for learning science by itself. For example exploration of text with brainstorming indicated a positive interplay and helped significantly to learning through writing.

On the other hand, writing-to-learn strategies, highlights the uses of non-traditional writing tasks includes diversified types of writing and are distinct from and more efficient than traditional science writing approaches (Gunel et al., 2007). Prain and Hand (1996) proposed a model for writing for learning science for effective use of writing. They explained necessary conditions which are prepared to guide teachers in the planning and implementation of writing tasks. Five elements are spotlighted in this framework. Writing types, writing purposes, topic structure, method of text production and audience or readership' are the five elements of this model. These elements are thought analogous to "interlocking keys within a combination lock" (p. 618). The model of elements for writing for learning in science is shown in figure 2.1; the expanded model of elements is shown in figure 2.2.

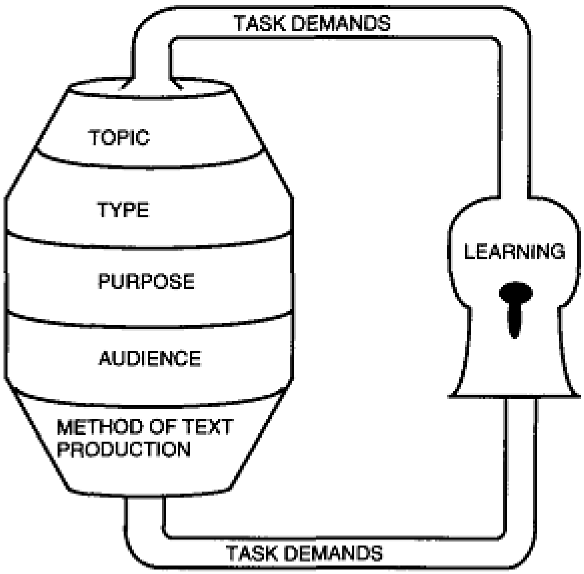


Figure 2.1 "Model of Elements for Writing for Learning in Science"
(Source: Prain & Hand, 1996)

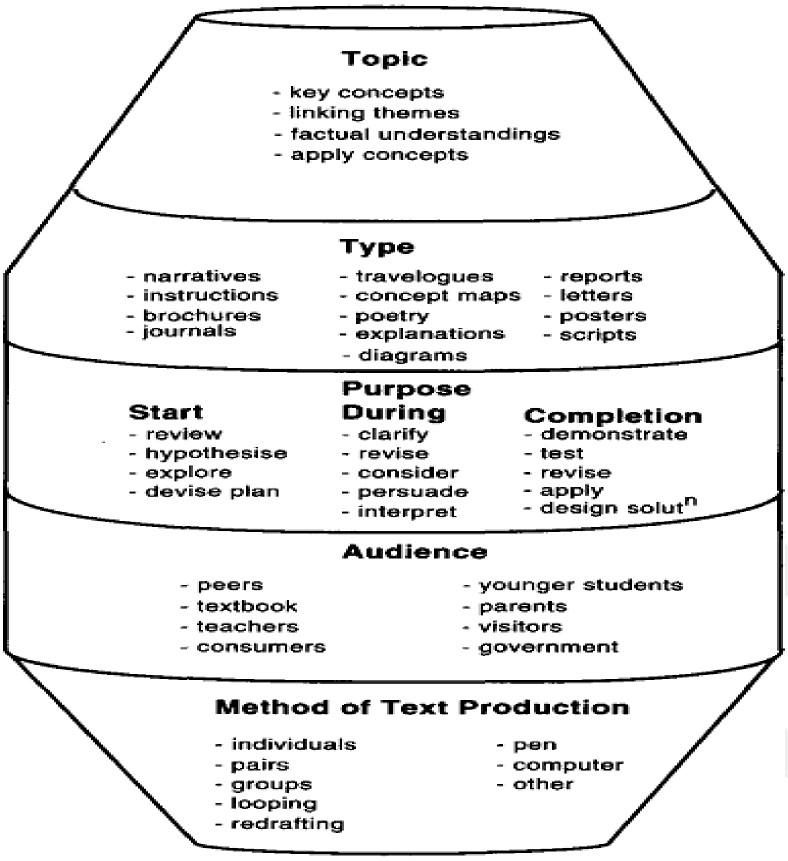


Figure 2.2 “Expanded Model of Elements”

(Source: Prain & Hand, 1996)

Prain and Hand (1996) emphasized the value of writing to real audience. Peers, teachers, younger students, parents, etc. can be the options of audience. Journals, concept maps, poetry, letters, posters, diagrams, reports, explanations, etc. can be counted as writing types. It is recommended that the topic should be centered on the ‘big ideas’ of the topic. According to them, these five elements and combination of preferences about the elements may change the success of writing. From this point of view, for example the effects of letter writing are depending on the true selection of audience and method options as much as topic and purpose. Klein (2006) added ‘sources’ as a sixth element to the model, because students are regularly examining and appreciating information from a great deal of sources. According to Holliday, Yore, and Alverman (1994), “meaningful writing should bridge new information and old knowledge structure, provide authentic authoring tasks for an uninformed audience, encourage minds-on learning, facilitate conceptual organization and restructuring, and promote metacognition" (p. 885).

Bangert-Drowns, Hurley and Wilkinson (2004) made a meta-analysis with 48 school-based writing to learn programs. They stated that note taking, answering comprehension question and summarizing which are traditional writing activities, help students to review, consolidate and retain information. On the other hand, analytic writing that entails investigation of relations between ideas and argumentation of a particular opinion was thought to foster complex understanding of selected information. Also according to them, writing can be a tool of self-reflective monitoring of comprehension, as a result of creating opportunities for students to assess their own understandings, confusions, and feelings about a topic. In this way, metacognitive comprehension-monitoring strategies are particularly potent candidates for development through writing. But they also stated that it would be unrealistic to think that writing always provides the exercise and development of metacognitive and other learning strategies or increase retention and achievement. Writing tasks, context and treatment length affect students' acquisitions.

Graham and Perin (2007) studied on a meta-analysis about the interventions of writing (Grades 4–12) with 123 documents in the literature. In view of their findings, they suggested the following features that need to be carefully considered:

- Planning, modifying and editing strategies should be engaged to students.
- Instructional arrangements should be made considering students' compositions with their plan, outline and editing.
- Clear purposes should be indicated containing the purpose of the writing and the features of the final work.
- Teachers should let students to utilize word-processing tools.
- Students should be involved in writing implementations that develop their inquiry skills.

- Students should be engaged in writing activities in which they can gather and organize their ideas.

Similarly, Tynjala, Mason and Lonka (2001, p.16) suggested some important recommendations for writing to learn tasks:

- Writing tasks should encourage active construction.
- Students' prior knowledge and their conceptions should be utilized by writing tasks.
- Students can reflect their own experiences and conceptualize explanations about them during writing processes.
- Students should be involved in implementing theories to practical conditions.
- Classroom discourse and other school work should be combined in writing tasks.

Günel, Hand, and Prain (2007) conducted a secondary analysis on six studies that centered on the advantages of writing-to-learn strategies and found that writing-to-learn strategies affected students' performance on tests, including those that measured conceptual understandings. The authors claim that students reshow their knowledge in distinct structures which is a great opportunity for learning if they use writing-to-learn strategies.

Günel, Atilla and Büyükkasap (2009) investigated effects of embedding multi modal representation into writing to learn activities in 6th grade students' academic achievement in the electricity concept. All students wrote letter about what they learnt about electricity to younger students. Treatment groups differentiate with the modes (text only, text & graph, text & math, any mode) that they embedded into their letters. Results show that restricting students to use a specific mode with textual representation is more beneficial than no restrictions.

To investigate the impact of diverse writing to learn activities on 6th grade students' academic achievement on mechanic topic; Günel, Uzoğlu and Büyükkasap (2009) made an experimental study. Letter writing to younger students and summary writing were compared with respect to effects of academic achievement. Looking the results it can be said that students who wrote letter to younger students and revised according to the feedbacks were more successful in the posttest.

Proper writing types for school science have been the topic of lots of studies and debates. Modernists argue that traditional language, genres and principles of scientific argument should be thought to students because personalized writing is inefficient for constructing meaning and also disempowering to learn scientific literacy by implying that real science is too difficult. Postmodernists claim that formal forms of writing permit students to critique the current state of the scientific enterprise. Conversely, constructivists believe that students should write for personal understanding. According to Prain and Hand (1996), the SWH approach supplies a framework for writing school science which at some points goes beyond this debate. Detailed information about the SWH approach was presented in the following part.

2.1.2 Science Writing Heuristic Approach

The Science Writing Heuristic has developed by Keys and Hand to promote learning from laboratory activities by promoting connections among research questions, procedures, data, evidence and claim. They stated that they had conceptualized their tool as a science writing heuristic because "it capitalizes on the power of writing to learn for generating science understandings" (Keys et al., 1999, p.1065). SWH was structured considering several contemporary theories of science education such as constructivist theory, nature of science, scientific literacy, argument based inquiry and writing-to-learn strategies. Hand, Norton-Meier, Staker and Bintz (2009) described SWH as an approach used in science classrooms, consolidates inquiry with reading and writing to learn strategies and classroom discourse. At the end of a series of SWH experiences, "students develop and test questions, justify their claims with evidence, compare their ideas with others and consider how their ideas have changed". Therefore SWH is more than a series of template; actually it is the very definition of science process (p.78). According to Hand, Wallace and Yang (2004), the heuristic requires acceptance of "meaning-making pedagogy" by the teacher to encourage students in constructing their knowledge.

The SWH has two components which are a teacher template and a student template. The teacher template (Figure 2.3) consists of a series of recommended activities to engage students in meaningful thinking, writing, reading, and discussion about the laboratory concepts.

Teacher Template

1. Exploration of pre-instruction understanding through individual or group concept mapping
2. Pre-laboratory activities, including informal writing, making observations, brainstorming, and posing questions
3. Participation in laboratory activity
4. Negotiation phase I-writing personal meanings for laboratory activity (For example, writing journals)
5. Negotiation phase II-sharing and comparing data interpretations in small groups (for example, making a group chart)
6. Negotiation phase III-comparing science ideas to textbooks or other printed resources (For example, writing group notes in response to focus questions)
7. Negotiation phase IV-individual reflection and writing (For example, writing a report or textbook explanation)
8. Exploration of post instruction understanding through concept mapping

Figure 2.3 The science writing heuristic, Part I: The teacher template
(Source: Keys et al., 1999)

Firstly, eliciting prior knowledge and getting understanding of the scientific context into which the laboratory is situated are expected from teachers. Individual or group concept mapping is advised for this step. Secondly, pre-laboratory activities such as brainstorming, constructing questions about the topic, or explaining prior knowledge can be planned. Then students attend laboratory investigation which allows for generation of authentic data and outcomes that are unique to that investigation. Also laboratory activities in which the results are not obvious to the students are the best candidates for using the SWH. After that students are permitted to think and write about the personal meanings of their data. This step is followed by students' negotiation about their interpretation with their peers. In this group discussion, students are encouraged to make claims. In negotiation phase III, students may consult authoritative text to compare their ideas. Then students are assigned a writing project to reflect their current understanding about the investigation. In this step diverse writing project such as persuasive essay, research poster, letter or multimedia presentation can be used. Finally, the students are engaged in post-investigation concept mapping for closure of the laboratory activities by the teacher. Depending on the nature of the laboratory investigation and the topic, students may loop back or enter the steps 3 – 6 which are shown in teacher template, as many times as necessary.

As mentioned above, the second component of the SWH is the student template (Figure 2.4) which used by students throughout the above phases of negotiation.

Student Template

1. Beginning Ideas—What are my questions?
2. Test—What did I do?
3. Observation—What did I see?
4. Claim—What can I claim?
5. Evidence—How do I know? Why am I making these claims?
6. Reading—How do my ideas compare with other ideas?
7. Reflection—How have my ideas changed?

Figure 2.4 The science writing heuristic, Part II: The student template
(Source: Keys et al., 1999)

Initially, students reveal their science questions related with the laboratory activity to offer an authentic context for inquiry. Then they assess their continuing procedures and observations to relate them to the scientific questions. Although making observations may be similar to traditional laboratory practices, the process of making claims and sustaining them with evidence from their experimental work provides students to interactively construct a deeper understanding (Burke, Greenbowe & Hand, 2005). After composing their own tentative explanations, students have a chance to compare their claims with the scientifically accepted explanations. In the last step, students reflect on how their scientific ideas have changed throughout the investigation.

SWH laboratory report format (SWH student template) varies from the traditional laboratory format in many directions (Table 2.1). In traditional laboratory format procedures are same also data and observations are similar for each student whereas in SWH format students investigate their own questions in border of the big idea. Therefore their procedures, data and observations differ in respect to their research questions (Burke et al., 2005). Also traditional laboratory reports have a tendency to disconnect purpose, procedure, observations, data and hypotheses from each other but SWH format supports peer discussions and writing about the connections between research questions, observations, data, claims and evidence (Keys et al., 1999; Kıngır, 2011).

Table 2.1 Comparison of the SWH student template and traditional laboratory format

SWH Student Template	Traditional Laboratory Format
1. Beginning Questions—What are my questions?	1. Title, purpose.
2. Tests—What do I do?	2. Outline of procedure.
3. Observations—What can I see?	3. Data and observations.
4. Claims—What can I claim?	4. Discussion.
5. Evidence—How do I know? Why am I making these claims?	5. Balanced equations, calculations, graphs
6. How do my ideas compare with other ideas?	
7. How have my ideas changed?	

In SWH approach learning environment, students are mentally and physically very active and the teacher behaves like a coach. Conversely, traditional laboratory learning environment is teacher-centered and the activities follow a step by step procedure like a cookbook. Mental activation and generation of meaning is not always possible with ‘cookbook laboratory’ applications (Hand et al., 2004).

In recent years, the SWH approach has being studied in diverse scope to clarify this construct, exploring the effectiveness of SWH approach over traditional approach regarding students’ understanding of science concepts at different grade levels Keys et al. (1999) investigated the influence of the SWH on the learning processes of students who are 8th grade, involved in an investigation of the water quality of a stream behind their school. Students' understandings of the nature of science were examined by interpretive techniques. The researchers claimed that use of the SWH approach assisted students' generation of meaning from data which students collect during their scientific process and making connections among procedures, data, evidence, and claims. Students' vague understandings of the nature of science at the beginning of the study were transformed to more complex and rich understandings. Also according to the researchers, there is exhibited evidence of SWH approach force students to metacognitive thinking.

Rudd, Greenbowe, Hand, and Legg (2001) measured the effect of type of laboratory report format (SWH vs. traditional) on student understanding the physical equilibrium concept with 80 freshman chemistry students. The results indicated that the simple implementation of the SWH student template reduced time on task for students and instructors. In addition to this, SWH laboratory report format enhance students' science performance and positive attitudes toward science. Moreover, the researchers reported that students engaged in more thinking about their laboratory work and learnt more from their laboratory work.

A quasi-experimental study was conducted by Hand, Wallace, and Yang (2004) to compare the SWH approach and traditional approach with respect to students' conceptual understanding. The study was done with 93 seventh grade students from five different classes and cell concept was covered. There were three groups in the study: one group of students (two classes) was exposed to SWH approach, another group (two classes) was given the SWH approach and textbook type summary for their peers and the last group (one class) was the control group. Results showed that students who used the Science Writing Heuristic performed significantly better as a group than students who did not, and that students who completed a textbook type summary as a write-up performed better as a group than those who completed a more traditional write-up format. Moreover, interview results indicated that SWH approach increased students' metacognition because they take responsibility for their learning and distinguish their own knowledge gaps. The researchers emphasized that more research is needed to understand the effect of SWH approach on students' metacognition.

Nam, Choi, and Hand (2011) compared the SWH approach and traditional approach classes regarding student voice, science argument, teacher role, and questioning using the modified Reformed Teaching Observation Protocol (RTOP). Students' performance (achievement) was also examined using Summary Writing Test (SWT). The quasi-experimental study which was done with 3 eight grade teachers and their 345 students covered the electricity concept. Significant differences were found between the experimental and the comparison groups regarding RTOP scores and SWT scores. The results also highlighted the importance of teachers' implementation levels. The researchers found that higher level of teachers' implementation of the SWH approach raise student science achievement.

Hohenshell and Hand (2006) studied the effects of SWH approach on students' performance regarding conceptual and recall questions about cells. They also investigated the influence of audience during report writing in the SWH process. The study was conducted to 91 ninth and tenth grade students in advanced biology course. The results showed that the SWH approach has positive effects on conceptual questions and no significant effect on recall questions. Besides, survey and interview results indicated that SWH approach makes students more aware of their own learning. The researchers emphasized female students who used the SWH approach together with summary reports to peers benefited most.

Poock, Burke, Greenbowe and Hand (2007) examined the effect of implementation level of SWH approach on college students' academic performance in general chemistry course. It was found that good implementation of the SWH approach was beneficial for achievement compared to poor implementation and compared to traditional laboratory practices. As the degree of implementation level of SWH approach increased, students' chemistry achievement level increased. Moreover, SWH approach was found very beneficial to students who have low prior knowledge about the concepts by comparing students in previous years with similar prior knowledge and who were not implemented SWH approach.

Similarly Akkuş, Günel and Hand (2007) investigated the effectiveness of the SWH approach to traditional approach on students' post-test scores in relation to students' science achievement level and teacher's implementation of the SWH approach. Seven teachers and 592 students in grades 7-11 participated to the study. Genetics, acid and bases, classification and forces concepts were covered. Each teacher was assigned an experimental group in which SWH approach was implemented and a comparison group. Before the implementation, all teachers attended 2-day workshop regarding applying the SWH approach. The quality of teacher implementation level was determined by teacher observational data. Students' science achievements across the groups were determined by test scores. Similar to result of Poock et al., the quality of the implementation have an impact on student science achievement and that high-quality implementation of the SWH approach has significant advantages in closing the achievement gap. The results also indicated that low-achieving students benefitted more from the SWH approach.

Chanlen (2013) explored the longitudinal effects of the SWH approach on student science achievement. Students' test scores were collected from 2000 to 2011 from a school district in which includes elementary, middle and high school grades and science classrooms had been arranged according to SWH approach. According to the results, the SWH approach initially raised the science achievement scores that measured by standardized test, Iowa Test of Basic Skills. The initial positive impact was continued and progressively increased when students were consistently exposed to the SWH approach. This study also indicated that students had not been equally affected by the implementation of the SWH approach. Disadvantaged students (low-achievers or needed special individual education program or from low socio-economic background) were benefited more from participating in the SWH classrooms. In this way, achievement gaps among at-risk students were narrowed. Moreover, the students who started experiencing the SWH approach in elementary school grades compared with the students who were introduced in high school grades. It was found that, the earlier experience with the SWH approach lead the better science achievement growth.

There is a national study also investigating the effectiveness of the SWH approach on disadvantages students' science achievement (Hasançebi & Günel, 2013). The researchers conducted a quasi-experimental study with 55 eight grade students from low socio-economic background. The study covered the properties and structures of matter concept. The results provided evidence that SWH approach help disadvantages students to achieve in science. In addition, the researchers emphasized that students' ability to generate argument developed over time.

Kıngır, Geban and Günel (2012) examined the effects of the SWH approach on ninth grade students' academic achievement level. The study covered the chemical change and mixture topics in the chemistry course. In the study, there were two teachers with their two classes. Each teacher was assigned an experimental group in which SWH approach was implemented and a comparison group. Students' achievement levels were decided according to their chemistry mean scores for the previous semester of the study. The findings supported the idea that the SWH approach directs better conceptual understanding than the traditional approach. Low and middle achieving students in the experimental group significantly outperformed low and middle achieving students in the comparison group on the post-test. In this way, the achievement gap between low-achievers and high-achievers closed. According to Kıngır et al., closing the achievement gaps in the SWH classrooms is a consequence of all students' involving the same cognitive and metacognitive processes.

Caukin (2010) investigated the effects of the SWH approach on secondary honors chemistry students' science achievement, science self-efficacy and scientific epistemological view in her dissertation. In the study there were 23 students in the experimental group that was treated with the SWH approach and 8 students in the comparison group that experienced with traditional teacher-delivered lecture, textbook-made laboratory activities, and minimal writing or providing evidence for claims. The study lasted five weeks and covered the gases concept. According to quantitative data analysis, no statistically significant difference found in traditional teacher-delivered lecture, textbook-made laboratory experiences, and minimal writing or providing evidence for claims. The researcher explained these results high-achieving students benefit equally well with traditional science instruction. Besides, when the results deeply analyzed it was found that females in the treatment group outscored their male counterparts regarding science achievement. Moreover, qualitative analysis results revealed that students (especially female students) had positive perceptions of utilizing the SWH approach as a way to actively engage in the scientific process and that it facilitated their learning. The researcher highlighted that the study lasted for 5 weeks and recommended longer period of implementation of the SWH approach to better evaluate its effects on students' science achievement, self-efficacy and scientific epistemological view.

2.2 Metacognition

Metacognition was first introduced by Flavell (1976) who defined as "one's knowledge concerning one's own cognitive processes and products or anything related to them" (p. 232). According to Flavell (1979) metacognition constructs are: (1) metacognitive knowledge, (2) metacognitive experiences, (3) tasks and (4) strategies. Figure 2.5 shows Flavell's model for metacognition.

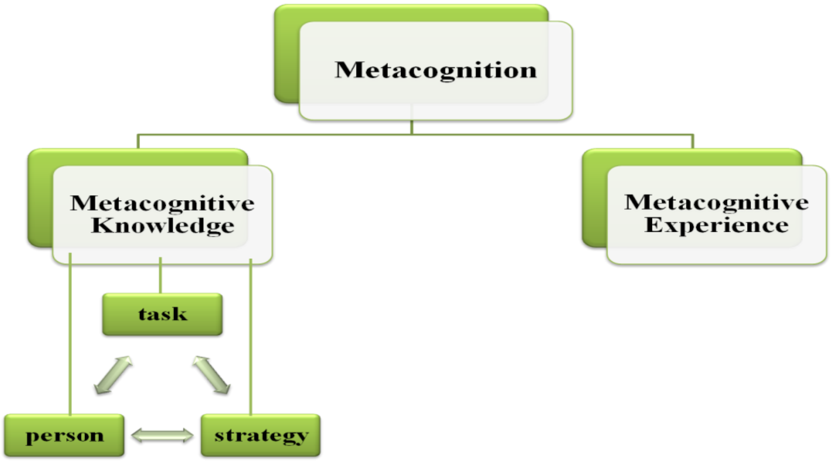


Figure 2.5 Flavell's model (1979) for metacognition

Metacognitive knowledge can be defined as the beliefs and knowledge that one's own cognition and learning. As indicated in figure 2.5 metacognitive knowledge includes task, person, and strategy components. According to Flavell (1979), these three components of metacognitive knowledge always interact with one another. Specifically, one's knowledge about people as cognitive processor affects one's perception of the nature of information within tasks and how to handle that information with the proper strategies. Additionally, Flavell (1979), emphasize that metacognitive knowledge is actually similar to the other knowledge stored in long-term memory. In other words, knowledge about one's own cognition and learning is stored just as any other type of knowledge.

Metacognitive experiences can be defined as any conscious cognitive or emotional experience that accompanies any intellectual activity. Metacognitive knowledge and metacognitive experiences are interconnected to each other. Flavell (1979) expressed this situation as "Metacognitive experiences can affect your metacognitive knowledge base by adding to it, deleting from it, or revising it. Finally, metacognitive experiences can activate strategies aimed at either of two types of goals-cognitive or metacognitive" (p.908). As can be understood from the quotation, each time one encounters a metacognitive experience their metacognitive knowledge, goals and actions are affected.

Knowledge of cognition and regulation of cognition were differentiated and seen as two major component of metacognition (Brown, 1987; Jacobs & Paris, 1987; Schraw & Dennison, 1994). Knowledge of cognition defined as awareness and students' knowledge about their own cognition or about cognition in general. Schraw and Dennison (1994) classified knowledge of cognition as declarative knowledge that means students' awareness of themselves, procedural knowledge which is the knowledge about how to use strategies and conditional knowledge which is the knowledge about when and why to use strategies and situations under which a specific strategy is the most efficient. On the other hand, regulation of cognition component of metacognition, includes a number of mental processes that facilitate the control aspect of learning. Regulation of cognition skills was categorized as planning, information management, monitoring, debugging and evaluation.

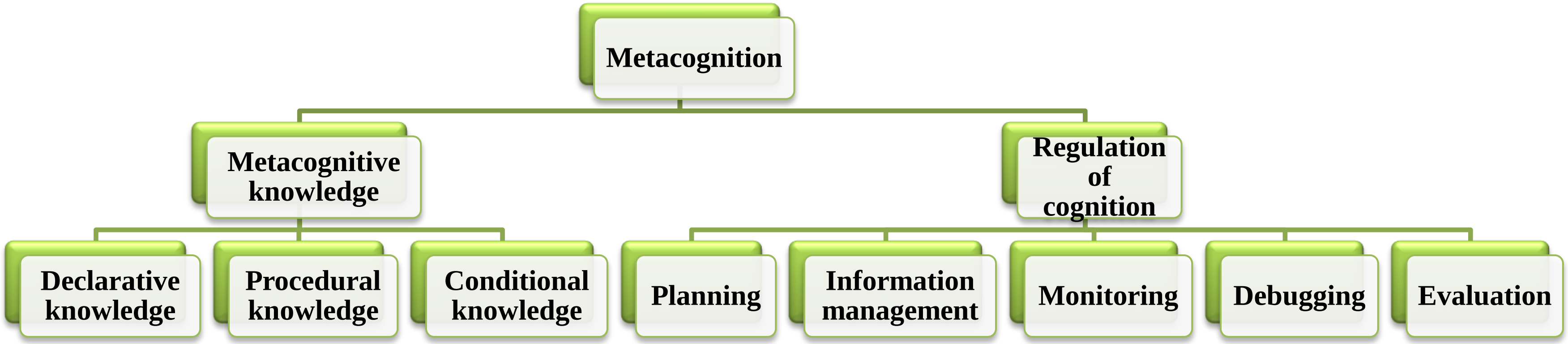


Figure 2.6 Schraw and Dennison (1994) model for metacognition

Planning involves goal setting, choosing of suitable strategies and time scheduling ways. Information management is related to students' awareness of their skills and strategies that used to process information successfully. Monitoring is associated with on-line awareness of students' own learning or strategy use. Debugging concerns the correction of performance errors or understanding. Finally, evaluation refers to judgments about regulatory processes and results of performance. Figure 2.6 shows the model of metacognition offered by Schraw and Dennison (1994).

Metacognitive knowledge is multidimensional, domain-general and teachable (Schraw, 1998; Thomas, 1999; Thomas & McRobbie 2001). Metacognitive knowledge and regulation of cognition skills can be improved through classroom instructional practices (Brown & Pressley, 1994; Schraw, 1998; Schraw, Crippen & Hartley, 2006; Kipnis & Hofstein, 2008; Hofstein, Kipnis & Kind, 2008). According to Hartman and Sternberg, 1993, there are four general ways to improve metacognition in classroom settings: fostering general awareness of the significance of metacognition, developing knowledge of cognition, enhancing regulation of cognition, and promoting environments that promote metacognitive awareness (as cited in Schraw, 1998). Thomas (2002) explained the features of metacognitive learning environment in eight dimensions rooted in the social constructivist theory: (1) metacognitive demands, (2) teacher modeling and explanation, (3) student-student discourse, (4) student-teacher discourse, (5) student voice, (6) distributed control, (7) teacher encouragement and (8) support an emotional support. This type learning environment is generally provided in inquiry-based classrooms. Thomas (2012) expressed why conscious thinking that is vitally necessary in inquiry-based learning environments is the hallmark of a metacognitive individual. He stated that:

> "to be able to undertake a process of scientific inquiry, there is a need for students to be able to consciously undertake particular procedures, both physical and cognitive, to monitor their progress towards the goal/s of the inquiry as they proceed, be aware of and evaluate their progress, and reflect on the outcomes of their inquiry with a view to improving their practices" (Thomas, 2012, p.132).

Davis (2003) emphasized that inquiry-based instruction promotes self-reflection which is a key element of metacognition (cited in Kipnis & Hofstein, 2008). On the other hand, according to Schraw and Hartley (2006) not all inquiry-based instruction is authentic, and only authentic inquiry supports metacognition and self-regulation since students are better able to monitor their learning and evaluate mistakes in their thinking or gaps in their conceptual understanding.

Thomas (2012) highlighted the importance of metacognition in science education and complained about its' remaining a fringe area. He thought that metacognition deserves increased attention in science education research.

2.2.1 Metacognition and Inquiry Based Approaches

There are some studies exploring inquiry approach and metacognition in the literature. In general, these studies investigated the effects of a kind of inquiry approaches on students' metacognition. For example, White and Frederiksen (1988) examined the effects of Thinker Tools Inquiry Curriculum which can be defined as computer enhanced inquiry activities with metacognitive support, on 7^{th}, 8^{th} and 9^{th} grade students' scientific inquiry expertise, physics knowledge and their attitudes about learning science. Their starting point was the rationale "students have difficulty with science, particularly physics, is not that they are too young or lack intelligence, but rather that they simply do not know how to construct conceptual models of scientific phenomena and how to monitor and reflect on their progress" (p.5). The study was implemented to 12 urban classes in two schools by three teachers and lasted 10.5 weeks. Data were collected through pre and post tests and also students' inquiry projects. Results showed that Thinker Tools Inquiry Curriculum led to substantial improvements in students' metacognitive and inquiry skills. Students' understanding of force and motion concept was also significantly affected. Besides, results indicated positive changes in students' attitudes and beliefs about learning and doing science.

After, Kipnis and Hofstein (2008) examined the potential of the inquiry laboratory for developing metacognitive skills among 11th and 12th grade chemistry students in urban and suburban academic high schools in Israel. In the study 15 inquiry-type experiments had implemented during 2 years. The data were collected through three sources that were: observation of students during the practical activity, interviews with the students, and the students' reflection essays. Based on the results they stated that inquiry laboratory activity offers students opportunities to practice their metacognition during the different phases of the inquiry-based experiment and further research is necessary for investigating the metacognitive aspect of inquiry-based activities.

2.2.2 Metacognition and SWH

In the literature it was stated that SWH approach positively affects students' metacognition. However, the statement was generally hypothetical because the researchers did not investigate these effects explicitly. On the other hand, Van Opstal (2014) investigated the effects of the SWH approach on undergraduate students' practice of metacognitive regulation skills. 62 students participated to the study. Majority of students were first year undergraduate students. 27 students became a part of experimental group and 35 students were in the comparison group. Acid base reactions, kinetics, solubility, and equilibrium concepts were covered in the study. The data about the students' perceptions of their use of metacognition was provided by self-report surveys and interviews. The findings of the interview revealed that students who experienced to the SWH approach, compared to non-SWH students, utilized metacognitive strategies to a greater degree and to a greater depth when solving open-ended laboratory problems. Students stated that the structure of the SWH approach and peer support impacted their metacognitive regulation strategy when solving open-ended lab problems.

2.3 Epistemological Beliefs

Hofer and Pintrich define epistemology is an area of philosophy interested in the nature and justification of human knowledge. The term had first used by Piaget in 1950 while describing his theory of intellectual development (Hofer & Pintrich, 1997). William Perry's work (1960s and 70s) students' interpretation of pluralistic educational experiences was approved the first step of psychological works on epistemological beliefs as cited by many research (Hofer & Pintrich, 1997; Schommer & Walker, 1997; Conley, Pintrich, Vekiri & Harrison, 2004). In his work, Perry interviewed generally with male students and discussed about their academic work also experiences related to their social life and extracurricular activities as they progressed through their undergraduate education. After considering students' responses, Perry and his colleagues outlined a scheme for students' intellectual and ethical development that included a sequence of nine positions. The nine positions have been clustered into four sequential categories: dualism, multiplicity, relativism and commitment with relativism (Hofer & Pintrich, 1997). Dualism has been characterized by a dualistic or absolutist that students suppose knowledge should be right- and-wrong and expect authorities know the truth and to transmit to the learner. Multiplicity includes the starting positions of the recognition of diversity and uncertainty. Individuals in this category believe that there are no absolute answers. The individuals at relativistic category suppose that knowledge as relative, contingent, and contextual and start to realize the need to choose and affirm one's own commitments. Commitment within relativism includes final positions; the individuals make and support commitments to values, careers, relationships, and personal identity (Hofer & Pintrich, 1997).

According to Hofer and Pintrich (1997) there were numerous limitations of Perry's work (1970) such as difficulty in generalization and the scheme's not being explicitly epistemological. However, Perry's work in which epistemologies defined as unidimensional developmental stages, has been followed by some researchers such as Belenky, Clinchy, Goldberg, and Traule (1986, examined women's ways of knowing); Baxter Magolda, (1987, developed the Epistemological Reflection Model and reported gender-related reasoning patterns across the ways of knowing); King and Kitchener (1994, studied the epistemic assumptions that underlie reasoning and proposed seven-stage, three level Reflective Judgment Model); Kuhn (1993, focused on argumentative reasoning and categorized the responses as absolutist, multiplist, and evaluatists) (as cited in Özkan, 2008).

Schommer (1990) defined epistemological beliefs from a multidimensional perspective, because capturing the complexity of personal epistemology and linking the personal epistemology and different aspects of learning may be failed by unidimensional perspective. She defined epistemological beliefs as a system of more or less independent beliefs and hypothesized five epistemological dimensions: certain knowledge (tentative or un-changing), simple knowledge (isolated or integrated), omniscient authority (authority or observation and reason), quick learning (quick or gradual), and innate ability (fixed at birth or lifelong improvement). Despite empirical evidence for these five factors, Hofer and Pintrich (1997) have discussed that quick learning and innate ability are not the dimensions of epistemology because these dimensions focus on the nature of learning not nature of knowledge. Hofer and Pintrich (1997) proposed a theoretical structure for personal epistemology construct. They suggested that two general areas which are beliefs about the nature of knowledge and the nature of knowing express the core structure of individuals' epistemological theories. Certainty of knowledge and simplicity of knowledge are the dimensions under nature of knowledge while source of knowledge and justification for knowing are the dimensions under the nature of knowing area.

Conley et al. (2004) investigated four dimensions of epistemological beliefs using Hofer and Pintrich's (1997) framework in fifth grade science classrooms: Source, certainty, development, and justification.

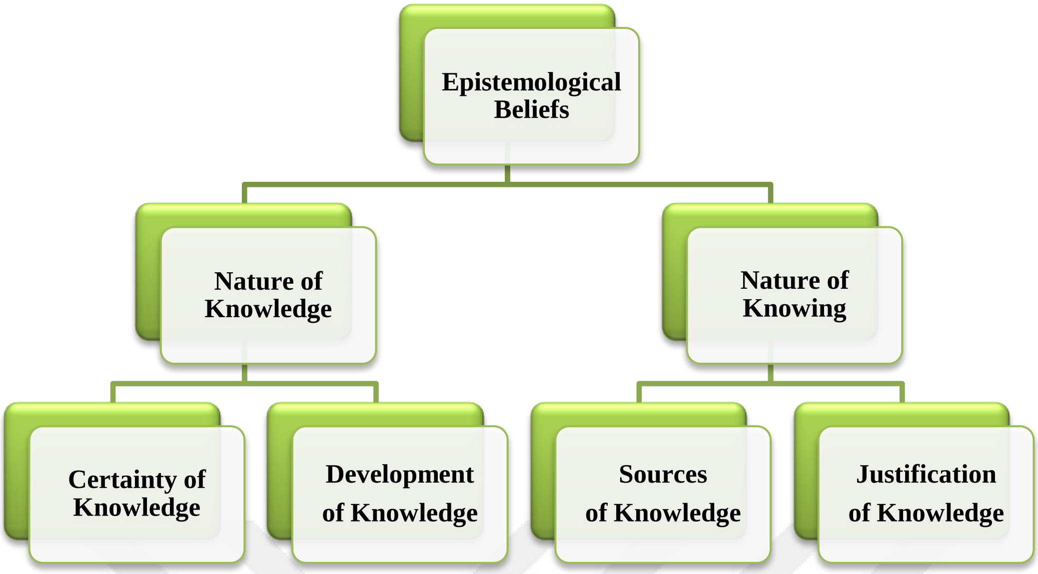


Figure 2.7 Theoretical structures of epistemological beliefs (Conley et al., 2004)

The source dimension is related with beliefs about knowledge residing in external authorities, the certainty dimension reflect beliefs in a single right answer, the justification dimension is concerned with the ways in which students use evidence and evaluate claims, and the beliefs in the evolving and changing nature of science are considered as the development dimension.

Conley et al. (2004) stated that explicit developmental research on epistemological belief generally has investigated over quite long periods of time and specific dimensions generally has not change in short periods. However they claimed that there may be developmental change on epistemological belief, especially in young students. They investigated 187 fifth grade students from 5 elementary schools. Hands on activities were conducted during nine-week in the chemical properties of substances unit. Results proved that young children’s epistemological beliefs about science changed over time especially in source dimension and certainty dimension. The difference is development and justification dimensions did not reach statistical significance. According to the researchers classroom talk during the implementation circled around procedural aspects of students' investigation and lack of from argumentation and reflection. The researchers explained that the absence of significant change along the justification and development dimensions may result from the absence of argumentation and reflection processes during the implementation. The effects of the different contextual and classroom factors on epistemological development were suggested for future research.

Özkal et al. (2009) developed a conceptual model indicating the relationships among constructivist learning environment perceptions, epistemological beliefs, and learning approaches. In the study surveys were administered to 1152 Turkish 8th grade students. The results of path analysis indicated that students' perceptions of constructivist learning environment affect learning approach directly and indirectly via their influence on scientific epistemological beliefs. Findings revealed that students who thought their learning environment as constructivist oriented believed that knowledge is evolving and subject to change. As a result in such learning environments students feel less dependent on external authorities that may lead to meaningful learning rather than rote learning.

Similarly, Kızılgüneş et al. (2009) modeled the relations among 6th grade Turkish students' epistemological beliefs, motivation, learning approach, and achievement. 1041 students with a mean age of 11.5 years from 11 public elementary schools were attended to the research. The data were collected through Classification Concept Things Test (CCT), Epistemological Beliefs Questionnaire (EBQ), Learning Approach Questionnaire (LAQ) and Achievement Motivation Questionnaire (AMQ). Results of the path analysis revealed that students who believed in development of knowledge and that source of knowledge do not have to be an authority, were more likely to be self-efficacious in their learning that leads higher levels of learning and goal orientations. On the other hand, students who believed that knowledge is accurate and true had a tendency to lower levels of learning and performance goal orientations.

2.3.1 Epistemological Beliefs and Inquiry Based Approaches

In the literature some studies investigated the effects of a kind of inquiry based approaches on students' epistemological beliefs. For example, Kaynar (2007) examined the effectiveness of 5E learning cycle which is a kind of inquiry based approaches, on 6th grade students' scientific epistemological beliefs. The study was conducted with 160 sixth graders in four intact classes. Two classes were randomly assigned as experimental group who received 5E learning cycle instruction and comparison group who received traditional instruction. The data were collected using Epistemological Belief Questionnaire (EBQ) and analyzed using multiple analyses of covariance (MANCOVA). The results indicated that 5E learning cycle had a statistically significant effect on 6th grade students' epistemological beliefs.

Likewise, Wu and Wu (2011) explored 5th grade students' epistemological views about their own experiences of scientific knowledge construction via inquiry based activities and investigated possible interactions between students' epistemological beliefs and their inquiry skills to make scientific explanations. The study was conducted with 68 fifth graders in two science classes at a public elementary school in Northern Taiwan. Students were implemented inquiry activities about force and motion concept during 5 weeks. In these activities, students investigated the effects of force, designed experiments to find the relationship between force and the length of a spring. Experimental data was collected and analyzed by students themselves and also they presented and shared their findings. In the study quantitative and qualitative data were collected from classroom video recordings, field notes, pre- and post-tests and semi-structured interview transcripts. Results of the study revealed that students developed better inquiry skills to construct scientific explanations and more students realized the probability of experimental errors, believed experimental data as evidence to support their claims, and had sophisticated understanding about the nature of scientific questions. Yet, the researchers reported that students' epistemological beliefs were still naïve and recommended explicit instruction about epistemological beliefs. According to them, students should have more opportunities to verbalize their epistemological views during inquiry activities.

CHAPTER III

METHOD

In this chapter, the analysis method for the present study was described. First, the design of the study was presented. This part followed by the population and sampling procedures, instruments, data collection procedure and data analysis. Finally, assumptions and limitations of the study were explained briefly.

3.1 Research Design

This study explored the effects of science writing heuristic (SWH) tasks on 8^{th} grade students' science achievement, metacognition and epistemological beliefs. For this purpose, a quasi-experimental research design was employed. In the experimental research, the researcher manipulates the independent variable and looks the effects of independent variable on one or more dependent variables. Differently, quasi-experimental research designs do not include the use of random assignment (Fraenkel & Wallen, 2006). According to Kenny (1975), all quasi-experimental designs ensure three prerequisites: "(a) There must be a treated and untreated group. (b)There must be pre-treatment and post-treatment measures, (c) There must be an explicit model that projects overtime the difference between the treated and untreated groups, given no treatment effect" (p.345). Specifically, the non-equivalent control group post-test only design was used with the aim to compare the experimental and the comparison groups mean difference with respect to dependent variables. To achieve this aim, quantitative descriptions of data were used. The research design of the study was displayed in Table 3.1.

Table 3.1 Research Design of the Study

Groups	Before Treatment	Treatment	After Treatment
EG	MAI, EBQ, SATEG	SWH	MAI, EBQ, SATEG,
CG	MAI, EBQ, SATEG	TI	MAI, EBQ, SATEG

In this table EG was represented the experimental group that treated with Science Writing Heuristic (SWH) approach. On the other hand, comparison group was symbolized as CG received teacher centered traditional instruction (TI). MAI was the Metacognition Awareness Inventory, EBQ was the Epistemological Belief Questionnaire and SATEG was the Science Achievement Test for Eight Graders. MAI, EBQ and SATEG were administered to both groups before and after the treatment.

3.2 Population and Sample

The target population of the study consists of all 8th grade public middle school students in Adana which is a city in Turkey. Since it is not easy to reach this target population, all 8th graders who study in a public school in Çukurova district of Adana was decided as accessible population which the researcher used to generalize the results. In Çukurova district, there were 22 public middle schools and these schools included nearly 5200 eight grade students. Among the accessible population, one public middle school was selected conveniently.

There were only two 8th grade classes in the selected school and science lessons were instructed by the same science teacher. One class was assigned as the experimental group and the other class was assigned randomly as the comparison group. There were 31 students (16 girls, 15 boys) in the experimental group while there were 29 students (13 girls, 16 boys) in the comparison group. Students' ages ranged from 13 to 15. Table 3.2 shows the demographic information of the participants.

Table 3.2 Students' characteristics

	Frequency	Percent (%)
Gender		
Girl	29	48.3
Boy	31	51.7
Last term "TEOG" science scores (National examination)		
20-39	1	1.7
40-59	7	11.7
60-79	29	48.3
80-100	23	38.3
Last term science grades		
20-39	1	1.7
40-59	7	11.7
60-79	29	48.3
80-100	23	38.3
Cumulative GPA		
40-54	5	8.3
55-69	15	25
70-84	18	30
85-100	22	36.7
Mother's education level		
Illiterate	2	3.3
Primary	8	13.3
Secondary	9	15
High school	23	38.3
University / Graduate	18	30
Mother's job		
Nonworking	34	56.7
Officer	12	20
Employee	6	10
Self-employment	1	1.6
Other	7	11.7
Father's education level		
Illiterate	2	3.3
Primary	12	20
Secondary	3	5
High school	24	40
University / Graduate	19	31.6

Table 3.2 (Cont'd)

	Frequency	**Percent (%)**
Father's job		
Nonworking	1	1.7
Officer	11	18.3
Employee	29	48.3
Self-employment	8	13.3
Other	11	18.3
Quantity of books at home		
0-10	6	10
11-25	12	20
26-100	21	35
101-200	13	21.7
200 +	8	13.3
Having a separate study room		
Have	48	80
Have not	12	20
The frequency of buying newspaper		
Never	7	11.7
Sometimes	35	58.3
Always	18	30

As seen from the table, 38 % of students got 80 or higher grades and 48 % of students' grades were in 60-80 points interval in the semester before the study. Their cumulative GPAs were generally higher than their science grades. 30 % of mothers and 31 % of fathers have college degree. 43 % of mothers and 98 % of fathers were working. 48 % of students had a study room in their home.

3.3 Variables

In the study there were two types of variables which were dependent and independent variables. "The dependent variable depends on what the independent variable does to it, how it affects it" (Fraenkel & Wallen, 2006, p.43). In this study, there were three dependent variables and one independent variable. The characteristics of all variables were shown in Table 3.3.

Table 3.3 Variables of the Study

Type of Variable	Name	Type of Value	Type of Scale
DV	MAI	Continuous	Interval
DV	EBQ	Continuous	Interval
DV	Achievement	Continuous	Interval
IV	Mode of Instruction	Categorical	Nominal

3.4 Instruments

The data, to explore the effects of SWH tasks on 8th grade students' achievement, metacognition, and epistemological beliefs were collected through Science Achievement Test for Eight Graders (SATEG), Turkish version of Metacognitive Awareness Inventory (MAI) (Sungur & Senler, 2009) and Turkish version of Epistemological Beliefs Questionnaire (EBQ) (Özkan, 2008). All instruments were administered by the researcher.

3.4.1 Science Achievement Test for Eight Graders (SATEG)

This instrument was used to assess eight graders' science achievement in four consecutive science units (Sound, Living Things & Energy, States of Matter & Heat and Electricity) which were taught in the second semester of the academic year 2013-2014.

SATEG was developed by the researcher taking into account the Bloom's revised taxonomy. In this study, New Taxonomy was preferred for categorizing educational objectives because Marzano and Kendall (2007) revised the taxonomy on the light of criticisms about it. One of the most common criticisms was that unidimensional, behaviorist model of it and it oversimplified the nature of thought and its relationship with learning. On the other hand, New Taxonomy was multidimensional and more constructivist in nature. The other criticism was the degrees of difficulty had been used as the basis of the differences between levels of Bloom's taxonomy. For example, evaluation activities were seen more difficult than other activities. However, even the most difficult mental processes can be learned (Anderson, 1995; LaBerge, 1995 cited in Marzano & Kendall, 2007). The New Taxonomy represented in Figure 3.1. As shown the cognitive system comprises four subsystems that have a hierarchic structure: retrieval, comprehension, analysis, and knowledge utilization.

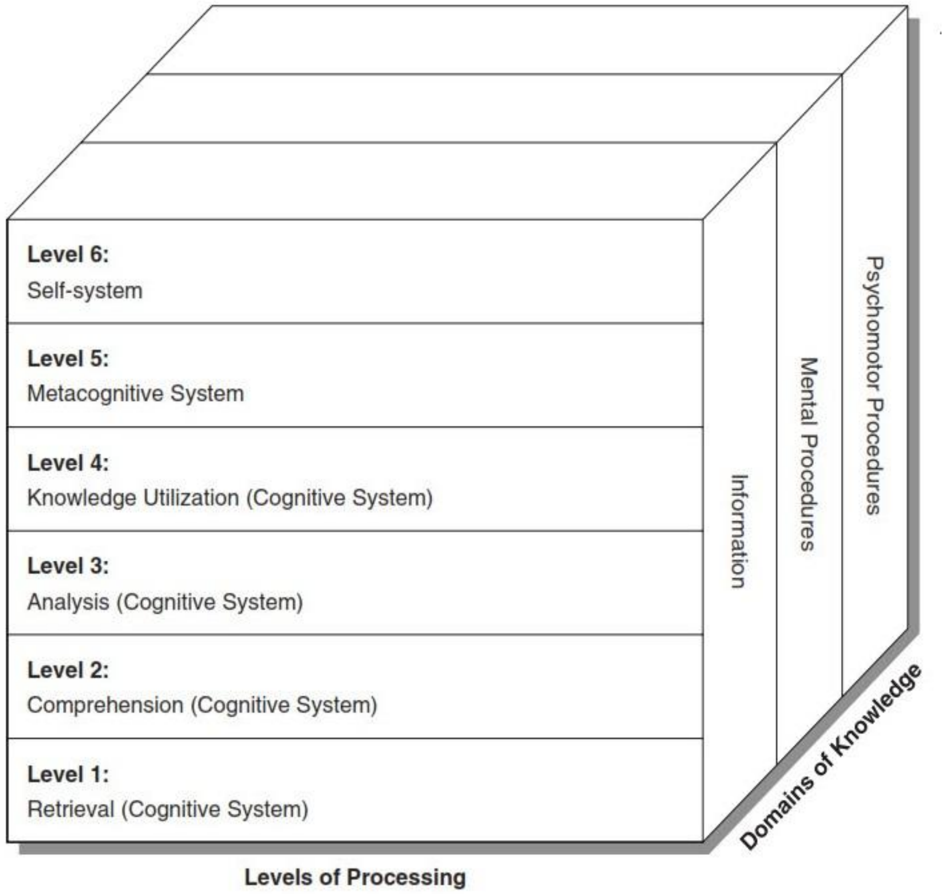


Figure 3.1 The New Taxonomy
Source: Marzano & Kendall (2007, p.2)

Retrieval refers transferring what we know but are currently not considering about to a present state of attention. Considering the degree of processing it can be separated as recognition or recall. Comprehension process is responsible for identifying the critical or defining attributes of knowledge and involves integrating and symbolizing processes. Analysis involves the construction of new information not already hold by the person. Matching, classifying, analyzing errors, generalizing and specifying are the five processes. Knowledge utilization is utilized when knowledge is used to carry out a specific task. Decision making, problem solving, experimenting and investigating are included. (pp. 16 – 20). The most important thing about the New Taxonomy is that specific terms or phrases do not have to refer a specific level. For example "assess" verb can be used in analyzing error (analysis) level but if students are familiar with concept then the objective can be assessed as lower level.

Most of the items in SATEG were "analysis" and "knowledge utilization" level which has operations like analyzing errors, experimenting, problem solving and decision making that are very important skills in laboratory applications. During question development process, the objectives of the four units in the 2006 science and technology curriculum were considered. Then 8 multiple choice questions with four alternatives (one correct answer and three distracters) for every unit were established. The researcher benefited from national examinations of the last 10 years and some international studies like PISA and TIMSS. The prepared 32 questions were examined by two professors and two research assistants in the field of science education and 10-year-experienced science teacher also examined the questions to establish content validity and appropriateness of student level. A pilot test was conducted for item distractor analysis and reliability.

3.4.1.1 Pilot Study for SATEG

Sound, Living Things & Energy, States of Matter & Heat and Electricity were taught in the second semester of the academic year 2013-2014. However, pilot study done in the first semester. The concepts in the SATEG had not known by the 8th graders, so the pilot study was done with 9th grade students who had already learned the concepts.

According to Nunnally (1967) sample size for item analysis can be 5 times as many subjects as items. There were 32 items, so to measure item difficulty and discrimination index 150 examinees were needed. The SATEG was administered to 155 ninth grade students from four different schools in Çukurova district. The items with a discrimination parameter greater than the minimum point biserial value, which is 2 standard errors above ".00" (.00 + 2 σp) where $\sigma_p = \frac{1}{\sqrt{N-1}}$, was retained in the test (Crocker & Algina, 1986). Distracters of two questions had higher point biserial value than the correct answers, so these two items were omitted. The final form of SATEG with 30 questions was presented in appendix-E. Also the reliability coefficient was found .87 for the final form of SATEG, demonstrates a good reliability (Pallant, 2007).

Table 3.4 Table of Specification of SATEG

Contents	Cognitive Process				Total
	Retrieval	Comprehension	Analysis	Knowledge of utilization	
Sound	-	-	6	2	8
Living Things and Energy	1	1	4	2	8
States of Matter and Heat	1	1	4	2	8
Electricity	1	-	2	5	8
Total	3	2	16	11	32

3.4.2 Metacognitive Awareness Inventory (MAI)

It is a 52-item, self-report questionnaire developed by Schraw and Dennison (1994) to assess university students' metacognition and the questionnaire requires students' responses to the items in a five point likert scale (5 = strongly agree to 1 = strongly disagree). It consists of two scales: the knowledge of cognition scale and the regulation of cognition scale.

The knowledge of cognition scale assesses students' knowledge about themselves as learners and their knowledge about strategies, also the situations in which to use those strategies. In detail, this scale comprises three subscales: declarative knowledge (8 items), procedural knowledge (4 items), and conditional knowledge (5 items). Declarative knowledge is about students' awareness of their skills, abilities, strengths, and weaknesses (e.g., ‘‘I understand my intellectual strengths and weaknesses’’). On the other hand, procedural knowledge concerns about different learning strategies and procedures that students can utilize in their learning (e.g., ‘‘I find myself using helpful learning strategies automatically’’). Variously, conditional knowledge is related to knowledge about when and why to use those strategies and procedures (e.g., ‘‘I use my intellectual strengths to compensate for my weaknesses”; Schraw & Dennison, 1994; Schraw & Moshman, 1995).

The regulation of cognition scale that involves five subscales assesses students' proficiency of planning (7 items), information management (10 items), monitoring (7 items), debugging (5 items) and evaluating (6 items) their own learning. Planning comprises goal setting, choosing of suitable strategies and time scheduling before learning (e.g., ‘‘I pace myself while learning in order to have enough time’’). Information management is related to students' consciousness of their skills and strategies that used to process information effectively (e.g., ‘‘I slow down when I encounter important information’’). Monitoring is associated with on-line evaluation of students' own learning or strategy use (e.g., ‘‘I ask myself periodically if I am meeting my goals”). Debugging concerns the correction of performance errors or understanding (e.g., ‘‘I re-evaluate my assumptions when I get confused”). Finally, evaluating refers to examination of performance and strategy effectiveness (e.g., ‘‘I ask myself how well I accomplished my goals once I'm finished”; Schraw & Dennison, 1994; Schraw & Moshman, 1995).

MAI was translated and adapted Turkish by Sungur and Senler (2009) for high school students (Appendix C). Since it was originally developed for university students, a pilot study was done prior to the study for its use with eight grade students.

3.4.2.1 Pilot Study of MAI

MAI was initially pilot tested with 200 eight grade students from four middle schools in the Çukurova district. Then, confirmatory factor analysis (CFA) reliability analysis and were employed.

Confirmatory Factor Analysis (CFA) of MAI

In order to validate factor structure of MAI for its use with 8^{th} grade students, confirmatory factor analysis was conducted using LISREL 8.8. CFA is a powerful technique, utilized to test whether measures of a construct are consistent with an identified and delimited model or theoretical framework (Brown, 2006).
The overall model fit was assessed using the fit indices of χ^2, χ^2/df, RMSEA (Root Mean Square Error of Approximation), NFI (Normed Fit Index), CFI (Comparative Fit Index) and NNFI (Non-Normed Fit Index). The Chi-square (χ^2= 1940.04, d*f* =1246), was not statistically significant (p=.00) which indicates good fit (Kline, 2011). The χ^2/df was calculated as 1.56 which is a good fit (Kline, 2011). RMSEA was .053, which shows a good fit (Hu & Bentler, 1999). The indices of NFI, and CFI were .91, .96 and .96 respectively, meaning a good fit (Sümer, 2000; Hu & Bentler, 1999; Kahn 2006). All of the fit values of the pilot study confirmed that the factor model of MAI had a good fit with the data from the LISREL output.

Table 3.5 Summary of fit indices

Fit Index	Cutoff Criteria	Fit Indices
χ^2	Not significant at p <.05 (good fit)	1940.04(d*f*=1246),p=.00
χ^2/df	< 3.0 (good fit), < 5.0 (acceptable fit)	1.56
RMSEA	<.03(excellent fit),<.06 (good fit)	.053
NFI	>.90 (good fit)	.91
CFI	>.90 (good fit)	.96
NNFI	>.90 (good fit)	.96

Reliability Analysis of MAI

Reliability analyses were utilized for each subscales and the total scale by calculating Cronbach alpha coefficient in SPSS Statistical Software Program 19. Since there were no negatively worded items, reliability analysis was directly conducted. According to Field (2005), in a reliable scale all items should correlate with total scale and so, item-total correlations values should be more than .3. Consistent with the situation all items except item 15 (.27) satisfied the condition. The value of alpha if item is deleted (for item 15) was not greater than the overall alpha, so there was no need to delete the item (Field, 2005).

According to Pallant (2007), Cronbach's alpha value between 0.6 – 0.7 shows acceptable reliability, 0.7 – 0.9 demonstrates good reliability, and 0.9 and higher represents excellent internal consistency. The scale overall produced a Cronbach alpha coefficient of .951 which is an excellent level of internal consistency. Concerning the internal consistency of the subscales, the Cronbach's alpha coefficients were found to be adequate to conduct further analyses for all of the subscales, specifically, declarative knowledge (α = .74), procedural knowledge (α = .75), conditional knowledge (α = .72), planning (α = .72), information management (α = .78), monitoring (α = .79), debugging (α = .63), evaluating (α = .68). Likewise, Sungur and Senler (2009) reported them as (α = .79), (α = .71), (α = .71), (α = .79), (α = .79), (α = .74), (α = .60) and (α = .75) respectively.

Table 3.6 Reliability of each subscale in MAI

Names of Subscales	Cronbach Alpha	Number of items
Declarative knowledge	.74	8
Procedural knowledge	.75	4
Conditional knowledge	.72	5
Planning	.72	7
Information management	.78	10
Monitoring	.79	7
Debugging	.63	5
Evaluating	.68	6
Overall	.95	52

3.4.3 Epistemological Beliefs Questionnaire (EBQ)

Epistemological Beliefs Questionnaire developed by Conley et al. (2004) was utilized in order to gather information about the eighth graders' epistemological beliefs (Appendix D). It is a 26-item Likert type agreement scale ranging from 1(strongly disagree) to 5 (strongly agree). The developers stated four dimensions which are Source, Certainty, Development and Justification. According to them the source and justification dimensions reflect "nature of knowing" related belief. Source (5 items) is concerned with 'knowledge residing in external authorities' (e.g., "Whatever the teacher says in science class is true") while justification (9 items) is related with 'the role of experiments and how individuals justify knowledge' (e.g., "Good answers are based on evidence from many different experiments"). Certainty and development dimensions reveal beliefs about the "nature of knowledge".

Certainty dimension (6 items) measures 'a belief about right answer' (e.g., "All questions in science have one right answer"). On the other hand, development dimension (6 items) evaluates beliefs about science as an evolving and varying subject (e.g., "Sometimes scientists change their minds about what is true in science").

EBQ was translated and adapted into Turkish by Özkan (2008). Turkish version of EBQ is conceptually different from the Conley et al.'s (2004) model. Source and certainty dimensions are merged into a single factor. Therefore, Turkish version of EBQ has three dimensions. Two items (item 2 and item 7) had found to have negative item-total correlation so they excluded from the analysis. Özkan (2008) had studied with 7th graders and found the total reliability of the scale as .76. Cronbach alpha coefficients for the three factor model of EBQ presented in Table 3.7 both for Özkan's study and the current study.

Table 3.7 Reliability of each subscale in EBQ

Names of Subscales	Number of items	Cronbach Alpha of Özkan's study	Cronbach Alpha of the current study
Justification	9	.77	.69
Source & Certainty	9	.70	.90
Development	6	.59	.68
Overall	24	.76	.89

3.5 Procedure

Firstly, the permission for administration of instruments was obtained both from Research Center for Applied Ethics at Middle East Technical University (Appendix A) and the Ministry of Education (Appendix B). Then, all of the schools included for the study were visited by the researcher and schools' administrators were informed about the purpose of the study. Necessary permissions from administrators, teachers, and students were received. Moreover, parents' of the treatment group's permission were obtained due to ethical concerns.

Pilot studies for scales were completed in January 2014. Main study started in the last week of February 2014 with pretests and completed in mid June. It lasted 15 weeks. First week was allocated for pretests and training about SWH to the students. Last week was assigned to posttests. Pre and posttests were applied in the classroom settings and lasted approximately two consecutive class hours.

This study was carried out over a thirteen-week period. The implementation was administered by the researcher for both groups because the teacher had no idea about the SWH approach. Still, the teacher was introduced the approach and explained the importance of the study and also detailed information about the study was given to get assistance from the teacher. By this way, implementation threat for internal validity was minimized. The researcher had regular meetings with the teacher in every week during the treatment. The objectives, activities and procedures were discussed in these meetings. The teacher participated in all class sessions for both groups with the researcher to observe and control the students.

3.6 Treatment

Although the topics were the same for the two groups, there were some differences in implementation between the experimental and the comparison group. Topics in the comparison group were instructed with traditional instruction by using traditional laboratory activities; on the other hand, experimental group was instructed by using SWH approach which includes series of student-centered activities. Four consecutive science units which are sound, living things and energy, states of matter and heat and electricity were included to the implementations. Two concepts were identified for each unit. Table 3.8 indicated the study plan regarding treatment group and comparison group.

Table 3.8 Study plan

Weeks	Activities/Implemented concepts in the experimental group	Activities/Implemented concepts in the comparison group
1	Pre-tests Presentation about SWH approach Mystery activity	Pre-tests
2-3	Properties of sound	Properties of sound
4	Dispersion of sound	Dispersion of sound
5-6	Heat transfer and changes in temperature	Heat transfer and changes in temperature
7-8	Boiling and melting points	Boiling and melting points
9-10	Photosynthesis	Photosynthesis
11	Respiration	Respiration
12-13	Magnetic effect of electric current	Magnetic effect of electric current
14	Heating effect of electric current	Heating effect of electric current
15	Post-tests	Post-tests

In the experimental group, researcher utilized writing, reading, small group and classroom discussion activities to provide students for meaningful learning. All units were planned around a big idea which is the beginning point for the unit and rest of the process flows from that (Hand et al., 2009). Big idea is the focus point that the students are wanted to reach (Hasançebi, 2014). Pre-laboratory activities which included inquiry were planned to assess students' prior knowledge and lead students to the big idea. Students were encouraged to investigate their own questions regarding big idea and benefitted from scientific methods during investigations. Students were also encouraged to use their own language to present their findings.

On the other hand, in the comparison group textbook which was recommended by MONE was followed. The concepts were taught by researcher using teacher-centered activities such as questioning, reading and note taking. Also traditional laboratory practices (hands-on activities) were applied. During laboratory practices all task aspects were externally controlled; researcher explained the procedures of the experiment step by step. Students followed the procedures; they made experiment and observed the results. They also completed a report which included purposes, procedures, observations and results.

The objectives of the comparison group were directly taken from the curriculum of MONE (2006). Due to its nature, SWH approach had different objectives. For example, students would be able to generate an explanation for reasons, provide justifications for what they believe in and evaluate alternative explanations and reasons.

Interventions were carried out in the classroom and laboratory settings according to the convenience of the laboratory. It was especially considered that the same topic was implemented in the same place in both groups. However, the place was enriched with materials such as supplementary books and internet in the experimental group. Because of the fact that students had to conduct investigations to complete the SWH approach. The books about the topics prepared by The Scientific and Technological Research Council of Turkey were placed in a research corner. Students in the experimental group were encouraged to consult these sources during their negotiations. On the other hand, students in the comparison group were encouraged to ask questions about unclear parts of the topics to the researcher.

Table 3.9 Comparison of the SWH student template and traditional laboratory format

SWH Student Template	Traditional Laboratory Format
1. Beginning Questions—What are my questions?	1. Title, purpose
2. Tests—What do I do?	2. Outline of procedure
3. Observations—What can I see?	3. Data and observations
4. Claims—What can I claim?	4. Discussion
5. Evidence—How do I know? Why am I making these claims?	5. Balanced equations, calculations,graphs
6. How do my ideas compare with other ideas?	
7. How have my ideas changed?	

Table 3.8 indicated that equal time was given to the groups for the implementation of the concepts. As can be seen from the Table 3.10 and 3.12 some experiments were similarly done in the groups. However, the students' and instructor's roles and scope of discussions were completely different during process (see Table 3.9).

Implementation processes were described briefly via sample activity for both groups in the following titles.

3.6.1 Experimental group

Table 3.10 demonstrated the general overview of the SWH approach implementations.

Table 3.10 General Overview of SWH Implementation

Unit	Big Idea	Content	Pre-laboratory activities conducted by researcher	Example of students' questions
	Your claims should be depend on evidence that you can collect by observing. How something appears is always a matter of perspective.	Question, claim and evidence	Mystery Activity	- Can too much anxiety and paranoia cause heart attack? - What are the symptoms of the death from poisoning?
Sound	Sound is the result of vibrations in molecules. The characteristics of sounds that we hear depends the properties of vibrations.	Properties of sound	Non-newtonian fluid on a speaker cone demonstration	-Is there any relationship between vibration and deepness of sound? -Can we change the deepness of sound by changing the amount of matter?
		Dispersion of sound	-Tin can phone experiment -Discussion about ecological bricks	- Does the sound disperse faster if we use thicker cable in tin can phone experiment? - Does the buzz of a fly disperse more in hot weather? -Can we increase or decrease the dispersion of sound?

Table 3.10 (cont.'d)

Unit	Big Idea	Content	Pre-laboratory activities conducted by researcher	Example of students' questions
States of Matter and Heat	Heat transfer between matters causes the changes in temperature and /or the states of matter.	Heat transfer and changes in temperature	Water density: hot and cold water demonstration	-Whether 50 ^{0}C water or 50 ^{0}C oil increase the temperature of 0 ^{0}C water most? -Does the mass of matter change with heating? -Does the temperature of hot water change if one drop of cold water is added into it?
		Boiling and melting points	Instant freezing video	-Do the tap water and pure water boil in the same temperature? -Can we melt the ice cube under 0 ^{0}C? -Does the amount of matter affect the melting / boiling point?
Living Things and Energy	All living things need energy to survive.	Photosynthesis	Discussion about the death of fish in plantless aquarium	-Can plants perform photosynthesis under artificial light? -CO_2 makes the water acidic. What will be if we put an aquatic plant to acidic environment? -Does the temperature affect photosynthesis?
		Respiration	- Bromothymol blue demonstration - Discussion about a plant and a fly in covered test tubes	-Do germinating seeds respire? -Do the plants respire in light? -Do the plants respire more in the night (dark)?

Table 3.10 (cont.'d)

Unit	Big Idea	Content	Pre-laboratory activities conducted by researcher	Example of students' questions
Electricity	Electric current cause magnetic and heating effects.	Magnetic effect of electric current	Discussion about electromagnetic crane video	-How does the electromagnetic force change by changing number of loops? -Can we increase the electromagnetic force by using different types of metal wire? - How does the electromagnetic force change by changing voltage of battery?
		Heating effect of electric current	Discussion about kettle	- How does the produced heat change with the time when current passes through the conductor? - Is there a relationship between resistance of the conductor and produced heat?

At the beginning of the treatment, students were introduced the SWH approach via presentation in which argument, claim and evidence terms were explained. Question development process was expressed with samples of researchable and non-researchable questions. Also SWH report format (see Appendix-G) was represented and detailed information about what students would do was given through the report. Then students were introduced SWH approach by using mystery activity (Burke et al., 2005, p. 39) (Appendix F).

The activity was not about their prior science knowledge; it was about the connections between question, claim and evidence which are so important concept in argumentation. In the activity students formed their own groups and they were required to read a story about the scenario of Mr. Xavier's mystery death. In their groups, they were asked to suggest beginning questions, how did Mr. Xavier die? Students discussed about the mystery death. Nearly all groups spoke out different claims but similar claims were grouped and written to the board, along with supporting evidence. For example the first claim was: "*Window has broken by storm. Mr. Xavier thought that somebody would kill him. He started to be afraid of being killed. He dropped the knife and the glass which was full of red vine. The glass was broken and the vine poured to the carpet. Then he had a heart attack. He fell down to broken glass. This is why there were laceration wounds in the dead body."* The supported evidences were as follows:

$E_{1:}$ *There was a terrible storm. The window has broken from the outside.*
$E_{2:}$ *He was paranoid.*
$E_{3:}$ *There was an open bottle of red wine so there must be a glass of wine somewhere.*
$E_{4:}$ *The knife with blood can be the result of the steak had cooked rare.*

The second claim was: "*The fired servants killed Mr. Xavier just for revenge. They shattered the window and came into the home. They hurt Mr. Xavier with broken glass. He died because of lacking blood.* The supported evidences were as follows:

$E_{1:}$ *The window has been smashed open from the outside.*

E_2: *The body has laceration wound and there is red stain under the dead body.*

The third claim was: "*The chef got bored with cooking same meal everyday and poisoned Mr. Xavier. The chef set up the scene for not being a suspicious for this murder.*" The supported evidences were as follows:

E_1: *Mr. Xavier could not finish his meal.*
E_2: *When a person poisoned, he cannot move his muscles. For this reason Mr. Xavier's dead body lied face down.*

Students were encouraged to ask clarifying questions about the claims and evidences or refute something about the arguments. Students were also let to use internet with the guidance of the researcher to investigate detailed information about paranoia and poisoning. Students were expended to defend their claims. They were asked to evaluate their own ideas with others. Some students revised or completely changed their claims after the discussions. After all these tasks were completed, the researcher summarized what they did. It was highlighted that how something appears is always a matter of perspective. New perspectives or information can change the ideas not only for us but also for scientists. With this activity students conceptualized the process of argumentation and they made connection between question, claim, and evidence.

After students gained experience about how to use SWH approach, topics started to handle using it. Students were required to look at the topics before coming to the lessons. The researcher initiated pre-laboratory discussions with an interesting video, demonstrations or a question from daily life considering the big idea of the topic (Table 3.10). For example, photosynthesis concept was studied under the living things and energy unit. The process was tried to explain via the teacher template.

1) Exploration of pre-instruction understanding:

The big idea of the unit was determined as "all living things need energy to survive" and it was written on the center of the board and a concept map was constructed with students. Since students read the topic before coming to class, they had fundamental knowledge about it. All things were written to board regardless of whether or not they were true.

2) <u>Pre-laboratory activities:</u>

Since the big idea was intended that students would leave the classroom with this idea at the end of the unit. For this purpose discussion about the death of the fish in plantless aquarium was made as a pre-laboratory activity. The photo of the plantless closed aquarium was indicated and the question "*The fish was feed properly and the temperature of water was suitable for the fish. What can be the reason of the death?*" was asked. The question was discussed and students reach consensus with the idea that lack of oxygen cause the death. If there was a plant in the aquarium, the fish would be alive because plant conduct photosynthesis and produce oxygen. Then students were asked to form six groups. Students decided their own groups and gave funny names to their groups. During pre-laboratory activities, concept map was extended with the students' responses but they were not evaluated. By this way students' prior knowledge was elicited and also students were led to think about the big idea and pose researchable questions for their investigation. Some groups had difficulty. The researcher encouraged them to decide their research question. Then all groups wrote their beginning questions on the board and these questions were discussed whether they were researchable and related with the big idea or not. For example a group decided to investigate the question: "*Why do leaves of some plants change color in autumn?*" Since the question cannot be answered by doing a laboratory experiment, it was adjusted as: "*Do the yellow leaves perform photosynthesis?*" In addition, dependent and independent variables, the materials which students would use during investigation and procedures that they are planning to follow were asked to the groups. Table 3.11 indicated the research questions proposed by the students.

Table 3.11 Research questions proposed by students

Group no	Research question	Independent variable	Dependent variable
1	Does the temperature affect photosynthesis rate?	Temperature	Photosynthesis rate
2	Can plants perform photosynthesis under artificial light?	Artificial light	Photosynthesis performance
3	Does the amount of produced O_2 increase with increasing amount of CO_2?	Amount of CO_2	Amount of produced O_2
4	CO_2 makes the water acidic. What will be if we put an aquatic plant to acidic environment?	Acidic environment	State of the aquatic plant
5	Do the germinating seeds conduct photosynthesis?	Germinating seeds	Performance of photosynthesis
6	Do the yellow leaves perform photosynthesis?	Yellow leaves	Performance of photosynthesis

3) <u>Participation in laboratory activity:</u>

After the research questions were decided by the students, each group made their investigations, discussions and started to fill out the SWH lab reports (Appendix G). The researcher moved among student groups to keep learners on task and ask guiding questions. For instance, students were familiar to elodea set-up that was shown in textbooks. One group investigated photosynthesis under artificial light by avoiding elodea set-up from sunlight and putting it under a white light as in Figure 3.2.

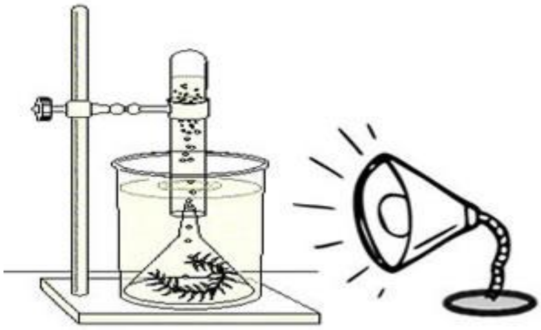


Figure 3.2 Elodea set-ups for photosynthesis under artificial light

However, the students in the group could not decide whether the elodea photosynthesizes or not. They understood what they would do after the following dialog with the researcher. $S_{1,}$ $S_{2,}$ S_3 were represented the students and R was represented the researcher.

S_1: *How do we know whether the elodea photosynthesizes or not?*

R: *What have you observed?*

S_1: *The amount of bubbles increased when we turn on the light.*

R: *So there were bubbles before the implementation.*

S_1: *Yes, we could rarely see them but now the frequency increased.*

S_2: *Maybe the plant was influenced by the light in the room.*

S_1: *I guess the test tube is full of oxygen.*

R: *Maybe, how can we be sure that the bubbles are comprised from oxygen not from carbon dioxide?*

S_3: *Can we understand by smelling?*

R: *I do not know is there a noticeable variation between their odor. But you can think about the characteristics of oxygen.*

S_2: *I think we can put the test tube a fly. If it will not die we can understand that the gas is oxygen.*

R: *It can be a good idea. Still you can use oxygen as burner. You can close the tube to a candle. If it flashes then you can think that there is oxygen in the tube.*

After the group followed the procedure and realized that the gas was oxygen mean that photosynthesis can occur under the artificial light. At this point researcher asked: *You said that plant may be influenced by the light in the room. What is your evidence for this claim?*

S_2: *We observed bubbles before we turn on our light.*
R: *Can you claim in numerical value?*
S_3: *If we observe again, we can count the number of bubbles given of in 1 minute.*
R: *How can you express this situation? Has your lamp more power than the room's?*
S_2: *This lamp is closer to the plant.*
R: *So you said the distance is an important factor for photosynthesis.*
S_1: *Intensity of light may be an important factor.*

4) <u>Negotiation phase I- writing personal meanings:</u>

When the investigations were completed by all groups students were asked to answer the 3rd (What did I find?), 4th (What inferences can I make?) and 5th (How do I know?) questions on their SWH reports (student template).

5) <u>Negotiation phase II-sharing and comparing science ideas:</u>

Students are explained that each group would make a presentation about their findings. So students were asked to make peer discussion then, a poster to present it. Students made presentations about their claims and evidences. At this point both the researcher and the other students asked some questions about their presentation. By this way, a discussion environment in the classroom was initiated. Sometimes students refuted the presenter group's claims with their evidences, sometimes complemented their deficiencies and sometimes students changed their own claims. For instance, the group who investigated photosynthesis under artificial light claimed that sunlight is not an obligatory option for photosynthesis. Moreover, they claimed that street lighting may cause plants' performing photosynthesis at night. By this way, more oxygen emission may be supplied. Some students made counterclaim by emphasizing that night lighting affects plants' cycles and developmental process. Besides night lighting causes the tree to shed its leaves.

6) <u>Negotiation phase III- comparing science ideas to textbooks or other sources:</u>

Actually this phase may overlap with negotiation phase II. Students were asked to answer the 6th question (How do my ideas compare with those of other?) on their report.

7) <u>Negotiation phase IV- individual reflection and writing:</u>
In this phase, students were wanted to write a paragraph about the 7th question in the template (How have my ideas changed?). During these negotiations, students were let to loop back the process. They could revise their experiment, interpretations or consult science books whenever they want. It does not mean that the instructor should simply let students what they want. The key point is that instructors "should actively guide students to help them to understand what they are doing, why they are doing it, and to develop conceptual understanding" (Burke et al., 2005, p. 11).

8) <u>Exploration of post instruction understanding through concept mapping:</u>

After the students completed their SWH reports, the students expressed what they had learned from the process through concept mapping. Again the big idea was written on the center of the board and a concept map was constructed as a class. For instance, photosynthesis topic was concluded that some factors including temperature, pH, acidity, CO_2 concentration and light intensity affect the photosynthesis rate. It was also explained that seeds do not photosynthesize before germination, yellow leaves perform photosynthesis in very slow rate. All living things need energy to survive. Photosynthesis transfers light energy into organic molecules. So it is very important reaction for life. Concept mapping help the researcher summarize the concept. In this way, the topic was connected with the big idea of the unit.

To sum up, students completed the SWH reports via their research question. Each group investigated their own questions. Students negotiated meaning during their group work and whole class discussions. When students made mistakes during experimentation or changed their claim, it was emphasized that scientists do as well. For each class session, the students followed the same approach for different units during 13 weeks.

A sample report was shown in Figure 3.3. Since the students filled the reports in Turkish, the sample report was translated.

Name / Class: **Date:**

Big idea: All living things need energy to survive.

What are my questions:

Does the temperature affect photosynthesis rate?

Variables:
Independent variable: Temperature
Dependent variable: Photosynthesis rate

Why do I ask this question?
We know that fish prefer to live in cold water. I wonder is it because of the fact that aquatic plants do more photosynthesis in cold water.

What do I do?

Three elodea setups were prepared using water at different temperatures (10 ^{o}C, 25 ^{o}C and 60 ^{o}C). Except temperature all conditions were controlled. We counted and recorded bubbles rising from elodea.

Observation:

No bubble was observed with the cold water setup (10 ^{o}C). I counted 30 bubbles in a minute with the 25 ^{o}C water-setup and 10 bubbles in a minute with the 60 ^{o}C water-setup.

What can I claim?

Temperature affects the photosynthesis rate.

How do I know? Why am I making these claims?

Photosynthesis rate decreased in hot water and photosynthesis stopped in cold water.

How do my ideas compare with other ideas?

One of my partners observed that bubbles increased when the temperature of

water decreased from 60 ^{o}C. We considered our teacher's advice and repeated the experiment using 40 ^{o}C degrees water. Then we counted 60 bubbles in a minute. After the group discussion, we decided that photosynthesis rate increases with increasing temperature until a specific degree.

What did I learn from other sources?

Oxygen is solved more in cold water that's why there is more oxygen in it. Photosynthesis stops under 0 ^{o}C temperature. The temperature, in which maximum photosynthesis rate occurs, is called optimum temperature and changes according to features of the plants. The enzymes that carry out photosynthesis do not work efficiently at low and high temperatures. After a specific temperature which also changes according to features of the plants, enzymes lose their shape and functionality and photosynthesis rate declines rapidly. For example desert-adapted plants can photosynthesize even 80 ^{o}C. Cold water plants also can adapt to the environments and photosynthesize less than 10 ^{o}C.

Carbon dioxide concentration, light density, wavelength of light also affect photosynthesis rate.

How have my ideas changed?

My ideas changed because other sources have much more knowledge than I have.

Figure 3.3 Sample report of SWH approach

3.6.2 Comparison group

Table 3.12 demonstrated the general overview of the traditional laboratory implementations.

Table 3.12 General Overview of Traditional Laboratory Implementation

Unit	Content	Purpose of the laboratory activities	Materials
Sound	Properties of sound	Observing the relationship between frequency (vibration) and deepness of sound	-Diapason -Bottle -Water
	Dispersion of sound	Demonstrating that sound disperse more in a dense environments	Air vacuum Pump
States of Matter and Heat	Heat transfer and changes in temperature	Observing that the heat flows from hot to cold until the temperatures become same	-Beaker -Erlenmeyer flask -Thermometer -Water -Chronometer -Heater
	Boiling and melting points	Observing the effects of substance addition to pure water on boiling and melting points	- Beaker -Thermometer -Salt - Heater
Living Things and Energy	Photosynthesis	Observing the effects of light and CO_2 on photosynthesis	-Elodea - Beaker -Test tube -Funnel -Sodium bicarbonate -Lamp -Candle
	Respiration	- Observing the germinating seeds respiration -Discussing the plants' respiration in light	-Erlenmeyer flask -Rubber stopper -U-shaped tube -Germinating seeds -Lime water

Table 3.12 (cont.'d)

Unit	Content	Purpose of the laboratory activities	Materials
Electricity	Magnetic effect of electric current	-Observing the magnetic effect of a coil carrying current - Observing the electromagnetic force by changing voltage of battery	-Coil -Nail png -Battery -Pins -Cable
	Heating effect of electric current	Observing the heat by current passes through a conductor	Thermometer -Copper wire -Battery - Beaker

Each concept was taught by teacher centered approaches such as lecturing and questioning. For example, when photosynthesis concept was taught, researcher explained the followings: At the base of an ecosystem, primary producers actively transfer light energy into stored chemical energy. Photosynthesis is the process of converting light energy, water and carbon dioxide into carbohydrates and oxygen. In this way, energy flows from sun to primary producers. This flow of energy is transported through the animals by food chain. Also majority of living things use oxygen for respiration. So photosynthesis is crucially important in the maintenance of life on Earth. During this process the researcher asked questions such as "*Why is photosynthesis so important to the survival of all?*" "*What are the elements used in photosynthesis?"* Students' answers were listened and the feedbacks were given. After this lecturing part completed, a hands on laboratory application was done. Students were grouped into six and reports were distributed to them. A sample report was shown in Figure 3.4. Since the students filled the reports in Turkish, the sample report was translated.

After experimentation, students wrote their reports (Appendix H) in which purposes, procedures, observations and results were stated. When all students completed their work, the researcher summarized what and why they have done and asked whether there is any unclear part or not. For each class session, a similar method was used during 13 weeks.

Name / Class: **Date:**
Concept: Living Things and Energy

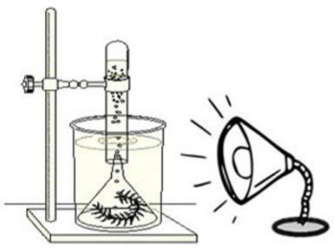
Title of the Experiment: Photosynthesis

Purpose of the Experiment: Observing the effects of light on phoyosynthesis

Materials: Elodea, beaker, test tube, funnel, sodium bicarbonate, lamp and candle

Procedure:

1- Get a beaker (250 mL) and add water up to half of it.
2- Add a pinch of sodium bicarbonate powder to the beaker and stir. Sodium bicarbonate supplies CO_2 to the water.
3- Take some liquid from the mixture to a test tube.
4- Put elodea into the funnel and insert them into the beaker.
5- Reverse the test tube which is filled with liquid on the funnel.
6- Repeat same procedure for same second setup.
7- Place one of the setups to dark.
8- Place the other setup to a 40 watt lamp 5 cm from the plant.
9- Count and record the number of bubbles rising from the elodea.



Observation: I counted 25 bubbles in a minute with the first setup however no bubbles was observed with the second setup.

Result: Plants need light and CO_2 to make photosynthesis.

Figure 3.4 Sample report of traditional approach

3.7 Analyses of Data

The data were analyzed using both descriptive and inferential statistics. In order to compare the two variables; MAI and EBQ, for the experimental and the comparison group multivariate analysis of variance (MANOVA) was conducted. These variables were analyzed separately because the variables have sub-dimensions. All the sub-dimensions were taken as dependent variables. MANOVA is an extension of analysis of variance when there is more than one dependent variable (Fraenkel & Wallen, 2006). To compare achievement between groups independent samples t-test was conducted.

3.8 Internal Validity Threats

Fraenkel and Wallen (2006) stated that "internal validity means observed differences on the dependent variable are directly related to the independent variable and not due to some other unintended variable" (p. 169). Possible internal validity threats and the ways to control them were discussed in this section.

Subject Characteristics: Differences in groups may arise from selection of subject. Using random assignment is the best way to cope with this threat. However, in this study, school was selected conveniently and the classrooms was assigned randomly as experimental and comparison group. Pre-tests were done to check whether there was a statistical difference between groups and no significant mean difference was found between the two groups regarding SATEG, MAI, and EBQ and scores before the treatment.

Loss of Subjects: This threat occurs if some subjects drop out of the study for some reason such as illness, family relocation or the requirements of other activities. In this study, not even one subject dropped out of the study.

Location: Location threat occurs if the data collection or intervention carried out in different conditions. In this study, similar classrooms and same laboratory was used. But the classroom in which experimental group worked, enriched with the supplementary books and internet access due to its nature of SWH approach.

Instrumentation: Instrumentation threats refer instrument decay, data collector characteristics, and data collector bias. Instrument decay occurs if the nature of the instrument or scoring procedure is the changed in some way. In the current study, three instruments (SATEG, MAI and EBQ) which have standardized scoring procedure were used. Thus, instrument decay did not a potential threat for this study. Data collector characteristics such as gender and age may also affect the results of the study. In this study, this threat was eliminated because all data were collected by the researcher who treated equally to all students. Data collector bias is the distortion of the data in order to make certain outcomes. This threat was controlled by standardizing all data collection procedure for both groups.

Testing: The use of pretests may create a "practice effect" that can affect the results or affect the way subjects respond to the intervention. In the current study, the treatment period was long enough (thirteen-week) to reduce the pretest effect on posttest. Also, since the same pretests were administered to both the experimental and the comparison group, it was assumed that the pretests affected both groups equally.

History: During the implementation of the study, one or more unanticipated and unplanned events may occur and this may affect the results of the study. In this study, implementation was done by the researcher, any unexpected events were not observed.

Maturation: This threat may be grounded in the change in subjects over time. The subjects of the study were eight graders who are adolescents and the study lasted thirteen weeks. It was assumed that both groups were affected maturation threat equally.

Attitude of Subjects: This threat may occur due to three reasons: Firstly, the subjects in the experimental group may improve their performance due to novelty of the treatment. Secondly, subjects in the comparison group may improve their performance due to novel circumstances. Lastly, subjects in the comparison group may demoralize and perform poorly since they think that they are given no treatment. In this study, subjects in the experimental group were aware of the new instruction and they were communicating with their friends in the comparison group about this issue. During laboratory practices in the comparison group, some examples were given from the other class. For example "*When this experiment was done in the other class, thermometer had broken. Please be careful while using it*." In this way the effect of demoralization threat was minimized.

Regression: If a group is selected because of its unusually high or low performance, this threat emerges. In this study, no regression threat was foreseen.

3.9 Assumptions of the Study

1. The instruments utilized in this study were proper enough to assess the intended purpose.

2. Students in the comparison group were not interacting with the students in the experimental group.

3. The students took the tests independent from each other without any interaction during the implementation of the tests.

4. Self-report questionnaires were used so it was assumed that the participants responded the items of the scales honestly and seriously.

5. The researcher was not biased to any group.

6. All group members took equal responsibilities during laboratory practices.

7. Students were not affected by out-of-school learning.

8. All the variables which were not controlled affect both groups equally.

3.10 Limitations of the Study

1. The study was limited to the sound, living things & energy, states of matter & heat and electricity units.

2. The study was conducted with 60 eight grade students indicating a small proportion of the accessible population. Findings cannot be generalized.

3. The generalizability of this study was limited because of the convenience sampling technique.

4. Students' attitude toward science can change as a result of the implementations. This situation can affect the results.

5. Only self-report questionnaires used to investigate students' achievement, metacognition and epistemological beliefs.

CHAPTER IV

RESULTS

The results were presented in two sections. In the first section, descriptive statistics for Science Achievement Test for Eight Graders (SATEG), Metacognitive Awareness Inventory (MAI), and Epistemological Belief Questionnaire (EBQ) were displayed; in the second section, inferential statistics were expressed.

To compare science achievement between groups, independent samples t-test was conducted. MANOVA was conducted before and after the treatment to decide whether there was a statistically significant mean difference between the comparison and the experimental group with regard to metacognition and epistemological belief. Statistical analyses were performed at .05 significant level using SPSS Statistical Software Program 19.

4.1 Descriptive Statistics

Descriptive statistics for pre-test and post-test results were displayed in Table 4.1 and Table 4.2 respectively. Moreover, some example items of the students' responses for the scales were represented for pre-tests and post-tests.

4.1.1 Descriptive Statistics for Pre-tests

Table 4.1 indicated the descriptive statistics of pre-test scores. In this table, comparison group (N = 29) was denoted as CG and experimental group (N = 31) was denoted as EG.

Table 4.1 Descriptive statistics of pre-test scores

Scale	Dimensions	EG		CG		Skewness	Kurtosis
		Item mean	SD	Item mean	SD		
MAI	Declarative Knowledge	4.06	4.774	4.18	3.869	-.463	-.044
	Procedural Knowledge	3.79	3.503	3.94	2.488	-.263	-.891
	Conditional Knowledge	4.05	3.432	4.17	2.356	-.594	-.079
	Planning	3.72	4.942	3.66	5.368	-.407	-.139
	Information Management	3.77	7.681	3.80	5.244	-.304	-.467
	Monitoring	3.69	4.076	3.64	5.134	.009	-.717
	Debugging	4.09	3.482	4.07	3.165	-.369	-.843
	Evaluation	3.65	5.118	3.71	3.876	.165	-1.197
EBQ	Justification	3.77	3.600	3.81	3.493	-.417	-.643
	Source & certainty	2.43	6.580	2.44	6.573	-.023	-.883
	Development	3.45	2.534	3.44	2.692	-.233	-1.274
SATEG		0.32	2.301	0.36	3.270	.696	-.492

According to George and Mallery (2001), skewness and kurtosis values between +2 and -2 are approved normally distributed. Table 4.1 revealed that all skewness and kurtosis values for pre-SATEG, pre-MAI, and pre-EBQ regarding experimental and comparison groups were found between +2 and -2. Histograms with normal curve for the dimensions of pre-MAI in terms of groups (Appendix I) illustrated that although clustering of the pre-MAI scores was similar for groups; the mean values of the scores were close to each other for the experimental and comparison groups. The mean values were above the mid-point of the 5-point Likert scale showed that participants of the study had reasonable knowledge about themselves as learners, control and awareness of their own learning processes. Moreover, Table 4.1 indicated that the students have more declarative and conditional knowledge and debugging strategies than other metacognitive strategies, especially planning, monitoring and evaluation strategies. Similarly, clustering of the scores and the mean values for pre-EBQ were close to each other for the experimental and comparison groups (Appendix I). It can be interpreted that the groups were similar in terms of pre-EBQ scores. The mean values (except source and certainty dimensions) were above the mid-point of the 5-point Likert scale revealed that participants of the study had moderate knowledge about the theories about the structure of knowledge and the nature of knowledge acquisition. The mean value of source and certainty dimension was lower than the mean of justification and development dimension. All the items in the source and certainty dimension were reverse worded.

Table 4.1 also showed that at the beginning of the study, the mean values of the pre-SATEG scores were low and close to each other for the experimental and comparison groups. The mean of questions answered correctly was 10.76 for the comparison group and 9.68 for the experimental group. There were 30 questions in the SATEG and maximum questions answered correctly were 16 for the experimental group and 18 for the comparison group. On the other hand one student from each group answered only 5 questions correctly. It can be interpreted that students have limited prior knowledge about the concepts. Moreover, when the students' responses analyzed deeply no clue was found that students were better at a specific concept.

Table 4.2 Descriptive statistics of post-test scores

Scale	Dimensions	EG		CG		Skewness	Kurtosis
		Item mean	SD	Item mean	SD		
MAI	Declarative Knowledge	4.54	2.438	4.05	3.649	-.360	-.867
	Procedural Knowledge	4.19	2.202	3.79	3.328	-.408	-.971
	Conditional Knowledge	4.37	2.146	4.04	2.932	-.250	-1.283
	Planning	4.30	2.642	3.70	4.992	-.743	-.255
	Information Management	4.43	3.400	3.80	6.563	-.604	-.755
	Monitoring	4.17	3.318	3.72	4.818	-.685	-.730
	Debugging	4.66	1.755	4.12	2.945	-.667	-.788
	Evaluation	4.26	2.850	3.77	4.679	-.409	-1.152
EBQ	Justification	4.26	3.458	3.84	3.719	-.169	-.582
	Source & certainty	3.33	6.038	2.98	6.142	-.003	-.615
	Development	3.86	2.141	3.45	2.551	-.273	-.309
SATEG		0.88	3.355	0.66	5.463	-.441	-1.299

4.1.2 Descriptive Statistics for Post-tests

Table 4.2 demonstrated the descriptive statistics of post-test scores. In this table, comparison group denoted as CG and experimental group denoted as EG. The table indicated that all skewness and kurtosis values for post-SATEG, post-MAI and post-EBQ regarding experimental and comparison groups were found between +2 and -2, approved that the scores were normally distributed (George & Mallery, 2001).

Histograms of post-SATEG (Appendix I) indicated that science achievement scores in the experimental group were spread out more on the left and the distribution was narrower than the comparison group. It can be interpreted as majority of students in the experimental group gave correct responses to the achievement test and the difference between high-achievers and low-achievers was decreased. The mean of questions answered correctly was 19.72 for the comparison group and 26.45 out of 30 for the experimental group. Only one student got 18 and two students got 19; however, five students responded all 30 questions correctly in the experimental group. Conversely, two students got 13, three students got 14 and only one student got 30 in the comparison group. As can be seen, the difference between high-achievers and low-achievers in the comparison group was bigger than the experimental group. When students' responses were analyzed deeply, it was seen that students in the comparison group made more mistakes in the questions that were on analysis and knowledge of utilization level. On the other hand, no pattern was found in the questions answered wrongly in the experimental group.

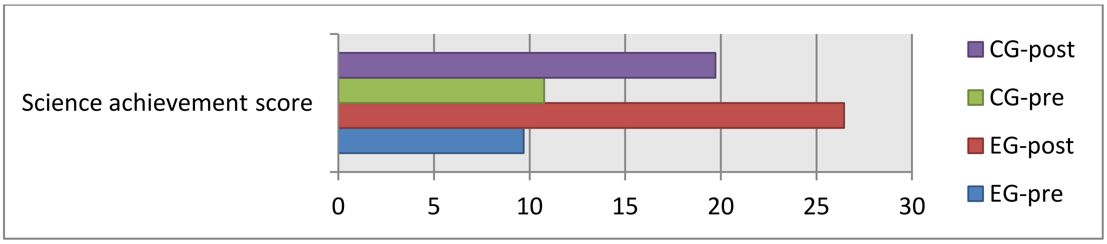


Figure 4.1 Pre – post mean comparison of SATEG regarding groups

Figure 4.1 indicated pre and post mean comparison of the SATEG. As can be seen from the figure, science achievement scores of groups were similar before the treatment. Since both groups learned, science achievement scores in the post-test increased. However the increase was bigger in the experimental group.

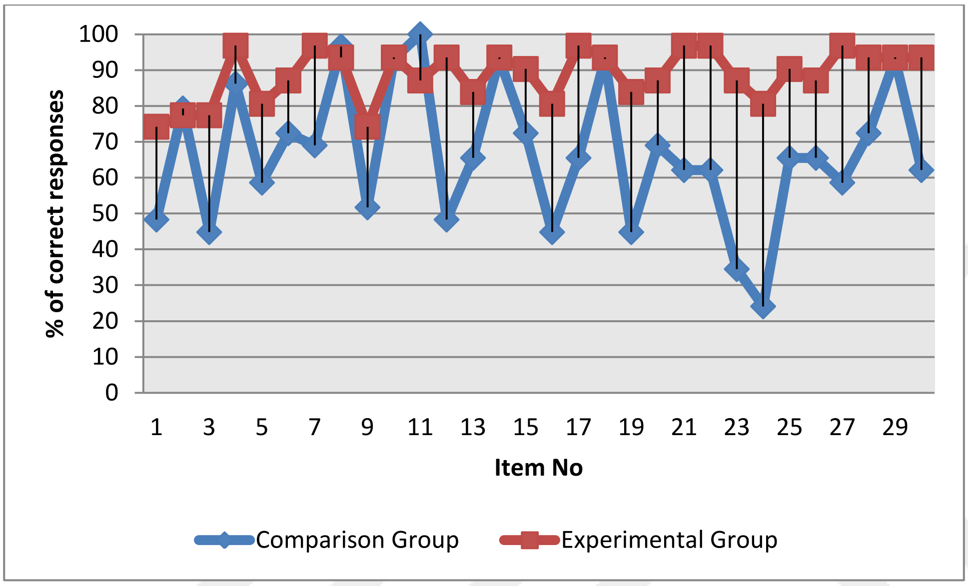


Figure 4.2 Comparison of the groups with respect to correct answers to the items of post-SATEG

When the Table 4.2 was compared with Table 4.1, it can be seen that all dimensions of EBQ and planning, monitoring, debugging and also evaluation dimensions of MAI were slightly increased for the comparison group in the post-tests; on the other hand, all values in the EBQ and MAI were considerably increased for the experimental group. The highest mean value was gotten from the debugging dimension of MAI for both groups. Also, debugging dimension was increased mostly for experimental group in the post-MAI. Declarative knowledge dimension of MAI followed the line as second highest mean value. Source and certainty dimension of EBQ was the lowest mean value not only in the pre-test but also in the post-test. Still there were .54 point and .90 point increments in the mean value for comparison group and experimental group respectively.

The frequencies of these values regarding the dimensions of EBQ and MAI were analyzed through histograms (Appendix I). The histograms of the dimensions of post-MAI and post-EBQ in terms of groups illustrated that the scores were widely distributed in the comparison group, whereas distribution was narrower in the experimental group. The width of distribution revealed the distance between minimum and maximum scores. It can be said that the difference between minimum and maximum scores were smaller in the experimental group. Moreover, debugging, planning and monitoring dimensions of post-MAI were spread out more on the left.

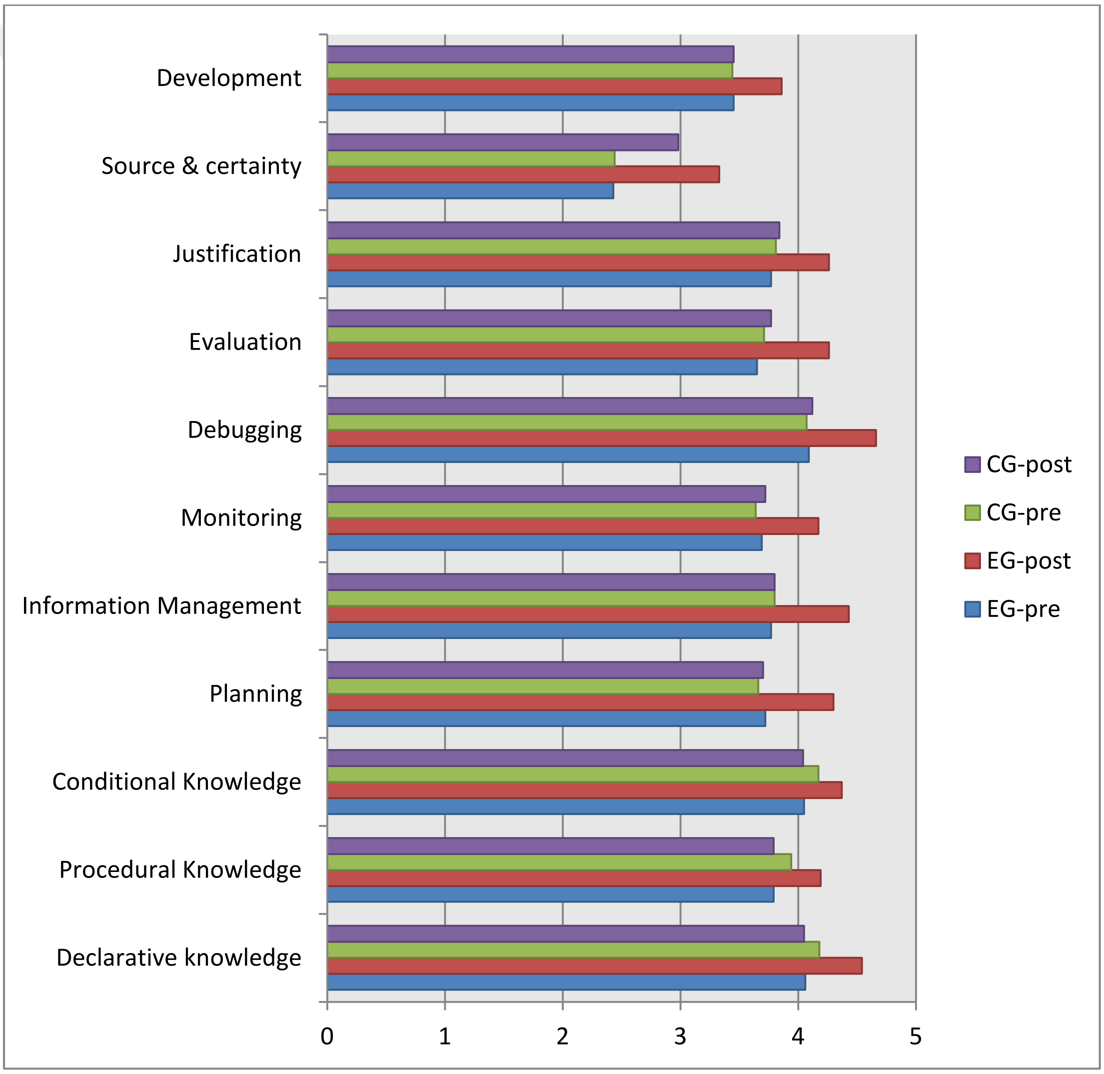


Figure 4.3 Pre – post mean comparisons of MAI and EBQ regarding groups

Figure 4.2 indicated pre – post mean comparisons of MAI and EBQ. As can be seen from the figure that there were no big difference between experimental and comparison group in the dimensions of pre MAI and EBQ. However, the improvement in the experimental group can be easily seen.

Table 4.3 and Table 4.4 showed the means of the items regarding the groups in the post-MAI and post-EBQ.

Tablo 4.3 Item means regarding the groups in post-MAI

Dimension	Item no	Item	Mean	
			CG	EG
Declarative knowledge	5	I understand my intellectual strengths and weaknesses.	4.26	4.77
	10	I know what kind of information is most important to learn.	3.90	4.58
	12	I am good at organizing information.	3.94	4.49
	16	I know what the teacher expects me to learn.	3.94	4.55
	17	I am good at remembering information.	4.00	4.16
	20	I have control over how well I learn.	4.23	4.52
	32	I am a good judge of how well I understand something.	3.81	4.46
	46	I learn more when I am interested in the topic.	4.30	4.77
Procedural knowledge	3	I try to use strategies that have worked in the past.	3.96	4.39
	14	I have a specific purpose for each strategy I use.	3.63	4.16
	27	I am aware of what strategies I use when I study.	3.84	4.10
	33	I find myself using helpful learning strategies automatically.	3.74	4.13
Conditional knowledge	15	I learn best when I know something about the topic.	4.32	4.61
	18	I use different learning strategies depending on the situation.	4.02	4.29
	26	I can motivate myself to learn when I need to.	3.90	4.35
	29	I use my intellectual strengths to compensate for my weaknesses.	4.16	4.52
	35	I know when each strategy I use will be most effective.	3.81	4.07

Table 4.3 (Cont'd)

Dimension	Item no	Item	Mean	
			CG	EG
Planning	4	I pace myself while learning in order to have enough time.	3.48	3.86
	6	I think about what I really need to learn before I begin a task.	3.72	4.51
	8	I set specific goals before I begin a task.	3.55	4.42
	22	I ask myself questions about the material before I begin.	3.28	4.52
	23	I think of several ways to solve a problem and choose the best one.	4.03	4.39
	42	I read instructions carefully before I begin a task.	4.27	4.23
	45	I organize my time to best accomplish my goals.	3.60	4.20
Information management	9	I slow down when I encounter important information.	3.90	4.20
	13	I consciously focus my attention on important information.	4.03	4.36
	30	I focus on the meaning and significance of new information.	4.00	4.39
	31	I create my own examples to make information more meaningful.	3.52	4.41
	37	I draw pictures or diagrams to help me understand while learning.	3.31	4.33
	39	I try to translate new information into my own words.	4.00	4.48
	41	I use the organizational structure of the text to help me learn.	3.76	4.51
	43	I ask myself if what I'm reading is related to what I already know.	4.00	4.74
	47	I try to break studying down into smaller steps.	3.93	4.29
	48	I focus on overall meaning rather than specifics.	3.55	4.61

Table 4.3 (Cont'd)

Dimension	Item no	Item	Mean	
			CG	EG
Monitoring	1	I ask myself periodically if I am meeting my goals.	3.84	4.15
	2	I consider several alternatives to a problem before I answer.	3.83	4.39
	11	I ask myself if I have considered all options when solving a problem.	3.65	4.33
	21	I periodically review to help me understand important relationships.	3.52	3.68
	28	I find myself analyzing the usefulness of strategies while I study.	3.84	4.20
	34	I find myself pausing regularly to check my comprehension.	3.71	4.22
	49	I ask myself questions about how well I am doing while I am learning something new.	3.68	4.19
Debugging	25	I ask others for help when I don't understand something.	3.94	4.84
	40	I change strategies when I fail to understand.	4.00	4.07
	44	I re-evaluate my assumptions when I get confused.	3.93	4.81
	51	I stop and go back over new information that is not clear.	4.30	4.75
	52	I stop and reread when I get confused.	4.45	4.83
Evaluation	7	I know how well I did once I finish a test.	4.41	4.10
	19	I ask myself if there was an easier way to do things after I finish a task.	3.38	3.68
	24	I summarize what I've learned after I finish.	3.58	4.32
	36	I ask myself how well I accomplished my goals once I'm finished.	3.69	4.61
	38	I ask myself if I have considered all options after I solve a problem.	3.69	4.52
	50	I ask myself if I learned as much as I could have once I finish a task.	3.84	4.32

Tablo 4.4 Item means regarding the groups in post-EBQ

Dimension	Item no	Item	Mean	
			CG	EG
Justification	3	Ideas about science experiments come from being curious and thinking about how things work.	4.10	4.24
	5	It is good to have an idea before you start an experiment.	3.03	3.45
	9	In science, there can be more than one way for scientists to test their ideas.	4.10	4.17
	11	Ideas in science can come from your own questions and experiments.	2.97	4.07
	14	One important part of science is doing experiments to come up with new ideas about how things work.	4.45	4.45
	18	It is good to try experiments more than once to make sure of your findings.	4.07	4.48
	22	Good ideas in science can come from anybody, not just from scientists.	3.07	4.45
	24	Good answers are based on evidence from many different experiments.	4.38	4.66
	26	A good way to know if something is true is to do an experiment.	4.35	4.35
Source and Certainty	1	Everybody has to believe what scientists say.	2.90	2.93
	6	In science, you have to believe what the science books say about stuff.	2.93	2.97
	10	Whatever the teacher says in science class is true.	2.97	3.14
	12	Scientists pretty much know everything about science; there is not much more to know.	3.41	3.45
	15	If you read something in a science book, you can be sure it's true.	2.76	2.86
	16	Scientific knowledge is always true.	2.80	4.00
	19	Only scientists know for sure what is true in science.	2.83	3.10
	20	Once scientists have a result from an experiment that is the only answer.	3.31	4.29
	23	Scientists always agree about what is true in science.	2.93	3.21

Table 4.4 (Cont'd)

Dimension	Item no	Item	Mean	
			CG	EG
Development	4	Some ideas in science today are different than what scientists used to think	3.48	3.76
	8	The ideas in science books sometimes change.	3.41	3.72
	13	There are some questions that even scientists cannot answer.	3.52	3.57
	17	Ideas in science sometimes change.	3.41	4.07
	21	New discoveries can change what scientists think is true.	3.45	4.00
	25	Sometimes scientists change their minds about what is true in science.	3.41	4.00

As mentioned before, all the mean values of post-tests for experimental group were greater than the mean values of the post-tests for comparison group. Whether the difference in post-test scores was significant or not was given in the inferential statistics part.

4.2 Inferential Statistics

In this section, first, preliminary analysis for the assumptions of t-test and MANOVA were done. Next, the results were presented.

4.2.1 Preliminary Analyses

Level of measurements, independence of observations, normal distribution and homogeneity of variance are the assumptions of independent samples t-test. Sample size, normality, independency of observations and homogeneity of variance-covariance matrix are the assumptions of MANOVA.

4.2.1.1 Assumptions of independent samples t-test

Level of measurements: Dependent variables, SATEG scores, are continuous.

Normal distribution: As can be seen from the Appendix I, histograms with normal curve for the pre-SATEG and post-SATEG scores in terms of groups showed the normal distribution. Moreover skewness and kurtosis values found between ± 2 as shown in Tables 4.1 and 4.2 so the normality assumptions was not violated.

Independency of observations: There is no practical way of this assumption. The researcher and the teacher warned the students about independent testing. It was assumed that the students took the tests independent from each other without any interaction during the implementation of the tests. The analysis was continued while being cautious about violation of independence.

Homogeneity of variance: To test this assumption, that the null hypothesis assumes no difference between the two group's variances (H_0: $\sigma_1^2 = \sigma_2^2$), the Levene's F Test for Equality of Variances was used.

Table 4.5 Levene's Test of Equality of Error Variances for SATEG

	F	Sig.
Pre-SATEG	2.603	.112
Post-SATEG	10.254	.002

As shown in Table 4.5, the *F* value for Levene's test of pre-SATEG was 2.603 with a Sig. (p) value of .112 ($p > .05$). The null hypothesis was retained and the assumption of homogeneity of variance was met for pre-SATEG. However, the *F* value of post-SATEG was 10.254 with a Sig. (p) value of .002 ($p < .05$). The null hypothesis was rejected and the assumption of homogeneity of variance was violated for post-SATEG. Therefore, alternative t-value which compensated for the fact that equal variances not assumed was interpreted for post-SATEG.

4.2.1.2 Assumptions of MANOVA

Sample size: The requirement about sample size shows having more cases in each cell than the number of dependent variables (Pallant, 2007) that was already met in this study.

Independent observations: It was assumed that the students took the test independent from each other without any interaction during the implementation of the test.

Normality: For this assumption, both univariate normality and multivariate normality were checked. Univariate normality was tested through histograms skewness and kurtosis values. As can be seen from the Appendix I histograms with normal curve for the pre-MAI, pre-EBQ, post-MAI and post-EBQ scores in terms of groups showed the normal distribution. Also skewness and kurtosis values found between ±2 as shown in

Tables 4.1 and 4.2 so the univariate normality assumption was not violated. To test for multivariate normality, Mahalanobis distances were calculated by using the Regression menu. Table 4.6 shows the max value for Mahalobis distance regarding pre and post MAI and EBQ.

Table 4.6 The Mahalobis Distance Regarding Pre and Post MAI and EBQ

Test	Max value for Mahalobis distance	Number of dependent variable	Critical value
Pre-MAI	24.14	8	26.13
Post-MAI	22.33		
Pre-EBQ	8.85	3	16.27
Post-EBQ	10.92		

If the maximum value for Mahalanobis distance was less than the critical value which is given according to the number of dependent variables (Pallant, 2007, p. 280), it can be assumed that there were no substantial multivariate outliers. There are eight dependent variables for MAI so the critical value is 26.13. Maximum values for Mahalanobis distance calculated as 24.14 and 22.33 which were less than the critical value. There are three dependent variables for EBQ and the critical value is 16.27. Maximum values for Mahalanobis distance calculated as 8.85 and 10.92 which were also less than the critical value. Thus the multivariate normality assumption was not violated.

Homogeneity of variance-covariance matrix: The assumption was checked through Box’s M Test of Equality of Covariance Matrices and Levene’s test which are both outputs of MANOVA.

Table 4.7 Box's Test of Equality of Covariance Matrices for the Dependent Variables of Pre-MAI, Post-MAI, Pre-EBQ, and Post-EBQ

	df1	df2	Box's M	*F*	Sig.
Pre-MAI	36	11210.164	57.672	1.365	.071
Post-MAI			59.433	1.406	.054
Pre-EBQ	6	24065.849	2.594	.408	.874
Post-EBQ			4.317	.679	.667

If Box's M Sig. value is larger than .001, the assumption has not been violated (Pallant, 2007, p.286). Since all the Sig. values in Table 4.7 > .001, Box's M Test result indicated that the covariance matrices of the dependent variables were equal across groups.

Table 4.8 Levene's Test of Equality of Error Variances for Dependent Variables

Dependent Variables	df1	df2	Pre/Post	*F*	Sig.
Declarative Knowledge	1	58	pre-MAI	1.820	.183
			post-MAI	4.111	.047
Procedural Knowledge	1	58	pre-MAI	1.610	.210
			post-MAI	12.953	.001
Conditional Knowledge	1	58	pre-MAI	.001	.971
			post-MAI	7.064	.010
Planning	1	58	pre-MAI	.051	.822
			post-MAI	19.483	.000
Information Management	1	58	pre-MAI	.173	.679
			post-MAI	20.071	.000
Monitoring	1	58	pre-MAI	.846	.362
			post-MAI	11.258	. 001
Debugging	1	58	pre-MAI	.314	.578
			post-MAI	15.712	.000
Evaluation	1	58	pre-MAI	3.613	.062
			post-MAI	19.688	.000
Justification	1	58	pre-EBQ	.149	.701
			post-EBQ	.052	.820
Source & certainty	1	58	pre-EBQ	.017	.895
			post-EBQ	.037	.849
Development	1	58	pre-EBQ	.490	.487
			post-EBQ	1.576	.214

Levene's test should be non-significant for all dependent variables if the assumption of homogeneity of variance has been met. Levene's test results are presented in Table 4.8 showed that this assumption was violated for $p < .05$ values in post-MAI. According to Tabachnick and Fidell (2007), once outliers are eliminated, homogeneity of variance is assessed with F_{max} in conjunction with sample-size ratios. If sample sizes are relatively equal an F_{max} as great as l0 is acceptable (p.86). F_{max} can be calculated with larger variance (1204.3) divided by smaller variance (557.4). Since $2.16 < 10$ F_{max} ratio is acceptable. Moreover, to avoid Type-I error more conservative α level can be set. For this situation, Bonferroni adjustment can be applied through dividing original alpha level of .05 by the number of dependent variables (Tabachnick & Fidell 2007, p.270). In post-MAI case, there were eight dependent variables to investigate; therefore, original alpha level of .05 was divided to eight, giving a new alpha level of .00625.

4.2.2 Analyses Results

In this section, pre-test and post-test results of SATEG, MAI, and EBQ were presented.

4.2.2.1 Pre-test Results

4.2.2.1.a Pre-SATEG Results

To determine whether there was a statistically significant mean difference between experimental and comparison groups with respect to science achievement in the units of sound, living things & energy, states of matter & heat and electricity, independent samples t-test was used. Table 4.9 demonstrated the pre-SATEG results.

Table 4.9 T-test Results for Pre-SATEG

		t	df	Sig. (2-tailed)	Mean difference	95 % Confidence interval of the difference	
						Lower	Upper
Science achievement score	Equal variances assumed	-1.489	58	.142	-1.081	-2.535	.372

An independent samples t-test was conducted to compare the science achievement scores for the experimental group and the comparison group before the treatment. There was no significant difference in scores for the experimental group (*M* = 9.68, *SD* = 2.30) and the comparison group, *M* = 10.76, *SD* = 3.27; *t* (58) = -1.49, *p* = .14 (two-tailed). The magnitude of the differences in the means (mean difference = 1.08, 95 % Cl: -2.54 to .37) was very small (eta squared = .03).

4.2.2.1.b Pre-MAI Results

To determine whether there was a statistically significant mean difference between experimental and comparison groups with respect to MAI scores before the treatment MANOVA was conducted. MAI has sub-dimensions which are declarative knowledge, procedural knowledge, conditional knowledge, planning, information management, monitoring, debugging, and evaluation. All these sub-dimensions were taken as dependent variables to conduct MANOVA. Results were displayed in Table 4.10.

Table 4.10 MANOVA Results of Pre-MAI for Treatment Groups

Effect	Wilks' Lambda	*F*	Hypothesis df	Error df	*P*	Partial η^2
Treatment	.87	.971	8.000	51.000	.469	.132

The findings indicated that before the treatment there was no statistically significant mean difference between the experimental and the comparison groups with respect to the collective dependent variables, Wilks' Λ= .87, F (8,51)= .97, p = .469; η^2 = .13.

4.2.2.1.c Pre-EBQ Results

To determine whether there was a statistically significant mean difference between experimental and comparison groups with respect to EBQ scores before the treatment MANOVA was conducted. EBQ has sub-dimensions which are justification, development and source & certainty. All these sub-dimensions were taken as dependent variables to conduct MANOVA. Results were displayed in Table 4.11.

Table 4.11 MANOVA results of pre-EBQ for treatment groups

Effect	Wilks' Lambda	F	Hypothesis df	Error df	*P*	Partial η^2
Treatment	.993	.125	3.000	56.000	.945	.007

The findings indicated that before the treatment there was statistically no significant mean difference between the experimental and the comparison groups with respect to the collective dependent variables, Wilks' Λ= .993, F (3,56)= .125, p = .945; η^2 = .007.

4.2.2.2 Post-test Results

4.2.2.2.a Post-SATEG Results

An independent-samples t-test was conducted to compare the science achievement scores after the treatment for the experimental group and the comparison group.

Table 4.12 T-test results for post-SATEG

		t	df	Sig. (2-tailed)	Mean differen ce	95 % Confidence interval of the difference	
						Lower	Upper
Science achievement score	Equal variances not assumed	5.701	45.91	.000	6.727	4.352	9.103

There was a statistically significant difference in scores for the experimental group (*M* = 26.45, *SD* = 3.36) and the comparison group, *M* = 19.72, *SD* = 5.46; *t* (45.9) = 5.70, *p* = .00 (two-tailed). The magnitude of the differences in the means (mean difference = 6.73, 95 % Cl: 4.35 to 9.10) was large (eta squared = .36).

4.2.2.2.b Post-MAI Results

Declarative knowledge, procedural knowledge, conditional knowledge, planning, information management, monitoring, debugging, and evaluation which are the sub-dimensions of MAI, were taken as dependent variables to conduct MANOVA. Results of post-MAI were displayed in Table 4.13.

Table 4.13 MANOVA results of post-MAI for treatment groups

Effect	Wilks' Lambda	F	Hypothesis df	Error df	*P*	Partial $\eta 2$
Treatment	.52	5.916	8.000	51.000	.000	.481

After the treatment, a significant mean difference between the experimental and the comparison groups with respect to collective dependent variables was found, *F* (8,51) = 5.92, *p* = .000 ; Wilks' Λ = .52, η^2 = .48. The multivariate based on Wilk's Λ was strong, 0.48, implying that the magnitude of the difference between the groups was not small. In order to determine whether the effect of treatment was significant on each dependent variable, Test of Between-Subjects Effects output box was interpreted.

When the results for the dependent variables were considered separately, the differences to reach statistical significance, using a Bonferonni adjusted alpha level of .00625 were declarative knowledge, (F (1,58) = 24.12, p = .000, η^2= .29); planning, (F (1,58) = 16.88, p = .000, η^2 =.23); information management, (F (1,58) = 22.37, p = .000, η^2= .28); monitoring, (F (1,58) = 8.48, p = .005, η^2= .13); debugging, (F (1,58) = 18.48, p = .000, η^2= .24) and evaluation, (F (1,58) =8.90, p = .004, η^2= .13). The eta squared values were obtained 29 %, 23 %, 28 %, 13 %, 24 % and 13 % respectively. Partial eta squared effect size statistics show the proportion of variance of the dependent variable that is explained by the independent variable (Pallant, 2007). That means treatment method, science writing heuristic, had large effect on declarative knowledge, planning, information management and debugging dimensions of metacognition while it had medium effect on monitoring and evaluation dimensions (Cohen, 1988). However, differences in procedural knowledge and conditional knowledge dimensions did not reach statistical significance.

Table 4.14 Test of Between-Subjects Effects of Post-MAI

Source	Dependent variables	Type III Sum of Squares	df	Mean Squares	*F*	Sig.	Partial Eta Squared	Observed Power
Treatment	Declarative Knowledge	229.185	1	229.185	24.115	.000	.294	.998
	Procedural Knowledge	38.443	1	38.443	4.894	.031	.078	.585
	Conditional Knowledge	39.898	1	39.898	6.107	.016	.095	.681
	Planning	264.054	1	264.054	16.879	.000	.225	.981
	Information Management	598.959	1	598.959	22.373	.000	.278	.996
	Monitoring	143.278	1	143.278	8.479	.005	.128	.817
	Debugging	106.785	1	106.785	18.476	.000	.242	.988
	Evaluation	131.471	1	131.471	8.901	.004	.133	.835

4.2.2.2.c Post-EBQ Results

Justification, source & certainty and development which are the sub-dimensions of EBQ, were taken as dependent variables to conduct MANOVA.

Table 4.15 MANOVA results of post-EBQ for treatment groups

Effect	Wilks' Lambda	F	Hypothesis df	Error df	*P*	Partial η^2
Treatment	.731	6.868	3.000	56.000	.001	.269

The findings indicated that after the treatment there was statistically significant mean difference between the experimental and the comparison groups with respect to the collective dependent variables, Wilks' Λ= .731, $F(3,56)$= 6.868, $p = .001$; $\eta^2 = .27$. In order to determine whether the effect of treatment was significant on each dependent variable, Test of Between-Subjects Effects output box was interpreted. Prior to the interpretation, Bonferonni adjustment was done to reduce the chance of a Type I error. Dividing the original alpha level of .05 by 3, new alpha level of .017 was obtained.

When the results for the dependent variables were considered separately, the differences to reach statistical significance, using a Bonferonni adjusted alpha level of .017 were justification and development. For justification, $F(1, 58) = 16.87$, $p = .000$, $\eta^2 = .23$. For development, $F(1, 58) = 16.18$, $p = .000$, $\eta^2 = .22$. The eta squared values; represented 23 % and 22 % of the variance in students' epistemological beliefs scores explained by treatment was considered a large effect (Cohen, 1988). However differences in source and certainty dimension did not reach statistical significance.

Table 4.16 Test of Between-Subjects Effects of Post-EBQ

Source	Dependent variables	Type III Sum of Squares	df	Mean Squares	*F*	Sig.	Partial Eta Squared	Observed Power
Treatment	Justification	216.968	1	216.968	16.868	.000	.225	.981
	Source&Certainty	144.724	1	144.724	3.904	.053	.063	.499
	Development	89.159	1	89.159	16.176	.000	.218	.977

CHAPTER V

DISCUSSION, IMPLICATIONS AND RECOMMENDATIONS

5.1 Discussion of the Results

The purpose of this study was to explore the effects of science writing heuristic approach on the 8^{th} grade students' achievement, metacognition and epistemological beliefs. In this study, pre-tests assessing students' metacognition, epistemological belief and science achievement in the four consecutive concepts which were sound, living things & energy, states of matter & heat and electricity were administered to the students in the experimental group and the comparison group to decide whether there was a statistical significant mean difference between the groups. Pre-test results revealed that there was no statistically significant mean difference between the two groups regarding SATEG, MAI and EBQ scores before the treatment. Since post-test only design was employed, post-tests' results were interpreted to understand the effects of SWH approach.

Post-SATEG results indicated that there was a statistically significant mean difference between the experimental and the comparison group in favor of the experimental group with large effect size (η^2 =.36) (Cohen, 1988). Post-MAI results indicated that there was a statistically significant mean difference between the experimental and the comparison group, in favor of the experimental group. The treatment method, the science writing heuristic approach, had large effect on declarative knowledge (η^2 =.29), planning (η^2 =.23), information management (η^2 =.28) and debugging (η^2 =.24) dimensions of metacognition while had medium effect on monitoring (η^2 =.13) and evaluation (η^2 =.13) dimensions (Cohen, 1988). Differences in procedural knowledge and conditional knowledge dimensions did not reach statistical significance.Post-EBQ results indicated that there was a statistically significant mean difference between the experimental and the comparison group, on the side of the experimental group. The treatment method had large effect on justification (η^2 =.23) and development (η^2 =.22) dimensions of students' epistemological belief (Cohen, 1988). Differences in source and certainty dimension did not reach statistical significance.

The effects of SWH approach on science achievement, metacognition and epistemological beliefs were explained separately.

5.1.1 The effects of SWH approach on students' science achievement

In SATEG there were 30 questions from sound, living things & energy, states of matter & heat and electricity concepts. Descriptive statistics results showed that mean of the science achievement score was 26.45 for the experimental group and 19.72 for the comparison group. Inferential statistics results revealed that SWH approach had large effect on students' science achievement. This result was consisted with the earlier researches that defended SWH approach has positive effects on students' science achievement (Greenbowe et al., 2007; Hohenshell & Hand, 2006; Günel et al., 2010; Günel et al., 2009; Kıngır et al., 2012; Poock et al., 2007).

Researchers have suggested that meaningful learning environments, in which learners are actively engaged in learning, relating new concepts to prior knowledge and utilizing their knowledge to explain experiences that they encounter as a main predictor of students' science achievement (Ausubel, 1963; Doğru-Atay & Tekkaya, 2008). The significant difference in the experimental group could be results of meaningful, nonthreatening and evaluative environment of SWH approach and students' constructing their own knowledge in this environment. During the treatment, the students were wanted to read the topic before coming to the lessons. Then brainstorming about the topic was done via teacher initiated questions and a concept map was constructed. By this way, students' prior knowledge was eliminated. Apart from that, Norton-Meier et al. (2008) stated that nonthreatening and evaluative environments were developed when students are given more time for thinking, debating, reasoning and questioning without judging their answers. Schoerning et al. (2015) stated that the less teacher voice contributes to the classroom, the more meaningful learning can occur. In the experimental group, the SWH approach provided students such environments.

Experimental group students were mentally and physically very active. Students were permitted to think and write about the personal meanings of their data which was generated during laboratory investigation and the students negotiated about their interpretation with their peers. Students in the experimental group were benefited a lot from peer negotiation. In addition, students were encouraged to investigate their own research questions. Investigating what they wonder, may positively affect their attitude. After their investigations, students consulted science books and they presented their findings utilizing their own language. In this process students stated their claims and evidences. Other students asked questions or stated their counter arguments. By this way a discussion environment was raised. For closure activities again a concept map was constructed. Chiou (2008) stated that concept mapping can help students to understand, integrate and clarify concepts so this situation enhances learning and achievement.

Furthermore, histograms indicated that science achievement scores in the experimental group were spread out more on the left and the distribution was narrower than the comparison group. It can be interpreted that the difference between high-achievers and low-achievers was smaller in the experimental group. Students' characteristics were investigated before the study and it was seen that both groups have disadvantaged students who were from low socio-economic background and low achievers. Also both groups have successful students. There was a huge difference between the students especially in academic achievement. Narrowing the achievement gaps was one of the important results of the present study. This result was coherent with the results reported by Akkuş et al. (2007) that compared the

SWH approach with traditional science approach regarding 7th to 11th grade students' science achievement level in the genetics, forces, classification and acid and bases concepts. They found that the SWH approach has significant advantages in closing the achievement gap. Chanlen (2013) reported similar results with his longitudinal study. He emphasized that disadvantaged students were benefited more from participating in the SWH classrooms. Likewise, Hasançebi and Günel (2013) reported the effectiveness of the SWH approach on 8th grade disadvantaged students' science achievement. SWH approach create a climate in which students from varying backgrounds and academic achievement level can actively engage and participate fully in the classroom community because SWH tasks consists a set of ordered activities that students can easily follow. The effects of SWH approach on students' metacognition explained in the following part.

5.1.1 The effects of SWH approach on students' metacognition

Post-MAI results revealed that SWH approach had large effect on declarative knowledge, planning, information management and debugging dimensions of metacognition while it had medium effect on monitoring and evaluation dimensions. These findings were not surprising as far as the nature of SWH approach was considered. Since the SWH approach provides opportunities for students to use metacognitive strategies (van Opstal & Daubenmire, 2014; Wallace & Hand, 2004; Choi, 2008; Akkuş et al., 2007). Many researchers agree that metacognitive knowledge and regulation of cognition skills can be improved through classroom instructional practices (Brown & Pressley, 1994; Schraw, 1998; Schraw, Crippen & Hartley, 2006; Kipnis & Hofstein, 2008; Hofstein, Kipnis & Kind, 2008).

Declarative knowledge includes knowledge about students' awareness of their skills, abilities, strengths and weaknesses. Students' judgment about their own understanding, their control about their learning, their awareness about teachers' expectation, their ability about organizing information and their decision about important information skills can be counted as metacognitive declarative knowledge.

Students who treated with the SWH approach have to use the abovementioned skills to complete the tasks. For example, the big idea which is the focus point that the students are wanted to reach, may be promoted students' awareness about teachers' expectation and selection of important knowledge. The mean of the item "I know what the teacher expects me to learn" was calculated as 4.55 in the experimental group, 3.94 in the comparison group. Moreover, construction of concept maps before and after the activities might have improved organizing information skills. Comparison group students did not find such opportunity and the mean of the related item was .55 point less than the experimental group's mean.

From a different point of view Kipnis and Hofstein (2008) expressed that while generating a beginning question and asking questions during inquiry-based activities, students revealed their thoughts about the questions that can be suggested by their own or their partners and expressed the metacognitive declarative knowledge. Together with these processes, students compared their ideas explicitly with other ideas during the SWH tasks. On the other hand, comparison group students did not find any opportunity to seek themselves about their abilities, strengths or weaknesses.

Although procedural knowledge and conditional knowledge dimensions of metacognition did not reach statistical significance in the post-MAI, the mean values of these dimensions for the SWH students were greater than before the treatment and also the comparison group students. Numerically .40 and .32 point increments occurred in the mean value of procedural knowledge and conditional knowledge in that order after the treatment. Procedural knowledge refers to knowing how to use strategies. Based on their research, Kipnis and Hofstein (2008) reported that students used procedural knowledge while choosing the starting questions and appropriate methods that lead to conclusions during performing experiments. On the other side, conditional knowledge refers to knowledge about when and why to use strategies and situations under which a specific strategy is the most efficient. For example, negotiation phases may lead students assess their strengths and weaknesses. By this way, students may utilize their intellectual strengths to compensate for their weaknesses.

The non-significant improvement in procedural knowledge and conditional knowledge can be expressed by the idea of Schraw and Moshman (1995). They emphasized that students routinely demonstrate and utilize procedural knowledge and conditional knowledge without being able to state that knowledge. Whitebread et al. (2009) expressed this situation with challenges in assessing metacognition. They argued that self-report methods, like rating scales or questionnaires that ask respondents to express their use of particular strategies, rely too heavily on verbal ability. In this situation, strategy and learning strategy words may not be understood exactly by students. On the other hand, early studies revealed that conditional knowledge is not only lately but also slowly develops (Schraw & Moshman, 1995; Schraw, 1998; Schraw et al., 2006).

When the mean values of regulation of cognition dimension were compared with pre-MAI scores, it was seen that planning, monitoring, debugging and evaluation dimensions were slightly increased for the comparison group whereas there was a statistically significant mean difference in the experimental group. These results showed similarities with the study conducted by van Opstal and Daubenmire (2015). They stated that weekly laboratory activities for both groups elicit qualitative differences in the degrees of use of the regulation strategies. As mentioned in the methodology part in detail, both groups did laboratory activities in the same concepts but the process was different for groups. Both groups conducted experiment, analyzed data, evaluated experiment and wrote report in general. Actually both group used regulation strategies such as planning, monitoring, evaluation. However Piaget's theory of regulation implies that using regulation strategies may not always be a conscious experience (Brown, 1987).

SWH approach provides students reflective prompting in this way regulation strategies that students used be a conscious experience (van Opstal, 2014). Reflective prompting encourages students to self-assess their knowledge and learning. For example, the question, “How do my ideas compare with other ideas?” was explicitly asked in the student template. This question may lead students to consider about others’ ideas and compare with their own ideas. By this way students may learn considering several alternatives or options (monitoring skills) during problem solving process. For example, a student’s SWH report about the effect of temperature on photosynthesis rate can explain this situation. The report indicated that students prepared a controlled experiment using water at 10^0C, 25^0C and 60^0C temperatures. Since enzymes did not work efficiently at high temperatures, the selected temperatures misled to students. However, a student in the group realized that when the temperature approached to 40^0C, the photosynthesis rate increased. The student reported that they set up the experimental design. Moreover, the sample can be expressed with debugging skills because the students re-evaluated their assumption. As can be seen, peer interaction is also a key concept in metacognitive awareness. Sandi-Urena et al. (2011) emphasized that peer interactions improved metacognitive awareness.

Moreover, the students were given limited time and expected to complete their experimentation, negotiation, investigation and filling in their SWH reports. This situation led students to use their time efficiently. The mean of the item, “I organize my time to best accomplish my goals”, was found 3.60 in the comparison group and 4.20 in the experimental group.

In the beginning of this section it was highlighted that considering the eta squared of the dimensions, SWH approach had medium effect on monitoring and evaluation dimensions which slowly develop (Schraw and Moshman, 1995). So, monitoring and evaluation dimensions may be affected by the longer period application of the SWH approach. The effects of SWH approach on students’ epistemological beliefs explained in the following part.

5.1.2 The effects of SWH approach on students' epistemological beliefs

Post-EBQ results indicated that science writing heuristic approach had large effect on justification and development dimensions of students' epistemological beliefs. Actually, it was also an expected result because inquiry-based learning approaches are considered effective for developing a sophisticated and informed view of science (NRC 2000). Since, inquiry is a question-driven learning process that permits students to formulate researchable questions, design informative investigations, collect and respect to evidence, and propose persuasive explanations (Wu & Wu, 2011). Engaging in inquiry practices lead students to be aware of the process of generating, testing, and revising scientific knowledge and the criteria of evaluating scientific claims. Therefore it is expected that inquiry-based approaches have positive effect on students' epistemological beliefs. Some earlier studies confirmed this expectation. For example Kaynar et al. (2009) found that sixth grade students who experienced 5E learning cycle, a kind of inquiry-based approach, showed a significant change in their epistemological beliefs.

Differences in the mean values of source and certainty dimension did not reach statistical significance. Similar results also cited in the literature. Wu and Wu (2011) explored the fifth graders epistemological views through inquiry activities. Their results indicated that students developed better inquiry skills to construct scientific explanations and more students recognized the probability of experimental errors, thought experimental data as evidence to support their claims, and had sophisticated understanding about the nature of scientific questions. However, the researchers reported that most students' epistemological beliefs were still naïve. In the same way, Caukin (2010) examined the effects of SWH approach on the secondary honors chemistry students' scientific epistemological view. Her analyses results revealed that students who treated with the SWH approach hold more constructivist epistemological view, however, the differences between the groups did not reach statistical significance.

Findings of the present study was consistent with the earlier studies in certain respects: Students realized that scientific knowledge or ideas can change, good ideas in science can come from anybody and there can be more than one way to test ideas. Students also noticed the importance of curiosity and repetition of experimentation. However, there was still unchanged part in students' epistemological beliefs. SWH approach did not only affect justification and development dimensions. On the contrary, from pre to post-EBQ the SWH students' item mean scores of source and certainty dimension increased by .90 points, nevertheless, did not reach statistical significance. The non-significant improvements in source and certainty dimension may be caused by comparing student generated ideas with science books or other authoritative sources during completing the negotiation phase III in the SWH approach. This process may lead students to think that the source of scientific knowledge is science books. Related item means confirmed that hypothesis. The mean of item 6, "In science, you have to believe what the science books say about stuff" calculated as 2.97 that indicated majority of experimental group students still believe this statement.

On the other hand, Sandoval (2005) expressed that students discriminate their epistemological ideas about their own inquiry and their point of view to professional science. Consequently, inquiry practices positively affect some aspects of students' epistemologies. Students' epistemology about professional science and scientific community may remain unchanged. According to Wu and Wu (2011) students should have more opportunities to verbalize their epistemological views during inquiry activities. Explicit instruction about students' epistemological beliefs may be necessary to complement unchanged part.

5.1.4 Limitation of the SWH approach

During the implementation of SWH approach some difficulties were observed. Sometimes students' research questions related the big idea of the topic were out of the curriculum objectives. Norton-Meier et al. (2008) suggested being flexible when planning a unit for SWH approach because sometimes curriculum objectives may not be the one that the students want to learn. Unfortunately, the Turkish education system is examination oriented. In order to attend universities or highly recognized high schools, students have to be prepared for high-stakes exams. Since the exams are normative in nature, following curriculum objectives gain importance. In the present study, students were convinced to change the questions. Moreover students had difficulty when constructing the research questions especially at the beginning of this treatment since students were used to be serviced everything that required to learn in the traditional learning environments. Except from these, classroom management can be uneasy. Nature of SWH approach promoted student-student interaction. It was observed that sometimes students got excited while debating and the voice volume increased. This situation can be seen problematic by traditional school administrators.

5.2 Implications

Turkish science curriculum has been redesigned in 2005 on the basis of constructivist approach. It was revised in 2013, the significance of inquiry-based approaches was emphasized and the importance of argumentation as an integral part of scientific inquiry was highlighted in this curriculum. However, teachers had difficulty when implementing inquiry-based approaches. Science writing heuristic approach consolidates inquiry with reading and writing to learn strategies and classroom discourse. Since it has a teacher template, it is easy to follow for teachers. For that reason the SWH approach can be a guide for teachers while implementing argument based inquiry approach.

This study indicated that science writing heuristic approach has significant effects on students' science achievements, metacognition and epistemological beliefs. Earlier studies revealed that it also affects conceptual understanding, critical thinking skills, nature of science views and attitude towards science. Therefore, teachers, textbook writers, curriculum developers and researchers should be informed about the importance and implementation of the SWH tasks. Activities based on question – claim – evidence should be developed more and textbooks should be revised considering this activities. Also laboratory settings should be enriched with materials such as supplementary books and internet access. Moreover, teachers should be trained with workshops included sample implementations and also pre-service teachers should be introduced with SWH approach.

Combination of previous research findings and findings of this study indicated that metacognition is inevitably important for being an independent learner. Therefore, metacognition is one of the important components of science education. Teachers should be aware of its importance for learning and should consider about how to develop it. The activities which include reflective prompting such as SWH approach can be implemented more frequently to develop students' metacognition.

Making all students scientifically literate is one of the major aims of science education. The nature of knowledge and knowing in other words epistemological beliefs should be improved for scientific literacy. Epistemological beliefs also enhance achievement. Hence, it should not be underestimated; conversely, teachers should consider about how to improve epistemological beliefs. For better development of epistemological beliefs, classroom discussions should focus more on the nature of scientific knowledge. An explicit classroom discourse about the nature of scientific knowledge can be implemented to the SWH templates.

5.3 Recommendations

For further studies, recommendations can be listed as following:

1. Similar research topics can be conducted with different grades, different schools, larger sample size and different science topics for the generalization of the findings.
2. Longitudinal studies can be conducted.

3. Further research can be carried out to examine the effects of implementation level of SWH approach.
4. Further studies can compare students' SWH reports with students' science achievement, metacognition and epistemological beliefs.
5. Further studies can investigate peer interactions during SWH tasks can be analyzed and its effect on students' achievement.
6. Further studies can investigate the effects of consulting authoritative sources on students' epistemological beliefs through interviews.
7. In further studies, video-recording methods can be used during SWH sessions and examined the discourse analyses.

REFERENCES

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*(14), 1745-1765.

Akyol, G., Sungur, S., & Tekkaya, C. (2010). The contribution of cognitive and metacognitive strategy use to students' science achievement. *Educational Research and Evaluation*, *16*(1), 1-21.

Anderson R. (2007). Inquiry as an organizing theme for science curricula. In: S. Abell & N. Lederman (Eds.), *Handbook of research on science education* (pp. 807-830). Mahwah, NJ: Lawrence Erlbaum Associates.

Ausubel, D. G. (1963). Cognitive structure and the facilitation of meaningful verbal learning 1. *Journal of Teacher Education*, *14*(2), 217-222.

Bangert-Drowns, R. L., Hurley, M. M., & Wilkinson, B. (2004). The effects of school-based writing-to-learn interventions on academic achievement: A meta-analysis. *Review of Educational Research*, *74*(1), 29-58.

Brown, A. (1987). Metacognition, executive control, self-regulation, and other more mysterious mechanisms. *Metacognition, Motivation, and Understanding*, 65-116.

Brown, R., & Pressley, M. (1994). Self-regulated reading and getting meaning from text: The transactional strategies instruction model and its ongoing validation. *Self-regulation of Learning and Performance: Issues and Educational Applications*, 155-179.

Brown, T.A. (2006). *Confirmatory Factor Analysis for Applied Research.* New York: Guilford Press.

Brown, T., Hand, B., Norton-Meier, L., Staker, J., & Bintz, J. (2009). *Negotiating Science: The Critical Role of Argument in Student Inquiry.* Heinemann.

Burke, K.A., Greenbowe, T.J., Hand, B.M. (2006). Implementing the science writing heuristic in the chemistry laboratory. *Journal of Chemical Education,*83(7), 1032-1038.

Carlsen, W. S. (2007). Language and science learning.In: S. Abell & N. Lederman (Eds.), *Handbook of research on science education* (pp. 57-74). Mahwah, NJ: Lawrence Erlbaum Associates.

Cavagnetto, A. R. (2010). Argument to foster scientific literacy a review of argument interventions in K–12 science contexts. *Review of Educational Research*, *80*(3), 336-37.

Caukin, N. S. (2010). *Science Writing Heuristic: A writing-to-learn strategy and its effect on students'science achievement, science self-efficacy, and scientific epistemological view.* Unpublished Doctoral dissertation, Tennessee State University.

Chanlen, N. (2013). *Longitudinal analysis of standardized test scores of students in the science writing heuristic approach.* Unpublished PhD Dissertation, Iowa State University, Ames.

Chiou, C. C. (2008). The effect of concept mapping on students' learning achievements and interests. *Innovations in Education and Teaching International*, *45*(4), 375-387.

Choi, A. (2008). *A study of student written argument using the science writing heuristic approach in inquiry-based freshman general chemistry laboratory classes.* Unpublished PhD Dissertation, Iowa State University, Ames.

Conley, A. M., Pintrich, P. R., Vekiri, I., & Harrison, D. (2004). Changes in epistemological beliefs in elementary science students. *Contemporary Educational Psychology*, *29*(2), 186-204.

Crocker, L, & Algina, J. (1986). *Introduction to classical and modern test theory.* Florida: Holt, Rinehart and Winston Inc.

Dogru-Atay, P., & Tekkaya, C. (2008). Promoting students' learning in genetics with the learning cycle. *The Journal of Experimental Education*, *76*(3), 259-280.

Emig, J. (1977). Writing as a mode of learning. *College Composition and Communication*, *28*(2), 122-128.

Field, A. (2005). *Discovering statistics: Using SPSS for windows*. London: SAGE Publications.

Flavell, J. H. (1976). Metacognitive aspects of problem solving. *The Nature of Intelligence*, *12*, 231-235.

Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of cognitive–developmental inquiry. *American Psychologist*, *34*(10), 906.

Ford, M. (2008). ‘Grasp of practice’ as a reasoning resource for inquiry and nature of science understanding. *Science & Education*, *17*(2-3), 147-177.

Fraenkel, J. R. & Wallen, N. E. (2006). *How to design and evaluate research in education.* New York: McGraw-Hill Inc.

Georghiades, P. (2004). From the general to the situated: three decades of metacognition. *International Journal of Science Education*, *26*(3), 365-383.

Graham, S., & Perin, D. (2007). A meta-analysis of writing instruction for adolescent students. *Journal of Educational Psychology*, *99*(3), 445.

Greenbowe, T. J., Poock, J.R., Burke, K. A., & Hand, B. (2007). Using the science writing heuristic in the general chemistry laboratory to improve students' academic performance. *Journal of Chemical Education*. 84(8) 1371.

Gormally, C., Brickman, P., Hallar, B., & Armstrong, N. (2009). Effects of inquiry-based learning on students' science literacy skills and confidence.*International Journal for the Scholarship of Teaching and Learning*, *3*(2), 16.

Günel, M. (2006). *Investigating the impact of teachers' practices of inquiry and non-traditional writing on students' academic achievement of science during longitudinal professional development program.* Unpublished PhD Dissertation, Iowa State University, Ames.

Günel, M., Hand, B., & Prain, V. (2007). Writing for learning in science: A secondary analysis of six studies. *International Journal of Science and Mathematics Education, 5*(4), 615-637.

Günel, M., Atila, M. E., & Büyükkasap, E. (2009). The impact of using multi modal representations within writing to learn activities on learning electricity unit at 6th grade. *Elementary Education Online*, *8*(1), 183-199.

Hand, B., Lawrence, C., & Yore, L. D. (1999). A writing in science framework designed to enhance science literacy. *International Journal of Science Education*, *21*(10), 1021-1035.

Hand, B., Wallace, C. W., & Yang, E. M. (2004). Using a science writing heuristic to enhance learning outcomes from laboratory activities in seventh-grade science: Quantitative and qualitative aspects. *International Journal of Science Education*, *26*(2), 131-149.

Hand, B. (2008). *Introducing the science writing heuristic approach. Science inquiry, argument and language: A case for the science writing heuristic.* Rotterdam, The Netherlands: Sense.

Hand, B., Norton-Meier, L., Staker, J., Bintz, J. (2009). *Negotiating science.* Heinemann: Portsmouth, NH.

Hasançebi, F., Günel, M. (2013). Effects of argumentation based inquiry approach on disadvantaged students' science achivement. *İlköğretim Online*, *12*(4), 1056-1073.

Hasançebi, F. (2014). *Argümantasyon tabanlı bilim öğrenme yaklaşımının (ATBÖ) öğrencilerin fen başarıları, argüman oluşturma becerileri ve bireysel gelişimleri üzerine etkisi.* Doktora Tezi, Atatürk Üniversitesi, Erzurum.

Hayes, J. R., & Flower, L. S. (1980). Identifying the organization of writing processes. In L.W. Gregg & E.R. Steinberg (Eds.), *Cognitive Processes in Writing* (pp. 3-30). Erlbaum Associates Inc.

Hofer, B. K., & Pintrich, P. R. (1997). The development of epistemological theories: Beliefs about knowledge and knowing and their relation to learning.*Review of Educational Research*, *67*(1), 88-140.

Hofer, B.K., & Pintrich, P.R. (2002). *Personal epistemology: The psychology of beliefs about knowledge and knowing*. Mahwah, NJ: Lawrence Erlbaum Associates Inc.

Hofstein, A., Kipnis, M., & Kind, P. (2008). Enhancing students' metacognition and argumentation skills. *Science Education Issues and Developments*, 59.

Hohenshell, L. M., & Hand, B. (2006). Writing-to-learn strategies in secondary school cell biology: A mixed method study. *International Journal of Science Education*, *28*(2-3), 261-289.

Holliday, W. G., Yore, L. D., & Alvermann, D. E. (1994). The reading–science learning–writing connection: Breakthroughs, barriers, and promises. *Journal of Research in Science Teaching*, *31*(9), 877-893.

Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal*, *6*(1), 1-55.

Jacobs, J. E., & Paris, S. G. (1987). Children's metacognition about reading: Issues in definition, measurement, and instruction. *Educational Psychologist, 22* (3-4), 255-278.

Kahn, J. H. (2006). Factor analysis in counseling psychology research, training, and practice principles, advances, and applications. *The Counseling Psychologist*, *34*(5), 684-718.

Kaynar, D. (2007). *The effect of 5E learning cycle approach on sixth grade students' understanding of cell concept, attitude toward science and scientific epistemological beliefs*. Unpublished Master Thesis. Middle East Technical University, Ankara.

Kaynar, D., Tekkaya, C., & Çakıroğlu, J. (2009). Effectiveness of 5e learning cycle instruction on students' achievement in cell concept and scientific epistemological beliefs. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi*, *37*(37).

Kenny, D. A. (1975). A quasi-experimental approach to assessing treatment effects in the nonequivalent control group design. *Psychological Bulletin*, *82*(3), 345.

Keys, C.W. , Hand, B. , Prain, V. , Collins, S. (1999). Using the science writing heuristic as a tool for learning from laboratory investigations in secondary science. *Journal of Research in Science Teaching,* 36(10),1065–1084.

Kıngır, S. (2011). *Using the science writing heuristic approach to promote student understanding in chemical changes and mixtures.* Unpublished Doctoral Dissertation, The Graduate School of Natural and Applied Sciences, Middle East Technical University, Ankara.

Kıngır, S., Geban, O., & Günel, M. (2012). How does the science writing heuristic approach affect students' performances of different academic achievement levels? A case for high school chemistry. *Chemistry Education Research and Practice*, *13*(4), 428-436.

Kipnis, M., & Hofstein, A. (2008). The inquiry laboratory as a source for development of metacognitive skills. *International Journal of Science and Mathematics Education, 6*(3), 601-627.

Kizilgunes, B., Tekkaya, C., & Sungur, S. (2009). Modeling the relations among students' epistemological beliefs, motivation, learning approach, and achievement. *The Journal of Educational Research*, *102*(4), 243-256.

Klein, P. D. (2000) Elementary students' strategies for writing-to-learn in science. *Cognition and Instruction*, 18(3), 317-348

Klein, P. D. (2006). The challenges of scientific literacy: From the viewpoint of second-generation cognitive science. *International Journal of Science Education*, *28*(2-3), 143-178.

Kline, R. B. (2011). *Principles and Practice of Structural Equation Modeling*. New York: Guilford Press.

Langer, J. A., & Applebee, A. N. (1987). *How Writing Shapes Thinking: A Study of Teaching and Learning. NCTE Research Report No. 22*. National Council of Teachers of English, 1111 Kenyon Rd., Urbana, IL 61801

Lederman, N. G. (2006). Syntax of Nature of Science within Inquiry and Science Instruction. In L.B. Flick & N.G. Lederman (Eds), *Scientific Inquiry and Nature of Science* (pp. 301-317). Springer Netherlands.

Lemke, J. L. (2004). The literacies of science. *Crossing Borders in Literacy and Science Instruction: Perspectives on Theory and Practice*, 33-47.

Marzano, R. J., & Kendall, J. S. (2007). *The new taxonomy of educational objectives*. Thousand Oaks, CA: Corwin Press.

Marzano, R. J., & Kendall, J. S. (2008). *Designing and assessing educational objectives: Applying the new taxonomy*. Thousand Oaks, CA: Corwin Press.

Milli Eğitim Bakanlığı [MEB] (2006). *İlköğretim fen ve teknoloji dersi öğretim programı 6–8. sınıflar*. Ankara: MEB.

Milli Eğitim Bakanlığı [MEB] (2013). *İlköğretim kurumları fen bilimleri dersi öğretim programı 3-8. sınıflar.* Ankara: MEB.

Minner, D. D., Levy, A. J., & Century, J. (2010). Inquiry-based science instruction-what is it and does it matter? Results from a research synthesis years 1984 to 2002. *Journal of Research in Science Teaching*, *47*(4), 474-496.

Nam, J., Choi, A., Hand, B. (2011). Implementatıon of the science writing heuristic approach in 8th grade science classrooms. *International Journal of Science and Mathematics Education,* 9, 1111-1133.

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

National Research Council (2012). *Next generation science education standards: For states by states.* The National Academies Press, Draft.

National Science Foundation. (2000). *Inquiry: Thoughts, views, and strategies for the K–5 classroom.* Division of Elementary, Secondary, and Informal Education.

Özkan, Ş. (2008). *Modeling elementary students' science achievement: The interrelationships among epistemological beliefs, learning approaches, and self-regulated learning strategies.* Unpublished Doctoral Thesis, Middle East Technical University, Ankara.

Özkal, K., Tekkaya, C., Çakıroğlu, J., & Sungur, S. (2009). A conceptual model of relationships among constructivist learning environment perceptions, epistemological beliefs, and learning approaches. *Learning and Individual Differences*, *19*(1), 71-79.

Pallant, J. (2007). *SPSS Survival manual: A step by step guide to data analysis using SPSS for windows: 3rd edition*. Berkshire, England: Open University Press.

Pinney, B. R. (2014) *Characterizing the changes in teaching practice during first semester implementation of an argument-based inquiry approach in a middle school science classroom*. Unpublished Doctoral Thesis, University of Iowa, Iowa.

Pintrich, P. R., Smith, D. A., García, T., & McKeachie, W. J. (1993). Reliability and predictive validity of the Motivated Strategies for Learning Questionnaire (MSLQ). *Educational and Psychological Measurement*, *53*(3), 801-813.

Poock, J. R., Burke, K. A., Greenbowe, T. J., & Hand, B. M. (2007). Using the science writing heuristic in the general chemistry laboratory to improve students' academic performance. *Journal of Chemical Education*, *84*(8), 1371.

Prain, V., & Hand, B. (1996). Writing for learning in secondary science: Rethinking practices. *Teaching and Teacher Education*, *12*(6), 609-626.

Rivard, L. P. (1994). A review of writing to learn in science: Implications for practice and research. *Journal of Research in Science Teaching*, *31*(9), 969-983.

Rivard, L. P. (2004). Are language-based activities in science effective for all students, including low achievers?. *Science Education*, *88*(3), 420-442.

Rudd, J.A., Greenbowe, T.J., Hand,B.M., Legg, M.J. (2001). Using the science writing heuristic to move toward an ınquiry-based laboratory curriculum: An example from physical equilibrium. *Journal of Chemical Education*,78(12),1680-1686.

Sandi-Urena, S., Cooper, M. M., & Stevens, R. H. (2011). Enhancement of metacognition use and awareness by means of a collaborative intervention. *International Journal of Science Education*, *33*(3), 323-340.

Sandi-Urena, S., Cooper, M., & Stevens, R. (2012). Effect of cooperative problem-based lab instruction on metacognition and problem-solving skills.*Journal of Chemical Education*, *89*(6), 700-706.

Sandoval, W. A. (2005). Understanding students' practical epistemologies and their influence on learning through inquiry. *Science Education, 89*(4), 634-656.

Schoerning, E., Hand, B., Shelley, M., & Therrien, W. (2015). Language, access, and power in the elementary science classroom. *Science Education,99*(2), 238-259.

Schommer, M. (1990). Effects of beliefsabout the nature of knowledge on comprehension. *Journal of Educational Psychology*, 82(3), 498-504.

Schommer, M., & Walker, K. (1997). Epistemological beliefs and valuing school: Considerations for college admissions and retention. *Research in Higher Education*, *38*(2), 173-186

Schraw, G., & Dennison, R.S. (1994). Assessing metacognitive awareness. *Contemporary Educational Psychology*, 19, 460–475.

Schraw, G., & Moshman, D. (1995). Metacognitive theories. *Educational Psychology Review*, *7*(4), 351-371.

Schraw, G. (1998). Promoting general metacognitive awareness. *Instructional Science*, *26*(1-2), 113-125.

Schraw, G., Crippen, K.J., & Hartley, K. (2006). Promoting self-regulation in science education: Metacognition as part of a broader perspective on learning. *Research in Science Education*, 36, 111–139.

Sungur, S. & Şenler, B. (2009). An analysis of Turkish high school students' metacognition and motivation. *Educational Research and Evaluation*: *An International Journal on Theory and Practice*, 15(1), 45-62.

Tabachnick, B. G., & Fidell, L. S. (2007). *Using multivariate statistics*(5th ed.). Boston : Allyn and Bacon.

Thomas, G. P. (1999). Student restraints to reform: Conceptual change issues in enhancing students' learning processes. *Research in Science Education*, 19, 89–109.

Thomas, G. P., & McRobbie, C. J. (2001). Using a metaphor for learning to improve students' metacognition in the chemistry classroom. *Journal of Research in Science Teaching*, *38*(2), 222-259.

Thomas, G. P. (2002). The social mediation of metacognition. In D. McInerny & S. Van Etten (Eds.), *Research on Sociocultural Influences on Motivation and Learning* (Vol. 2,pp. 225–247). Greenwich, CT: Information Age Publishing.

Thomas, G. P. (2012). Metacognition in science education: Past, present and future considerations. In B. J. Fraser, K. Tobin, & C. J. McRobbie (Eds.),*Second International Hand-book of Science Education* (Vol. 24, pp. 131–144). Dordrecht: Springer.

Tynjälä, P., Mason, L., & Lonka, K. (2001). *Writing as a learning tool: An introduction*. Springer Netherlands.

van Opstal, M. T. (2014). *Extending Students' Practice of Metacognitive Regulation Strategies in the Undergraduate Chemistry Laboratory and Investigation of Pb2+ Binding to Calmodulin with Circular Dichroism and Molecular Dynamics Modeling.* Unpublished Doctoral Dissertation. Loyola University. Chicago.

van Opstal, M. T., & Daubenmire, P. L. (2015). Extending Students' Practice of Metacognitive Regulation Skills with the Science Writing Heuristic. *International Journal of Science Education*, *37*(7), 1089-1112.

Veenman, M. V., Van Hout-Wolters, B. H., & Afflerbach, P. (2006). Metacognition and learning: Conceptual and methodological considerations.*Metacognition and Learning*, *1*(1), 3-14.

Veenman, M. V. (2012). Metacognition in science education: Definitions, constituents, and their ıntricate relation with cognition. In A. Zohar & Y. J. Dori (Eds.), *Metacognition in Science Education* (pp. 21-36). Springer Netherlands.

Wallace, C. S., Hand, B. B., & Prain, V. (2004). *Writing and learning in the science classroom* (Vol. 23). Springer Science & Business Media.

White, B. Y., & Frederiksen, J. R. (1998). Inquiry, modeling, and metacognition: Making science accessible to all students. *Cognition and Instruction*, *16*(1), 3-118.

Whitebread, D., Coltman, P., Pasternak, D. P., Sangster, C., Grau, V., Bingham, S., & Demetriou, D. (2009). The development of two observational tools for assessing metacognition and self-regulated learning in young children.*Metacognition and Learning*, *4*(1), 63-85.

Wu, H. K., & Wu, C. L. (2011). Exploring the development of fifth graders' practical epistemologies and explanation skills in inquiry-based learning classrooms. *Research in Science Education*, *41*(3), 319-340.

Wyre, S. H. (2007). *Critical thinking, metacognition, and epistemological beliefs.* Doctoral dissertation. Universıty of Phoenıx.

Yılmaz-Tüzün, Ö., & Topçu, M. S. (2009). Elementary students' metacognition and epistemological beliefs considering science achievement, gender and socioeconomic status. *Elementary Education Online*, *8*(3), 676-693.

APPENDICES

APPENDIX A: PERMISSION OBTAINED FROM APPLIED ETHICS RESEARCH CENTER

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
APPLIED ETHICS RESEARCH CENTER

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Gönderen : Prof. Dr. Canan Özgen
IAK Başkanı

İlgi : Etik Onayı

Danışmanlığını yapmış olduğunuz İlköğretim Fen ve Matematik Eğitimi Bölümü öğrencisi Sabahat Tuğçe Tucel'in "(Exploring The Effects of Science Writing Heuristic Tasks on 8th Grade Students' Metacognition Skills and Achievement) Argümantasyon Tabanlı Bilim Öğrenme Yaklaşımının 8. Sınıf Öğrencilerinin Üstbiliş Becerileri ve Fen Başarısına Etkisi " isimli araştırması "İnsan Araştırmaları Komitesi" tarafından uygun görülerek gerekli onay verilmiştir.

Bilgilerinize saygılarımla sunarım.

Etik Komite Onayı

Uygundur

13/02/2014

Prof.Dr. Canan Özgen
Uygulamalı Etik Araştırma Merkezi
(UEAM) Başkanı
ODTÜ 06531 ANKARA

APPENDIX B: PERMISSION OBTAINED FROM MINISTRY OF EDUCATION

ÖĞRENCİ İŞLERİ DAİRE BAŞKANLIĞI
REGISTRAR'S OFFICE

ORTA DOĞU TEKNİK ÜNİVERSİTESİ
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28.03.2014

EĞİTİM FAKÜLTESİ DEKANLIĞINA

Ankara Valiliği Milli Eğitim Müdürlüğü'nden alınan, İlköğretim Fen ve Matematik Eğitimi Ana Bilim Dalı Yüksek Lisans Programı öğrencisi Tuğce Tucel'e ait yazı ilgisi nedeni ile ilişikte sunulmuştur.

Bilgilerinize arz ederim.

Saygılarımla.

Nesrin ÜNSAL
Öğrenci İşleri Daire Başkanı

SSD/

31/03 01/04 01/04 GS

T.C.
ADANA VALİLİĞİ
İl Milli Eğitim Müdürlüğü

ÖĞRENCİ İŞLERİ DAİRESİ BAŞKANLIĞI
Ev. Arş. Md. Saat :
25 Mart '14

TÜRKİYE CUMHURİYETİ
1,10 TÜRK LİRASI
RESMİ POSTA

Sayı : 48836810/100/1232663 24/03/2014
Konu: Tez Çalışması

ORTA DOĞU TEKNİK ÜNİVERSİTE REKTÖRLÜĞÜNE
ANKARA

İlgi: 11/03/2014 tarihli ve 1186 sayılı yazınız.

Fakülteniz Fen ve Matematik Eğitimi Anabilim Dalı Yüksek Lisans Öğrencisi Tuğçe Tucel tarafından hazırlanmakta olan "Argümantasyon Tabanlı Bilim Öğrenme Yaklaşımının 8. Sınıf Öğrencilerinin Üstbiliş Becerileri ve Fen Başarısına Etkisi" konulu tez çalışmasının Çukurova İlçesine bağlı Güzelyalı İlkokulu/Ortaokulunda 8. Sınıf öğrencilerine uygulanması ile ilgili Valilik Makamının 21/03/2014 tarihli ve 1201479 sayılı oluru ekte gönderilmiştir.

Bilgilerinizi rica ederim.

Hamit ŞENTÜRK
Vali a.
Müdür Yardımcısı

Eki: Valilik Oluru (1 Adet)

Güvenli Elektronik İmzalı
Aslı ile Aynıdır
24.03.2014

İsmail UZKUÇ
V.H.K.İ.

27.03.2014 - 5546.

Bu belge, 5070 sayılı Elektronik İmza Kanununun 5 inci maddesi gereğince güvenli elektronik imza ile imzalanmıştır
Evrak teyidi http://evraksorgu.meb.gov.tr adresinden 9ec2-34d1-3900-abb3-47d4 kodu ile yapılabilir.

Adana İl Milli Eğitim Müdürlüğü Temel Eğitim Şubesi
e-posta: temelegitim01@meb.gov.tr

Ayrıntılı bilgi için: Emine YİĞİT VHKİ
Tel: (0 322) 4588372-1302
Faks: (0 322) 4588391-95

T.C.
ADANA VALİLİĞİ
İl Milli Eğitim Müdürlüğü

Sayı : 48836810/100/1201479 21/03/2014
Konu: Tez Çalışması

VALİLİK MAKAMINA

İlgi: Orta Doğu Teknik Üniversitesi Rektörlüğünün 11/03/2014 tarihli ve 1186asyılı yazısı.

Ankara İli Orta Doğu Teknik Üniversite İlköğretim Fen ve Matematik Eğitimi Ana Bilim Dalı Yüksek Lisans Öğrencisi Tuğçe Tucel tarafından yürütülen "Argümantasyon Tabanlı Bilim Öğrenme Yaklaşımının 8. Sınıf Öğrencilerinin Üstbiliş Becerileri ve Fen Başarısına Etkisi" başlıklı tez çalışmasını Çukurova İlçesine bağlı Güzelyalı İlkokul/Ortaokulunda uygulamak isteği ile ilgili ilgi yazı ekte sunulmuştur.

İlimiz "İl Araştırma Değerlendirme Komisyonu"nun 20/03/2014 tarihli komisyon kararı doğrultusunda, Tezli Yüksek Lisans Öğrencisi Tuğçe Tucel'in "Argümantasyon Tabanlı Bilim Öğrenme Yaklaşımının 8. Sınıf Öğrencilerinin Üstbiliş Becerileri ve Fen Başarısına Etkisi" başlıklı tez çalışmasının 03/03/2004-09/06/2014 tarihleri arasında Çukurova İlçesi Güzelyalı İlkokulu/Ortaokulunda, okul müdürlerinin denetim, gözetim ve sorumluluğunda, eğitim ve öğretim aksatılmadan istekli 8. sınıf öğrencilerine uygulanması Müdürlüğümüzce uygun görülmektedir.

Makamlarınızca da uygun görülmesi halinde olurlarınıza arz ederim.

Mehmet Ali SELAMET
Milli Eğitim Müdür V.

OLUR
21/03/2014

Cengiz HOROZOĞLU
Vali a.
Vali Yardımcısı

Bu belge, 5070 sayılı Elektronik İmza Kanununun 5 inci maddesi gereğince güvenli elektronik imza ile imzalanmıştır
Evrak teyidi http://evraksorgu.meb.gov.tr adresinden b029-7c31-3c4b-98bb-bfd0 kodu ile yapılabilir.

Adana İl Milli Eğitim Müdürlüğü
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Tel: (0 322) 4588371-80
Faks: (0 322) 4588391-95

APPENDIX C: METACOGNITION AWARENESS INVENTORY

Sevgili Öğrenciler;

Fen ve teknoloji dersinde kullanılan öğretim yöntemlerinin, ilköğretim 8. sınıf öğrencilerinin üstbilişsel becerilerine etkisini belirlemek amacıyla bir araştırma yapılmaktadır. Bu nedenle görüşlerinize başvurulmaktadır. Ankette aşağıda yazan ifadeleri (fen ve teknoloji dersini düşünerek) ne sıklıkta gerçekleştirdiğinizi belirtmeniz istenmektedir. Bu ifadelerde verilen derecelendirmede size en yakın olduğunu düşündüğünüz tek bir seçeneği işaretleyiniz. Kişisel bilgileriniz kesinlikle gizli tutulacaktır. Araştırma amacının gerçekleşmesi, cevaplarınızın içtenliğine ve anketi eksiksiz olarak doldurmanıza bağlıdır.

Teşekkür ederim.

Tuğçe TUCEL
ODTÜ İlköğretim Bölümü

	Her Zaman	**Çoğunlukla**	**Bazen**	**Nadiren**	**Hiçbir Zaman**
1. Hedeflerime ulaşıp ulaşmadığımı düzenli olarak sorgularım.					
2. Bir problemi çözmeden önce farklı alternatifleri göz önüne alırım.					
3. Çalışırken daha önce işe yarayan yöntemleri kullanmaya çalışırım.					
4. Yeni konular öğrenirken daha fazla zamana sahip olmak için öğrenme hızımı ayarlayabilirim.					
5. Zihinsel olarak güçlü ve zayıf yönlerimi bilirim.					
6. Yeni bir ödeve başlamadan önce gerçekten neyi öğrenmem gerektiği konusunda düşünürüm.					
7. Bir sınavı bitirdiğimde, o sınavda ne kadar iyi yaptığımı bilirim.					
8. Bir ödeve başlamadan önce kendime açık, net ve özel hedefler belirlerim.					
9. Önemli bir bilgiyle karşılaştığımda çalışma hızımı yavaşlatırım.					
10. Ne tür bilgiyi edinmenin önemli olduğunu bilirim.					
11. Bir problemi çözerken her türlü çözüm yolunu gözönüne alıp almadığımı kendime sorarım.					
12. Bilgiyi iyi bir şekilde organize edebilirim.					
13. Bilinçli olarak dikkatimi önemli bir bilgiye odaklayabilirim.					
14. Öğrenirken kullandığım her bir strateji için özel bir amacım vardır.					
15. Bir konu hakkında önceden bilgim varsa en iyi o zaman öğrenirim.					

	Her Zaman	Çoğunlukla	Bazen	Nadiren	Hiçbir Zaman
16. Öğretmenimin benden neyi öğrenmemi istediğimi bilirim.					
17. Öğrendiğim bilgiyi iyi bir şekilde hatırlayabilirim.					
18. Hedeflerime ulaşıp ulaşmadığımı düzenli olarak sorgularım.					
19. Bir problemi çözmeden önce farklı alternatifleri göz önüne alırım.					
20. Çalışırken daha önce işe yarayan yöntemleri kullanmaya çalışırım.					
21. Yeni konular öğrenirken daha fazla zamana sahip olmak için öğrenme hızımı ayarlayabilirim.					
22. Zihinsel olarak güçlü ve zayıf yönlerimi bilirim.					
23. Yeni bir ödeve başlamadan önce gerçekten neyi öğrenmem gerektiği konusunda düşünürüm.					
24. Bir sınavı bitirdiğimde, o sınavda ne kadar iyi yaptığımı bilirim.					
25. Bir ödeve başlamadan önce kendime açık, net ve özel hedefler belirlerim.					
26. Önemli bir bilgiyle karşılaştığımda çalışma hızımı yavaşlatırım.					
27. Ne tür bilgiyi edinmenin önemli olduğunu bilirim.					
28. Bir problemi çözerken her türlü çözüm yolunu gözönüne alıp almadığımı kendime sorarım.					
29. Bilgiyi iyi bir şekilde organize edebilirim.					
30. Bilinçli olarak dikkatimi önemli bir bilgiye odaklayabilirim.					
31. Öğrenirken kullandığım her bir strateji için özel bir amacım vardır.					
32. Bir konu hakkında önceden bilgim varsa en iyi o zaman öğrenirim.					
33. Öğretmenimin benden neyi öğrenmemi istediğimi bilirim.					
34. Öğrendiğim bilgiyi iyi bir şekilde hatırlayabilirim.					
35. Kullanıdğım her bir öğrenme stratejisinin ne zaman en fazla yararlı olacağını bilirim.					
36. Çalışmanın sonuna geldiğimde, hedeflerime ne ölçüde ulaştığımı sorgularım.					
37. Öğrenirken, konuları daha iyi anlayabilmek için resimler ya da şekiller çizerim.					
38. Bir problemi çözdükten sonra, her türlü seçeneği göz önüne alıp almadığımı kendime sorarım.					
39. Yeni bilgiyi kendi cümlelerimle ifade etmeye çalışırım.					
40. Bir konuyu anlayamazsam, kullandığım öğrenme stratejisini değiştiririm.					

	Her Zaman	Çoğunlukla	Bazen	Nadiren	Hiçbir Zaman
41. Öğrenmeme yardımcı olması için bir konunun nasıl organize edildiğine dikkat ederim.					
42. Bir ödeve başlamadan önce ilgili yönergeleri (ne yapmam gerektiğini) dikkatle okurum.					
43. Okuduklarımın daha önceden bildiklerimle ilgili olup olmadığını kendime sorarım.					
44. Kafam karıştığında konu doğrultusundaki varsayımları tekrar gözden geçirim.					
45. Zamanımı hedeflerime en iyi şekilde ulaşabilmek için programlarım.					
46. Bir konuya ilgim olduğunda daha iyi öğrenirim.					
47. Bir konuyu aşama aşama çalışırım.					
48. Konunun ayrıntılarından çok genel anlamına odaklanırım.					
49. Yeni bir konuyu çalışırken ne kadar iyi öğrendiğime dair kendime sorular sorarım.					
50. Bir konuyu çalıştıktan sonra sonra gerektiği kadar öğrenip öğrenmediğimi kendime sorarım.					
51. Yeni bilgi anlaşılır değil ise durur ve üzerinden bir kez daha giderim.					
52. Bir şeyler okurken kafam karıştığında durur ve yeniden okurum.					

APPENDIX D: EPISTEMOLOGICAL BELIEFS QUESTIONNAIRE

EPİSTEMOLOJİK İNANÇLAR ANKETİ	**Kesinlikle Katılmıyorum**	**Katılmıyorum**	**Kararsızım**	**Katılıyorum**	**Kesinlikle Katılıyorum**
1. Tüm insanlar, bilim insanlarının söylediklerine inanmak zorundadır.	1❑	2❑	3❑	4❑	5❑
2. Bilimde, bütün soruların tek bir doğru yanıtı vardır.	1❑	2❑	3❑	4❑	5❑
3. Bilimsel deneylerdeki fikirler, olayların nasıl meydana geldiğini merak edip düşünerek ortaya çıkar.	1❑	2❑	3❑	4❑	5❑
4. Günümüzde bazı bilimsel düşünceler, bilim insanlarının daha önce düşündüklerinden farklıdır.	1❑	2❑	3❑	4❑	5❑
5. Bir deneye başlamadan önce, deneyle ilgili bir fikrinizin olmasında yarar vardır.	1❑	2❑	3❑	4❑	5❑
6. Bilimsel kitaplarda yazanlara inanmak zorundasınız.	1❑	2❑	3❑	4❑	5❑
7. Bilimsel çalışma yapmanın en önemli kısmı, doğru yanıta ulaşmaktır.	1❑	2❑	3❑	4❑	5❑
8. Bilimsel kitaplardaki bilgiler bazen değişir.	1❑	2❑	3❑	4❑	5❑
9. Bilimsel çalışmalarda düşüncelerin test edilebilmesi için birden fazla yol olabilir.	1❑	2❑	3❑	4❑	5❑
10. Fen Bilgisi dersinde, öğretmenin söylediği herşey doğrudur.	1❑	2❑	3❑	4❑	5❑
11. Bilimdeki düşünceler, konu ile ilgili kendi kendinize sorduğunuz sorulardan ve deneysel çalışmalarınızdan ortaya çıkabilir.	1❑	2❑	3❑	4❑	5❑
12. Bilim insanları bilim hakkında hemen hemen her şeyi bilir, yani bilinecek daha fazla bir şey kalmamıştır.	1❑	2❑	3❑	4❑	5❑
13. Bilim insanlarının bile yanıtlayamayacağı bazı sorular vardır.	1❑	2❑	3❑	4❑	5❑
14. Olayların nasıl meydana geldiği hakkında yeni fikirler bulmak için deneyler yapmak, bilimsel çalışmanın önemli bir parçasıdır.	1❑	2❑	3❑	4❑	5❑
15. Bilimsel kitaplardan okuduklarınızın doğru olduğundan emin olabilirsiniz.	1❑	2❑	3❑	4❑	5❑
16. Bilimsel bilgi her zaman doğrudur.	1❑	2❑	3❑	4❑	5❑
17. Bilimsel düşünceler bazen değişir.	1❑	2❑	3❑	4❑	5❑

	Kesinlikle Katılmıyorum	Katılmıyorum	Kararsızım	Katılıyorum	Kesinlikle Katılıyorum
18. Sonuçlardan emin olmak için, deneylerin birden fazla tekrarlanmasında fayda vardır.	1❑	2❑	3❑	4❑	5❑
19. Sadece bilim insanları, bilimde neyin doğru olduğunu kesin olarak bilirler.	1❑	2❑	3❑	4❑	5❑
20. Bilim insanının bir deneyden aldığı sonuç, o deneyin tek yanıtıdır.	1❑	2❑	3❑	4❑	5❑
21. Yeni buluşlar, bilim insanlarının doğru olarak düşündüklerini değiştirir.	1❑	2❑	3❑	4❑	5❑
22. Bilimdeki, parlak fikirler sadece bilim insanlarından değil, herhangi birinden de gelebilir.	1❑	2❑	3❑	4❑	5❑
23. Bilim insanları bilimde neyin doğru olduğu konusunda her zaman hemfikirdirler.	1❑	2❑	3❑	4❑	5❑
24. İyi çıkarımlar, birçok farklı deneyin sonucundan elde edilen kanıtlara dayanır.	1❑	2❑	3❑	4❑	5❑
25. Bilim insanları, bilimde neyin doğru olduğu ile ilgili düşüncelerini bazen değiştirirler.	1❑	2❑	3❑	4❑	5❑
26. Bir şeyin doğru olup olmadığını anlamak için deney yapmak iyi bir yoldur.	1❑	2❑	3❑	4❑	5❑

APPENDIX E: SCIENCE ACHIEVEMENT TEST FOR EIGHT GRADERS

Sevgili Öğrenciler;

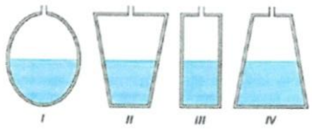
Aşağıdaki test ilköğretim öğrencileri için yapılacak bir araştırma kapsamında uygulanıyor olup, testin sonuçları kesinlikle notlandırılmayacaktır ve gizli tutulacaktır. Araştırma amacının gerçekleşmesi için soruları ciddiyetle ve bireysel olarak cevaplamanız önemlidir.

Teşekkür ederim.

Tuğçe TUCEL
ODTÜ İLKÖĞRETİM BÖLÜMÜ

1) Sıvı haldeki bir maddenin molekülleri ile gaz halindeki bir maddenin molekülleri karşılaştırıldığında aşağıdaki ifadelerden hangisi doğrudur?

A) Sıvı haldeki maddenin molekülleri daha yavaş ve birbirinden daha uzaktadır.
B) Sıvı haldeki maddenin molekülleri daha hızlı ve birbirinden daha uzaktadır.
C) Sıvı haldeki maddenin molekülleri daha yavaş ve birbirine daha yakındır.
D) Sıvı haldeki maddenin molekülleri daha hızlı ve birbirine daha yakındır.

2) 

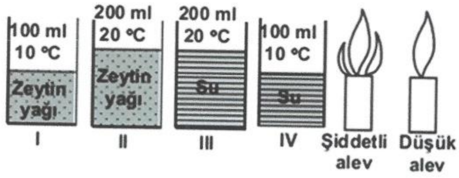
Şekildeki dört kabın her biri yüksekliğinin yarısına kadar çeşme suyuyla doldurulmuştur. Bu kapların diğer yarıları kaynar suyla dolduruluyor.

Aşağıdakilerden hangisi bu kaplardaki suların son sıcaklıkları ile ilgili olarak söylenemez?

A) II. ve IV. kaptaki sular aynı sıcaklıktadır.
B) I. ve III. kaptaki sular aynı sıcaklıktadır.
C) II. kaptaki su en sıcaktır.
D) IV. kaptaki su en soğuktur.

3) Bir öğrenci saf maddelerde donma sıcaklığının ayırt edici bir özellik olduğunu göstermek istiyor. Bunun için X ve Y maddelerini alıyor. Bu öğrenci aşağıdaki deneylerden hangisini yaparsa amacına ulaşır?

A) Bir tüpte X maddesini eriterek, erimenin başladığı sıcaklığı ölçmek.
B) Erimiş haldeki Y maddesinin donmaya başladığı sıcaklığı ölçmek.
C) Donma sıcaklığında bulunan X ve Y maddelerinin donma sırasında dışarıya verdikleri ısıları ölçmek.
D) X ve Y maddelerini ayrı tüplerde eriterek, erimeye başladıkları sıcaklıkları ölçmek.

4) 

Yukarıdaki düzenekler ile aşağıdaki deneylerden hangisi yapılırsa, "Farklı cins maddelerin eşit ısı almalarına karşın sıcaklık artışları farklı olur" yargısı test edilebilir?

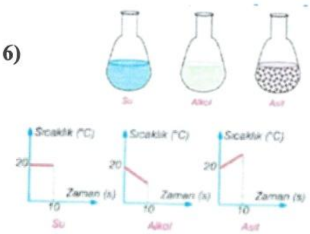
A) I ve II nolu kapları şiddetli alevde eşit süre ısıtmak
B) I ve II nolu kapları düşük alevde eşit süre ısıtmak
C) II ve III nolu kapları düşük alevde eşit süre ısıtmak
D) III ve IV nolu kapları şiddetli alevde eşit süre ısıtmak

5) Erime sıcaklıklarındaki aynı miktar X, Y ve Z katı maddeleri özdeş ısıtıcılarla ısıtıldığında;

- X katısı 3 dakika
- Y katısı 8 dakika
- Z katısı 11 dakika

sonra tamamen sıvı hale geçiyor. Bu maddelerin erime ısılarının <u>büyükten küçüğe</u> doğru sıralanışı aşağıdakilerden hangisidir?

A) X > Y > Z   B) Y > Z > X   C) Z > Y > X   D) Z > X > Y

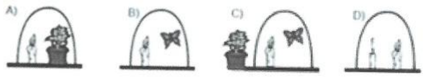
6) 

Şekildeki kaplarda 20 °C de su, alkol ve asit bulunmaktadır. Bu kaplara eşit kütlede farklı sıcaklıktaki kendi sıvılarından eklenerek 10 s süreyle sıcaklıkları ölçülüyor. Sıcaklık-zaman grafikleri şekildeki gibi gözleniyor. Buna göre eklenen sıvıların sıcaklıkları hangisindeki gibi <u>olabilir</u>?

	Su (°C)	Alkol (°C)	Asit (°C)
A)	25	25	25
B)	20	15	25
C)	10	15	25
D)	20	15	15

11)

Kağan, sınıfındaki bir etkinlikte fotosentezin önemini anlatmaktadır. Düzeneği hangi hale getirirse mum yanmaya devam eder?



12)

Karbondioksitli ortamda bulunan kireç suyu bulanır. Bu prensibi kullanarak bitkilerin solunum sırasında CO_2 verdiğini görmek isteyen bir öğrenci yandaki düzeneği kurmuştur. Ancak kireç suyunun beklendiği gibi bulanmadığı gözlenmiştir.

Bu deneyden aşağıdakilerden hangisi beklenen etkiyi gözlemeyi engellemiş olabilir?

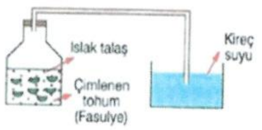
A) Güneş ışığının terlemeyi arttırması

B) CO_2 nin fotosentezde kullanılması

C) Küçük yapraklı bitkinin daha çok CO_2 üretmesi

D) Bitkinin gövdeden solunum yapması

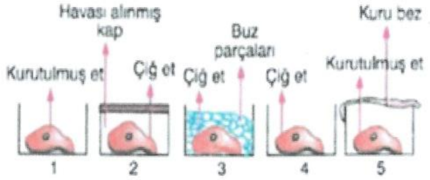
13)



Bu düzeneği kuran araştırmacı deneyi hangi soruyu cevaplamak için yapmış olabilir? (Kireç suyu, karbondioksitli ortamda bulanır.)

A) Tohumlar çimlenirken karbondioksit kullanır mı?
B) Ortam sıcaklığı solunumu etkiler mi?
C) Tohumlar solunum yapar mı?
D) Kireç suyu çimlenme için gerekli mi?

14)



Bir bilim insanı "N bakterisi, oksijenli solunum yaptığı için sadece açıkta bırakılan besinler üzerinde çoğalır." iddiasını deneyle ispatlamak istiyor.

Bu deney için aşağıdaki deney düzeneklerinden <u>hangilerini</u> seçmelidir?

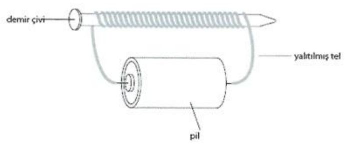
A) 1 ve 5 B) 2 ve 4 C) 1, 3 ve 4 D) 2, 3 ve 5

15)

Ezgi şekildeki deneyden elde ettiği sonuçlara göre , arkadaşının K bakterisiyle ilgili <u>hangi iddiasını çürütmüş</u> olabilir.

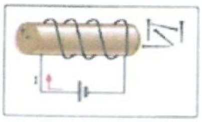
A) En fazla ekmek üzerinde çoğalır.
B) Kendi besinini kendisi üretir.
C) Nemli ve besinli her ortamda çoğalır.
D) Oksijenli solunum yapar.

16) Şekilde üzerine yalıtılmış tel sarılmış bir demir çivi görülmektedir. Yalıtılmış telin uçları bir pile şekildeki gibi bağlanmıştır.



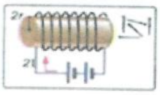
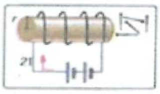
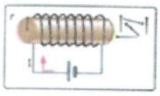
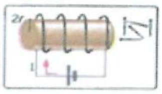
Telden akım geçtiğinde demir çiviye ne olur?

A) Çivi erir.
B) Çividen elektrik akımı geçer.
C) Çivi mıknatıslanır.
D) Çivide hiçbir değişim olmaz.

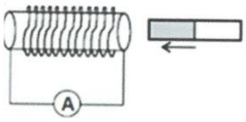


17) Bir öğrenci bobinin manyetik alan şiddetinin üzerinden geçen akıma göre değiştiğini, toplu iğnelerin hareketine bakarak göstermek istiyor.

Bunun için yukarıda verilen düzeneğe ek olarak aşağıdaki deneylerden hangisini yapmalıdır?

A) 
B) 
C) 
D) 

18) Şekildeki iletken tel sarılı bobinin içerisine,mıknatıs ok yönünde hareket ettirildiğinde ampermetrede okunan değerden daha büyük bir değerin elde edilebilmesi için gözlemci aşağıdakilerden hangisini yapmamalıdır?



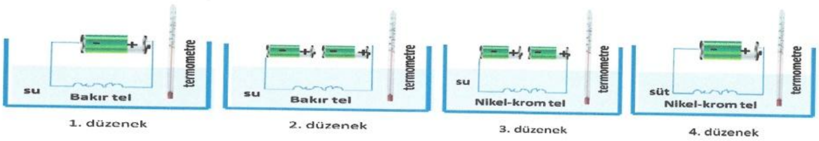
A) Ampermetreyi değiştirmeli

B) Bobin sarım sayısını arttırmalı

C)Mıknatısın hızını arttırmalı

D) Mıknatısın yanına yeni bir mıknatıs eklemeli

19) Özdeş pil ve eşit miktarda sıvı kullanılarak hazırlanan düzeneklerle üzerinden akım geçen bir iletkende **açığa çıkan ısı miktarının iletkenin direnci ile ilişkisini** araştırmak isteyen öğrenci hangi deney düzeneklerini birlikte kullanabilir?



A) 1. ve 3. B) 1. ve 4. C) 2. ve 3. D) 3. ve 4.

20) 1.hipotez: Bobindeki sarım sayısı arttıkça elektromıknatısın çekim gücü artar.

2. hipotez: Üzerinden geçen akım arttıkça elektromıknatısın çekim gücü artar.

Bir öğrenci yukarıdaki hipotezleri için özdeş çivi, tel ve pillerle I, II ve III elektromıknatıslarını yapıyor.

Daha sonra her bir elektromıknatısı özdeş iğnelere yaklaştırarak kaçar tane iğne çektiklerini kaydediyor.

Buna göre öğrenci 1. ve 2. hipotezlerini test etmek için hangi elektromıknatısları ile elde ettiği verileri birlikte değerlendirmelidir?

	1. hipotez	2. hipotez
A)	I-II	I-III
B)	II-III	I-II
C)	I-III	II-III
D)	I-II	II-III

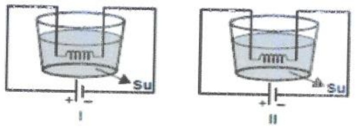
21) Ahmet, özdeş pil ve telleri kullanarak oluşturduğu üç devreyi, içlerinde oda sıcaklığında eşit miktarda su ve termometre bulunan kaplara şekildeki gibi daldırıyor:

Her bir devreyi, kaplar altında belirtilen sürelerde çalıştıran Ahmet, termometrelerde okuduğu değerleri karşılaştırıyor.

Ahmet, üzerinden akım geçen bir iletkende açığa çıkan ısının, iletkenin üzerinden geçen akım ve akımın geçiş süresinin ilişkili olup olmadığını göstermek için hangi düzeneklerin sonuçlarını karşılaştırmalı?

	Geçen akım için	Akımın geçiş süresi için
A)	I ve II	I ve III
B)	I ve III	I ve II
C)	I ve III	II ve III
D)	II ve III	I ve II

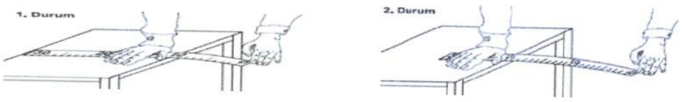
22) Fatih her bakımdan özdeş aşağıdaki iki devreyi kuruyor.



Fatih bu iki devreyi kullanarak üzerinden akım geçen bir telde açığa çıkan ısı miktarı ile ilgili olarak aşağıdaki sonuçlardan hangisine ulaşabilir?

A) Telin cinsine bağlıdır.
B) Telin direncine bağlıdır.
C) Telin üzerinden geçen akımın şiddetine bağlıdır.
D) Telin üzerinden geçen akımın geçiş süresine bağlıdır.

23) Mert 30 cm uzunluğundaki cetveli bir sehpanın kenarına iki farklı şekilde yerleştiriyor.



Her iki durumda da cetveli bir eliyle sehpa üstüne bastıran Mert, diğer eliyle de cetvelin boştaki ucunu aşağı doğru esnetip bırakıyor. Bu işlem sonunda 2. durumda çıkan sesin daha kalın olduğunu fark ediyor.
Buna göre Mert **sesteki kalınlaşmanın nedenini nasıl açıklar?**

A) Sesin genliğinin artmasıyla
B) Sesin frekansının artmasıyla
C) Sesin genliğinin azalmasıyla
D) Sesin frekansının azalmasıyla

24) "Madde miktarı, maddenin titreşimini ve buna bağlı olarak oluşturduğu sesin özelliğini değiştirmektedir." iddiası nasıl test edilebilir?

A) Bir havuza yakın ve uzak mesafeden aynı taşı atmak
B) Farklı maddeden yapılmış tellere vurarak
C) İçerisinde farklı miktarda su bulunan şişelere üfleyerek
D) Bir lastiği önce az, sonra çok gerip titreştirerek

25)

Sol eliyle gitarın en üst telinde K noktasına basan Hasan, sağ eliyle aynı tele şekildeki gibi vurarak çıkan sesi dinliyor. Hasan, **çıkan sesin yüksekliğini ve şiddetini azaltmak istiyor.**

Buna göre, sol elini aynı tel üzerindeki L ve M noktalarından hangisini basarak sağ eliyle bu tele nasıl vurmalıdır?

	Sol elini	Sağ eliyle
A)	M noktasına	daha hızlı
B)	M noktasına	daha yavaş
C)	L noktasına	daha hızlı
D)	L noktasına	daha yavaş

26)

Çubuk yardımıyla tahtalara vurularak çıkan sesler dinlenmektedir. Tahtaların boyu kısaldıkça, çıkan sesin incelmesi **nasıl açıklanabilir?**

A) Tahtanın boyu kısaldıkça sesin yüksekliği artar.

B) Tahtanın boyu kısaldıkça sesin yüksekliği azalır.

C) Tahtanın boyu kısaldıkça sesin genliği artar.

D) Tahtanın boyu kısaldıkça sesin genliği azalır.

27) Sıcaklıkları ve derinlikleri aynı, tuz yoğunluğu farklı iki gölde bir araştırma yapılıyor. Araştırmacılar iki göle de, belli aralıklarla ses çıkaran bir cihaz bırakıyorlar. Araştırmanın amacı ne olabilir?

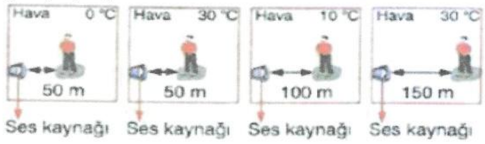
A) Tuzlu suyun sesi iletip, iletmediğini anlamak

B) Sıcaklığın, sesin yayılma hızına etkisini incelemek

C) Yoğunluğun, sesin yayılma hızına etkisini incelemek

D) Cihazın su altında çalışıp, çalışmadığını kontrol etmek

28) Bir gözlemci ses kaynağının şiddetini değiştirmeden şekillerdeki gibi değişik durumlarda sesi duymaya çalışmaktadır.



Buna göre gözlemci, aşağıdaki sorulardan hangisine ya da hangilerine cevap verebilir?

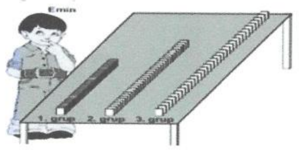
I. Sesin yayılma hızı sıcaklıkla değişir mi?

II. Kaynaktan uzaklaştıkça sesin şiddeti artar mı?

III. Sesin şiddeti farklı ortamlarda azalır mı?

A) Yalnız I B) I ve II C) Yalnız III D) I, II ve III

29) Sesle ilgili modelleme yapan Emin, 300 adet domino taşından 100erli 3 grup yapıyor. Birinci gruptaki taşları 1cm, ikinci gruptaki taşları 1,5cm ve üçüncü gruptaki taşları 2cm arayla şekildeki gibi diziyor. Üç grupta da baştaki taşa aynı itme kuvvetini uygulayan Emin, son taş düşene kadar geçen süreyi aşağıdaki tabloya kaydediyor.



Emin'in ölçüm sonuçları:

Grup	Geçen süre
1. Grup	2 saniye
2. Grup	2,5 saniye
3. Grup	3 saniye

Buna göre Emin, hangi bilgi için modelleme yapmıştır?

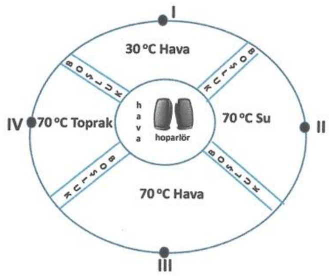
A) Ses en hızlı katılarda, sonra sırasıyla sıvı ve gazlarda yayılır.

B) Sesin şiddeti artsa da yayılma hızı değişmez.

C) Ses bir enerjidir ve başka bir enerjiye dönüşebilir.

D) Ses enerjisi kaynağa yaklaştıkça büyür.

30) Ses hızını inceleyen bilim insanları şekildeki gibi bir düzenek kuruyorlar. İşaretli noktalarda bekleyip sesi duydukları anı kaydediyorlar. Eğer bu bilim insanları, **ortam sıcaklığının sesin yayılma hızına etkisini araştırıyorlarsa hangi noktalarda beklemeliler?**



A) I ve II B) I ve III C) II ve III D) I ve IV

APPENDIX F: THE MYSTERY ACTIVITY

ATBÖ BAŞLANGIÇ ETKİNLİĞİ

Süre: 2 ders saati

Kazanımlar: Dersin sonunda öğrenciler:

- Açıklama, tahmin ve model oluştururken kanıtlardan yararlanır.
- Kanıt ve iddia arasında eleştirel ilişki kurabilir.
- Alternatif açıklama ve tahminleri analiz eder.
- İddialarını tartışır ve savunur.
- Argümantasyon tabanlı bilim öğrenme yaklaşımı hakkında fikir sahibi olurlar.

Öğretim Metot ve Yöntemleri : Argümantasyon Tabanlı Bilim Öğrenme Yaklaşımı

BAY HAVYAR'IN ENTERESAN ÖLÜMÜ

Sen ve partnerin zenginliği ve yalnızlığıyla tanınan zengin fakat tuhaf bir adam olan Bay Havyar'ın ölümünü incelemek üzere kiralanmış özel dedektiflersiniz. O, her zaman endişeli ve kolay korkan bir insan olduğundan, diğer insanların etrafında olmaktan kaçınmıştır. O aynı zamanda paranoya sıkıntısı çekmektedir. Hizmetlilerinin ona karşı gizli bir şekilde komplo kuruyor olmalarından korktuğu için uzun zaman önce işe aldığı hizmetlilerini işten çıkarmıştır. O her gece, akşam yemeği olarak aynı yemeği: çok az pişmiş (kanlı) iki biftek ve fırında pişmiş ekşi soslu iki patates yerdi.

Size olay yerine varmanızın üzerine, Bay Havyar'ın bu sabah erken bir saatte evinde hizmetlileri tarafından ölü olarak bulunduğu söylenmiştir. Önceki akşam aşçı Bay Havyar'ın her zamanki yemeğini yaptıktan sonra, Bay Havyar korkunç bir fırtına olmasından dolayı çalışanlarının evlerine sorunsuz dönebilmeleri için onlara erken izin vermişti. Hizmetliler sabah geri döndüklerinde Bay Havyar'ı yemek odasında yüz üstü yatarken buldular.

Siz, odanın içine bakarak incelemelerinize başlarsınız. Yemek odasındaki büyük pencere camı kırılmış paramparça olmuştur. Cam dışarıdan darbe ile kırılarak açılmış gibi görünmektedir. Ölünün vücudunda kesik yaraları teşhis edilmekte ve masanın hemen yanında yüzüstü yatmaktadır. Ayrıca, cesedin tam altında halının üzerinde büyük kırmızı bir leke göze çarpmaktadır. Açılmış vaziyette bir şişe kırmızı şarap ve bir kısmı yenmiş bir biftek masanın üzerinde durmaktadır. Cesedin hemen yanında devrilmiş bir sandalye ve masanın altında üzerinde kan olan bir bıçak görülmektedir.

Öğrenciler bu hikâyeyi okuduktan sonra "*Partnerinizle çalışarak, ilk gözlemlere göre dün gece neler olduğu (Bay Havyar'ın nasıl öldüğü) hakkında iddialar sunun. Lütfen her iddianızla ilgili olabildiğince kanıt bulun*." denir. Öğrenciler iddialarını ve kanıtlarını bir kâğıda not alırlar. Daha sonra her grup tahtaya gelerek iddialarını ve kanıtlarını sınıftaki diğer arkadaşlarına anlatır. Bu sırada sınıfta bir tartışma ortamı yaratılır. Bu sırada tahtaya "*Fikirlerim diğer fikirlerle nasıl kıyaslanabilir? (Arkadaşlarım bu konu hakkında ne düşünüyorlar?)*" yazılır ve öğrencilerden farklı fikirleri (iddia ve kanıtları) not almaları istenir. Tartışma bittikten sonra da "*Arkadaşlarınızla tartıştıktan sonra iddialarınızda değişme oldu mu?*" diye sorulur.

Bu aktiviteden sonra Argümantasyon Tabanlı Bilim Öğrenme yaklaşımı (SWH) hakkında bilgi verilir ve bundan sonraki laboratuvar derslerinde nasıl çalışılacağı anlatılır. Öğrenci şablonu tahtaya yansıtılır ve basamak basamak nelerin yapılacağı üzerine konuşulur. Araştırılabilir soru nedir, nasıl hazırlanır örneklerle anlatılır. 5. Sınıfta öğrenmeye başladıkları bağımlı-bağımsız değişken konusu hatırlatılır, örnekler verilir.

APPENDIX G: SWH REPORT FORMAT

Ad Soyad / Sınıf:

KONU:

Tarih:

Araştırma sorum:

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Bağımlı ve bağımsız değişkenlerim:

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Soruma teşkil eden düşüncelerim (Neden bu soruyu soruyorum?)**:**

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Sorumu cevaplandırmak için yaptığım deneyler:

Gözlemlerim (Deney sırasında neler gözlemledim/ deneyin sonucu ne oldu?)**:**

İddialarım (Deneyimizle ilgili nasıl çıkarımlar yapabilirim?) **:**

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Kanıtlarım (Neden bu tür iddialarda bulunuyorum?) **:**

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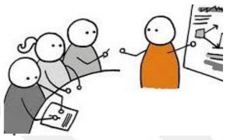
Fikirlerim diğer fikirlerle nasıl kıyaslanabilir? (Arkadaşlarım bu konu hakkında ne düşünüyorlar?) **:**



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Diğer kaynaklardan okuduklarım/öğrendiklerim (ders kitabı, yardımcı kitaplar, internet, vs.) **:**

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Diğer kaynaklardan edindiğim bilgiler, iddialarım ve kanıtlarımla nasıl bir benzerlik / zıtlık içerisindedir? :

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Fikirlerim değişti / değişmedi çünkü:

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APPENDIX H: TRADITIONAL REPORT FORMAT

Ad Soyad / Sınıf:
KONU: **Tarih:**

Deneyin Adı:

Deneyin Amacı:

Kullanılan Malzemeler:

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Deneyin Yapılışı:

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Gözlemlerim:

Deneyin Sonucu:

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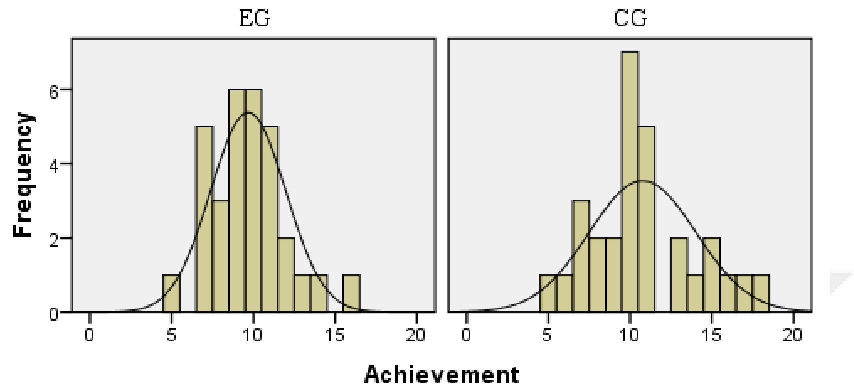
APPENDIX I: HISTOGRAMS

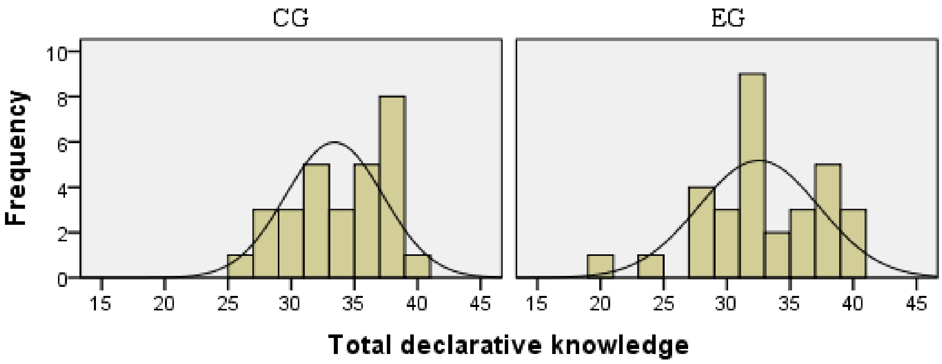
Histograms with normal curve of pre-SATEG in terms of groups



Mean = 9.68
Std. Dev = 3.270
N = 31

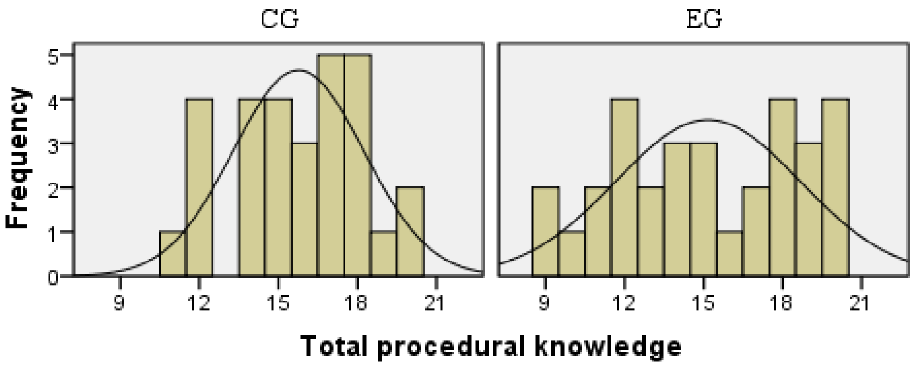
Mean = 10.79
Std. Dev = 2.301
N = 29

Histograms with normal curve for the dimensions of pre-MAI in terms of groups



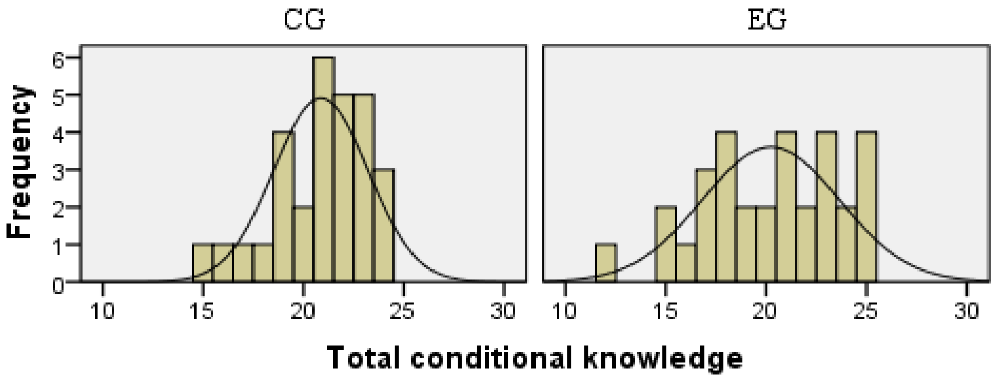
Mean = 33.41
Std. Dev = 3.869
N = 29

Mean = 32.52
Std. Dev = 4.774
N = 31



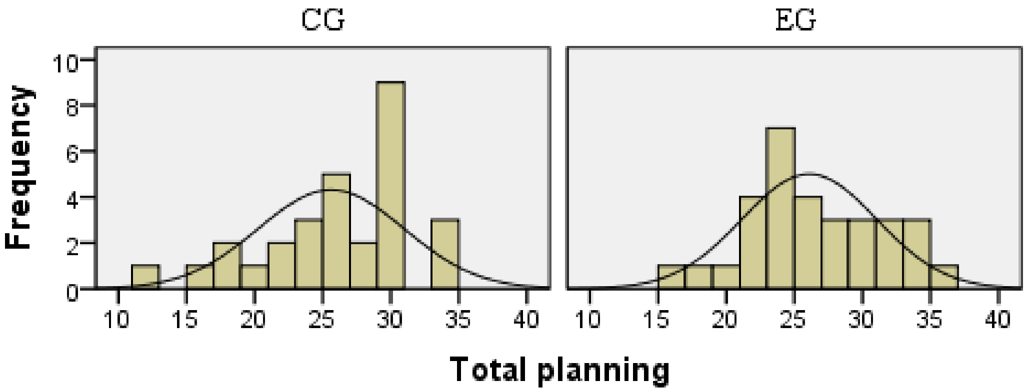
Mean = 15.76
Std. Dev = 2.488
N = 29

Mean = 15.16
Std. Dev = 3.503
N = 31



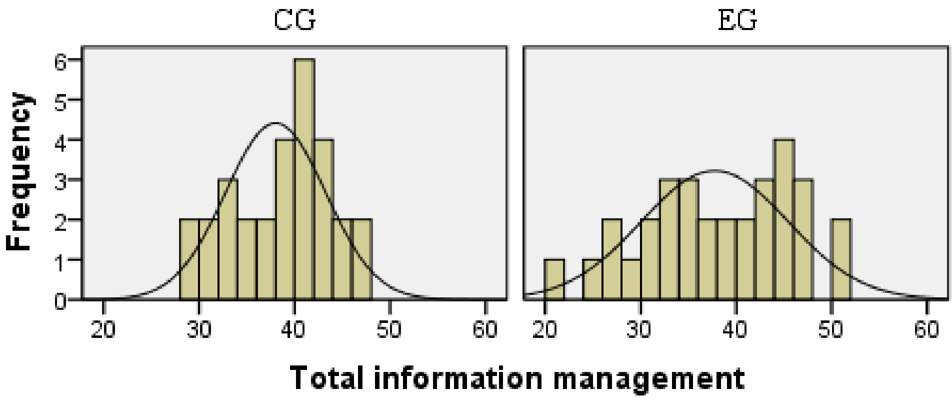
Mean = 20.86
Std. Dev = 2.356
N = 29

Mean = 20.23
Std. Dev = 3.432
N = 31



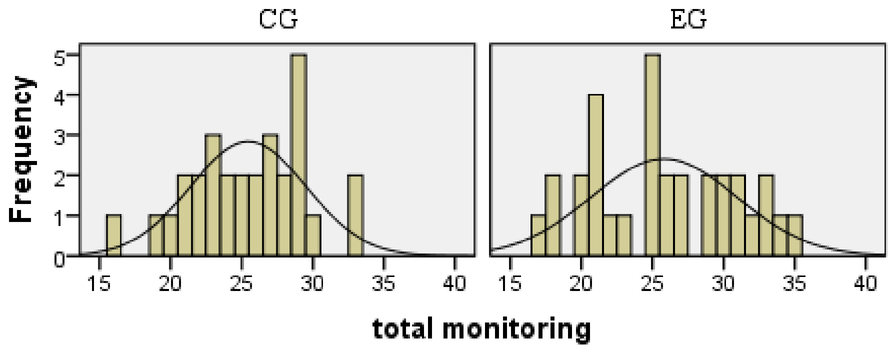
Mean = 25.62
Std. Dev = 5.368
N = 29

Mean = 26.10
Std. Dev = 4.942
N = 31



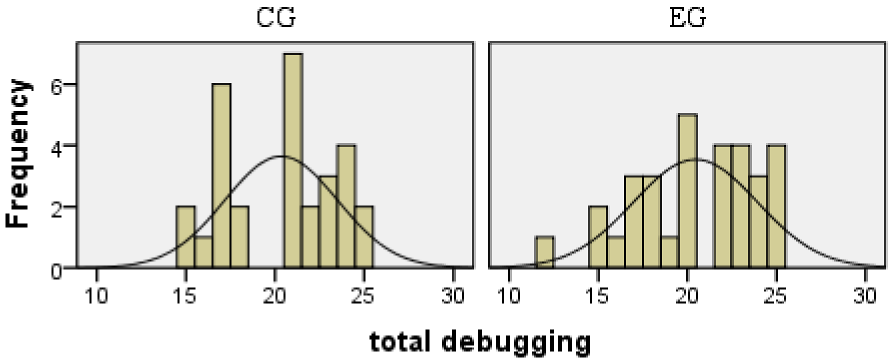
Mean = 38.00
Std. Dev = 5.244
N = 29

Mean = 37.74
Std. Dev = 7.681
N = 31



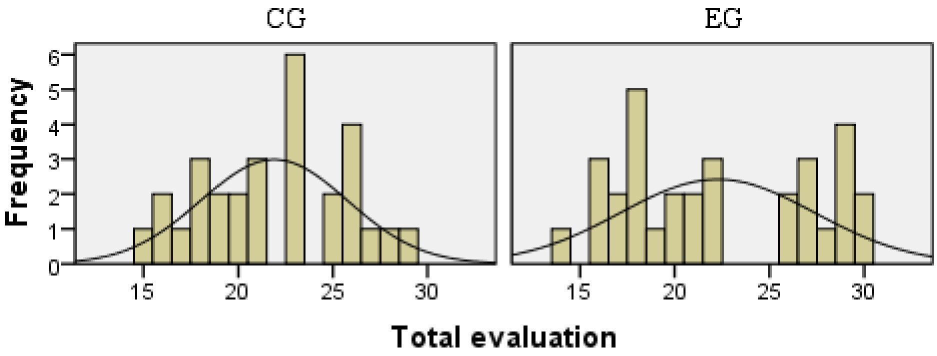
Mean = 25.45
Std. Dev = 5.134
N = 29

Mean = 25.81
Std. Dev = 4.076
N = 31



Mean = 20.34
Std. Dev = 3.165
N = 29

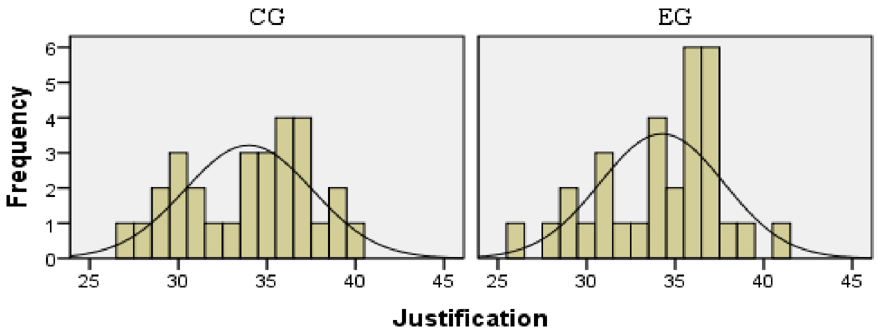
Mean = 20.45
Std. Dev = 3.482
N = 31



Mean = 22.26
Std. Dev = 3.876
N = 29

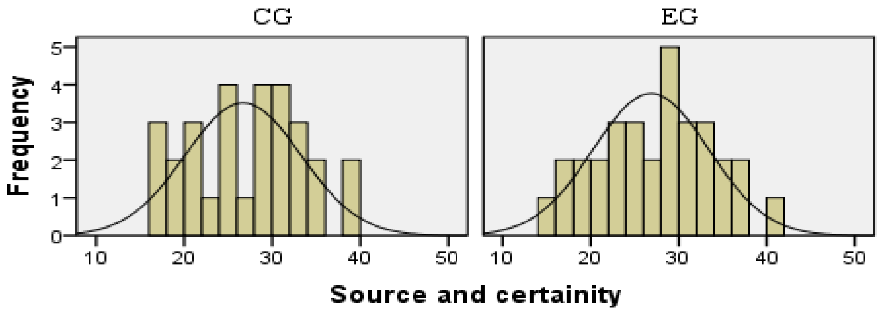
Mean = 21.90
Std. Dev = 5.118
N = 31

Histograms with normal curve for the dimensions of pre-EBQ in terms of groups



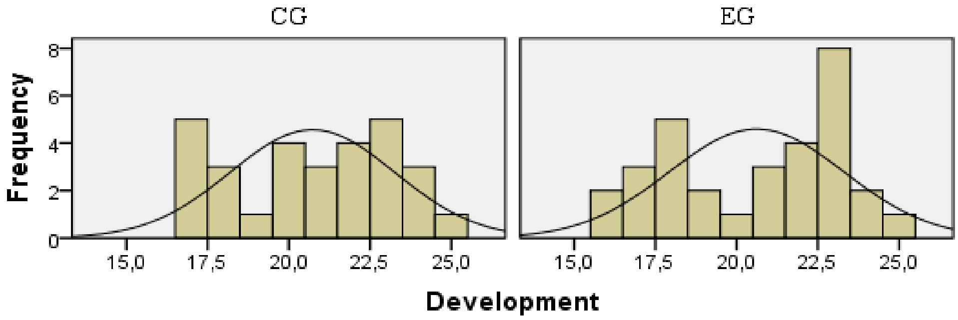
Mean = 34.26
Std. Dev = 3.493
N = 29

Mean = 33.97
Std. Dev = 3.600
N = 31



Mean = 26.84
Std. Dev = 6.573
N = 29

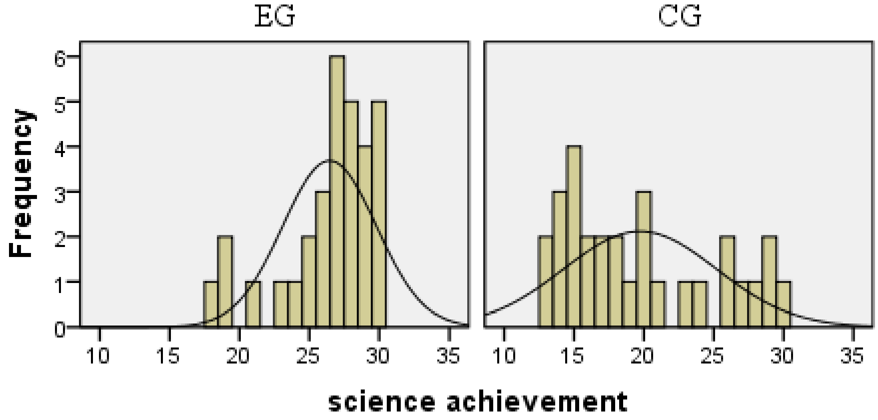
Mean = 26.69
Std. Dev = 6.580
N = 31



Mean = 20.61
Std. Dev = 2.692
N = 29

Mean = 20.72
Std. Dev = 2.534
N = 31

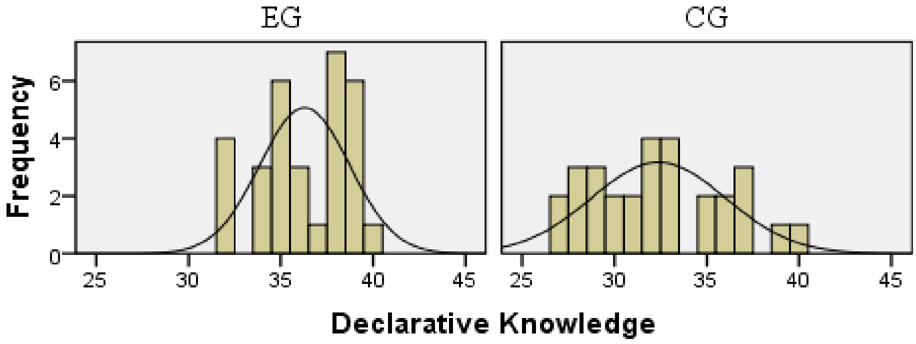
Histograms with normal curve of post-SATEG in terms of groups



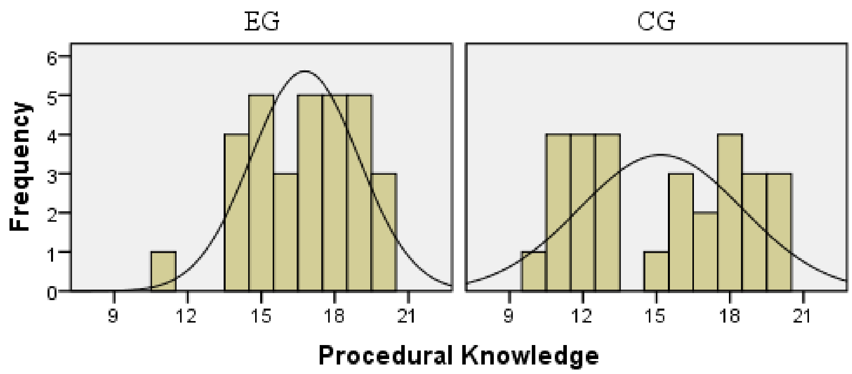
Mean = 26.45
Std. Dev = 3.355
N = 31

Mean = 19.72
Std. Dev = 5.463
N = 29

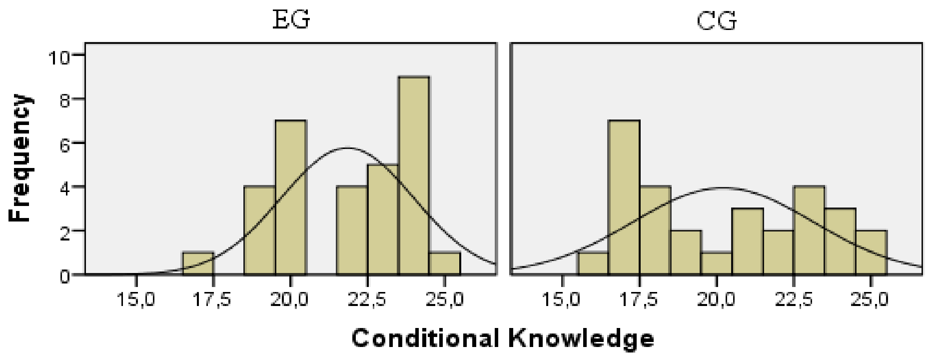
Histograms with normal curve for the dimensions of post-MAI in terms of groups



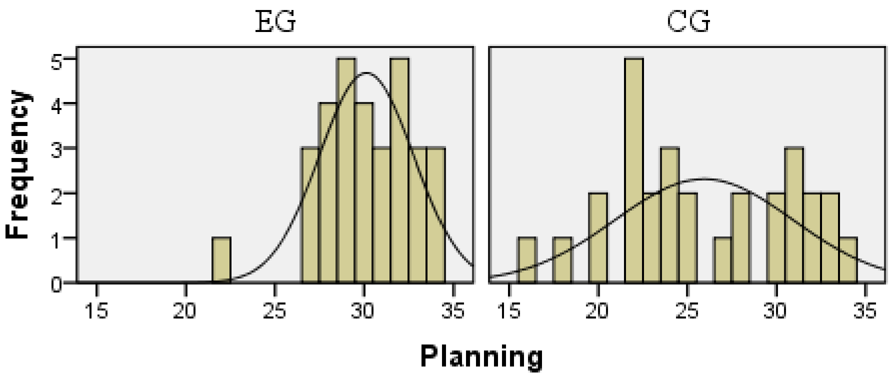
Mean = 36.29	Mean = 32.38
Std. Dev = 2.438	Std. Dev = 3.649
N = 31	N = 29



Mean = 16.77	Mean = 15.17
Std. Dev = 2.202	Std. Dev = 3.328
N = 31	N = 29

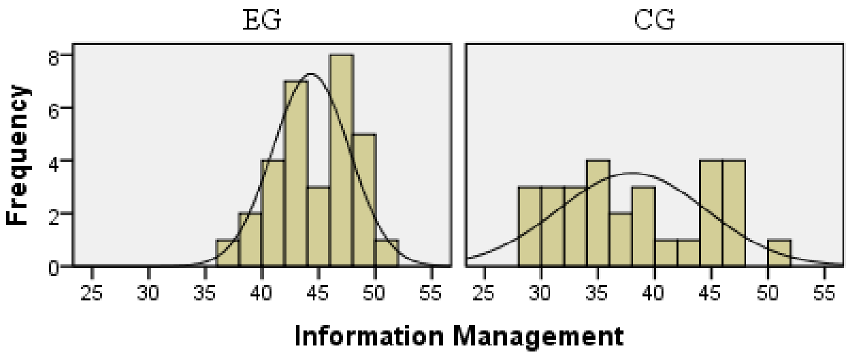


Mean = 21.84	Mean = 20.21
Std. Dev = 2.146	Std. Dev = 2.932
N = 31	N = 29



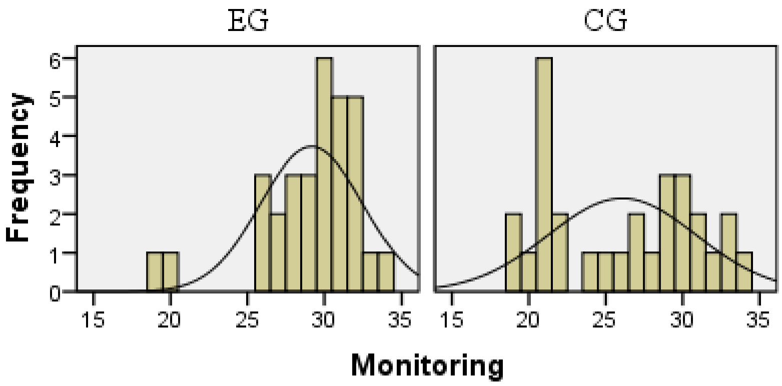
Mean = 30.13
Std. Dev = 2.642
N = 31

Mean = 25.93
Std. Dev = 4.992
N = 29



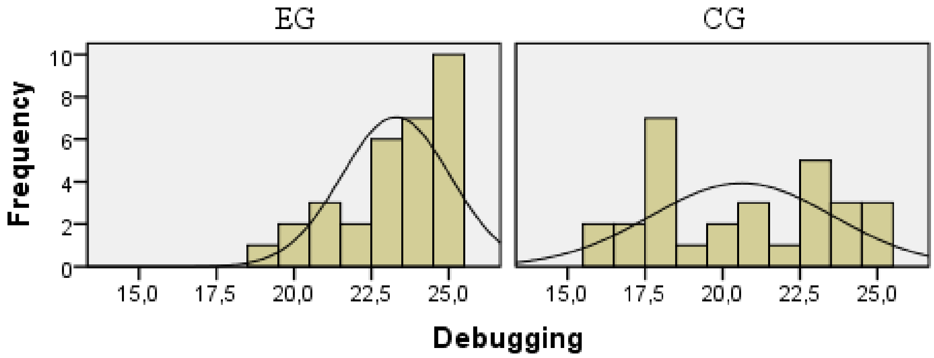
Mean = 44.32
Std. Dev = 3.400
N = 31

Mean = 38.00
Std. Dev = 6.563
N = 29



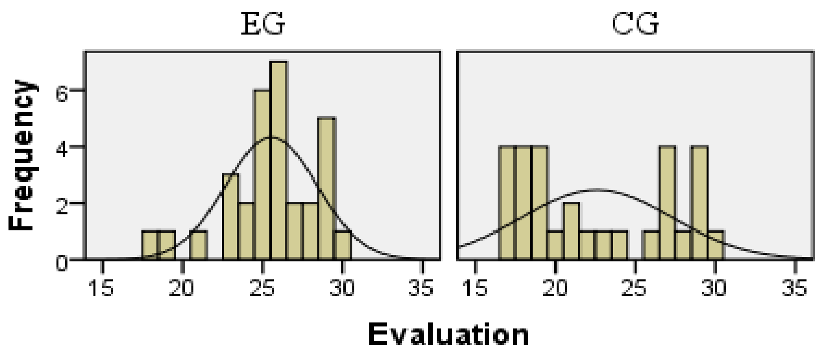
Mean = 29.16
Std. Dev = 3.318
N = 31

Mean = 26.07
Std. Dev = 4.818
N = 29



Mean = 23.29
Std. Dev = 1.755
N = 31

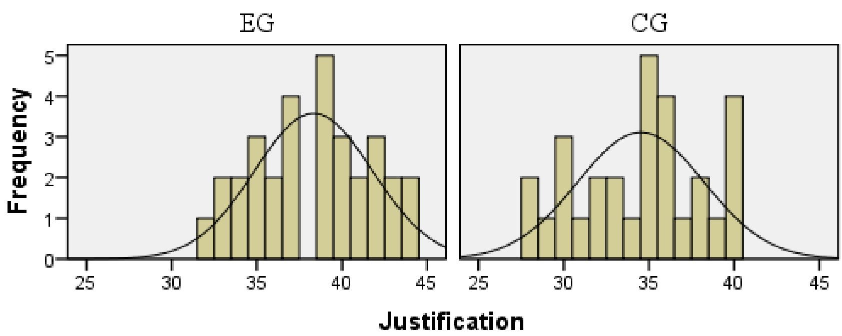
Mean = 20.62
Std. Dev = 2.945
N = 29



Mean = 25.55
Std. Dev = 2.850
N = 31

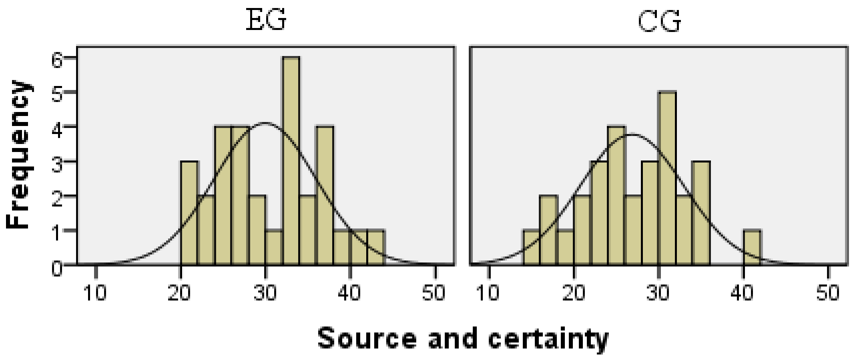
Mean = 22.59
Std. Dev = 4.679
N = 29

Histograms with normal curve for the dimensions of post-EBQ in terms of groups



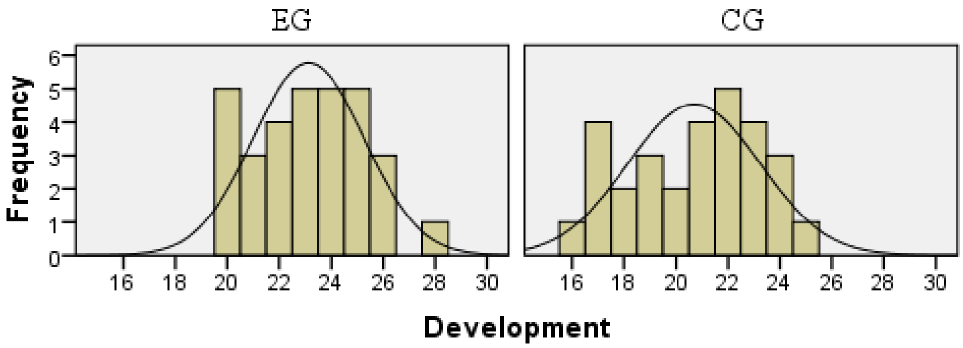
Mean = 38.32
Std. Dev = 3.458
N = 31

Mean = 34.52
Std. Dev = 3.719
N = 29



Mean = 29.94
Std. Dev = 6.038
N = 31

Mean = 26.83
Std. Dev = 6.142
N = 29



Mean = 23.13
Std. Dev = 2.141
N = 31

Mean = 20.69
Std. Dev = 2.551
N = 29

APPENDIX J: TURKISH SUMMARY

Giriş

1980'li yıllar itibariyle uluslararası ve ulusal alanda yapılan birçok çalışma fen öğretiminde araştırma sorgulama tabanlı öğrenme yaklaşımının değişik perspektiflerden önemini vurgulamaya başlamıştır. Bu çalışmalar araştırma sorgulama tabanlı öğrenmenin öğrencilerin yaratıcılıklarını beslediğini, bilimsel süreç ve kritik düşünme becerilerini geliştirdiğini, öğrencilerin fen konularını daha iyi anlamlandırmalarını sağlağını (Choi, 2008; Chanlen, 2013); onların üst bilişlerini (Sandi-Urena vd., 2012; Kipnis & Hofstein, 2008) ve epistemolojik inançlarını (Conley, Pintrich, Vekiri & Harrison, 2004; Kaynar, Tekkaya & Çakıroğlu, 2009) geliştirdiğini göstermektedir.

Argümantasyon tabanlı bilim öğrenme (ATBÖ) yaklaşımı, araştırma sorgulama tabanlı öğrenmenin bir çeşidi olup "soru – iddia – kanıt" üçlemesine dayalı bir yöntem izlemektedir. Diğer araştırma sorgulama tabanlı öğrenme yöntemlerinden en önemli farkı bilimsel açıklamaların gerekçelendirilmesi yapılırken akran müzakeresine başvurmasıdır (Pinney, 2014). *Gelecek Nesil K12 Fen Standartlarına* (NGSS, 2013) göre argümantasyon fen eğitimi için oldukça önemlidir. Bu durumun gerekçeleri açıklanırken öğrencilerin bilimsel argümantasyonlara katılmalarının onların bilim insanlarının içinde bulundukları kültürü daha iyi anlamalarını sağlayacağı böylece bilim ve mühendislik uygulamalarının toplumun yararına hizmet edeceği vurgulanmıştır (NRC, 2012).

Uluslararası reform hareketlerine paralel olarak Milli Eğitim Bakanlığı [MEB] 2013 Fen Bilimleri Dersi Öğretim Programında araştırma - sorgulamaya dayalı öğrenme yaklaşımını temel almıştır. Ancak, araştırma - sorgulama sürecini sadece "keşfetme ve deney" olarak değil, "açıklama ve argüman" oluşturma süreci olarak da ele almanın önemi vurgulanmıştır.

ATBÖ yaklaşımı öğrencilerin kendi bilgilerini yapılandırmasına yardımcı olmak ve bu süreçte öğretmenlerin yapması gerekenleri, tavsiye edilen yöntemleri sunmak amacıyla öğretmen şablonu ve öğrenci rapor şablonu olmak üzere iki şablon içermektedir. Genel olarak, öğretmenler öğrencilerinin mevcut bilgilerini hatırlatan yeni bilgileriyle ilişki kurmasını sağlayan tartışmalar başlatarak, onların düşüncelerini rahatça ifade edebildikleri öğrenme ortamları sağlarlar. Bu ortamlarda öğrenciler iddialarını farklı gerekçelerle destekleyebilirler ve arkadaşlarının iddialarını çürütmek amacıyla karşıt argümanlar oluşturacak diyaloglar içerisinde yer alırlar. Öğretmen şablonu basamak basamak takip edilmesi zorunlu aktiviteler olarak algılanmamalı aksine, ATBÖ yaklaşımının uygulama sürecini yansıtan temel parçalar olarak düşünülmelidir. Öğretmen şablonundaki tavsiye edilen basamaklar: 1) Bireysel ya da grup kavram haritası yapmada ön bilgileri ortaya çıkarma, 2) İnformal yazma, açıklamalar yapma, beyin fırtınası ve soru sormayı içeren ön laboratuvar aktivitesi, 3) Laboratuvar aktivitesine katılma, 4) Görüşme / Müzakere I- Laboratuvar aktivitesi için kişisel yazma aktivitesi yapma (Örneğin; makale yazma), 5) Görüşme / Müzakere II- Küçük gruplardaki veri yorumlarını paylaşma ve kıyaslama (Örneğin; grup kartları yapma), 6) Görüşme / Müzakere III- Kitap ya da diğer kaynaklar ile karşılaştırma (Örneğin; odaklanan soruları cevaplamada grup notlarını yazma), 7) Görüşme / Müzakere IV- Bireysel yansıma ve yazma (Örneğin; büyük dinleyiciler için rapor ya da poster gibi sunumlar yaratma), 8) Kavram haritası yapmada son bilgileri ortaya çıkarma (Hasançebi, 2014).

Görüldüğü gibi öğrenme fikirlerin müzakeresi sürecinde oluşuyor. Bununla birlikte öğrenci rapor şablonu soru, iddia ve kanıt bileşenlerini içeriyor. Öğrenci rapor şablonu “Sorularım neler?”, “Ne yapabilirim?”, “Ne gözlemledim?”, “Ne iddia edebilirim?”, “Neden bu iddiaları yapıyorum?”, “Fikirlerim diğer fikirler ile nasıl kıyaslanabilir?”, “Fikirlerim nasıl değişti?” soruları üzerinden yansıtıcı öğrenme amaçlı yazma fırsatları sunuyor (Hand & Keys, 1999). Öğrenciler yukarda bahsi geçen sorulara cevap verirken kendi öğrenmelerinin ve bunu geliştirmek için seçeneklerinin farkına varıyorlar. Kısacası ATBÖ yaklaşımı öğrencilere öğrenme sürecini kontrol etmek ve öğrenme ile ilgili içsel farkındalık yaratmak için bir çok fırsat sunuyor. White'ın (1986) üst bilişi içsel farkındalık olarak tanımladığını düşünürsek ATBÖ yaklaşımının üst bilişsel aktiviteler için fırsat sağladığını düşünebiliriz. Ayrıca, ATBÖ yaklaşımında öğrencilerin bilgilerini deney, gözlem ve müzakere yoluyla elde etmeleri onlarda bilimsel bilgilerin oluşturulma ve geliştirilme süreciyle ilgili farkındalık yaratabilir.

Yukarıda bahsedildiği gibi ATBÖ yaklaşımı öğrencilerin başarılarını, üst bilişlerini ve epistemolojik inançlarını etkileyebilir. Bu nedenle bu çalışma, ATBÖ yaklaşımının 8. sınıf öğrencilerinin fen başarılarına, üst bilişlerine ve epistemolojik inançlarına etkisini araştırmayı amaçlamıştır.

Önemli Terimlerin Tanımları

Argümantasyon Tabanlı Bilim Öğrenme Yaklaşımı: Fen derslerinde kullanılan bu yaklaşım araştırma sorgulama tabanlı öğretimle, öğrenme amaçlı okuma ve yazma stratejileri ile argümantasyonu birleştirmiştir (Hand, Norton-Meier, Staker & Bintz, 2009).

Fen Başarısı: Fen dersinde öğrenilenlerin bir göstergesidir. Mevcut çalışmada 0-30 arası SATEG puanlarıyla belirtilmektedir.

Üst Biliş: Öğrencilerin kendi düşünsel süreçleri hakkındaki bilgileri ve kendi öğrenme süreçleri hakkındaki farkındalıklarıdır (Schraw & Moshman, 1995).

Epistemolojik İnanç: Öğrencilerin bilmenin ve bilginin doğası ile ilgili inançlarıdır (Hofer & Pintrich, 1997).

Geleneksel Fen Eğitimi: Öğretmen merkezli bir yaklaşımdır. Laboratuvar uygulamaları içerse de bunlar yöntemin basamak basamak takip edilmesiyle gerçekleşir.

Çalışmanın Önemi

Son 20 yılda yapılan çalışmalarda argümantasyon tabanlı öğrenme yöntemlerinin önemi belirtilse de, bu yöntemler fen sınıflarında sıkça kullanılmamaktadır

(Cavagnetto, 2010). Argümantasyon tabanlı öğrenme yöntemlerini fen derslerinin bir parçası haline getirmek için öğrenme - öğretme sürecine etkilerinin farklı açılardan incelenmesi önemlidir. Bu yöntemlerin uygulanabilirliğinin gösterilmesi onların sadece teorik bilgi olarak alanyazında kalmasının önüne geçebilir. Diğer yandan yöntemin sınırlılıklarının ve zorluklarının belirtilmesi uygulama yapan kişinin bu konulara dikkat etmesini sağlayarak yöntemin verimini arttırabilir.

Öğrenciler kendi öğrenmelerini yapılandırdıklarında ezberin önüne geçerek anlamlı öğrenmeler gerçekleştirirler. Bu nedenle üst bilişsel gelişim, anlamlı öğrenme gerçekleştirmede hayati bir öneme sahiptir (White, 1998; Georghiades, 2004; Thomas, 2012). Buna ek olarak Hand, Lawrance ve Yore (1999) öğrencilerin fen öğrenmesinin onların epistemolojik inançlarında farkındalık oluşturmalarıyla tam olarak mümkün olacağını belirtmişlerdir. Alanyazında fen başarısının, üst bilişsel becerilerle (Akyol vd., 2010; Topçu & Yılmaz-Tüzün, 2009) ve epistemolojik inançlarla (Kızılgüneş vd., 2009; Tsai, 1998) ilişki içerisinde olduğu vurgulanmıştır. Görüldüğü gibi fen başarısı elde etmede öğrencilerin üst bilişleri ve epistemolojik inançları önemli bir rol üstlenmektedir. Bu yüzden ATBÖ yaklaşımının öğrencilerin fen başarısı üzerindeki etkisini incelerken, başarının önemli elementlerinden olan üst biliş ve epistemolojik inançları da incelemek önemlidir. Ancak, alanyazında ATBÖ yaklaşımının öğrencilerin üst bilişi ve epistemolojik inançları üzerindeki etkisini inceleyen çalışma sayısı çok sınırlıdır. Bu yüzden bu çalışmanın ve sonuçlarının alanyazındaki boşlukları doldurmaya yardımcı olacağı, ayrıca öğretmenler, kitap yazarları ve program geliştirme uzmanlarına uygulama konusunda ışık tutacağı düşünülmektedir.

Yöntem

Örneklem

Araştırmanın evrenini, Adana ilinin Çukurova ilçesinde eğitim gören 8. sınıf öğrencileri oluşturmaktadır. Araştırmanın katılımcıları kolaylık örnekleme yolu ile seçilen bir devlet okulunun 8. sınıf öğrencileridir. Bahsi geçen okulda 2 adet 8. sınıf bulunmaktadır. Bu sınıflardan biri rastgele deney grubu, diğeri karşılaştırma grubu olarak seçilmiştir. Deney grubunda 16 kız, 15 erkek olmak üzere 31 öğrenci bulunmaktayken, karşılaştırma grubunda 13 kız 16 erkek öğrenci bulunmaktadır. Öğrencilerin yaşları 13-15 arası değişmektedir. Öğrencilerin geçmiş dönem fen notları ve TEOG sınavındaki fen sonuçları incelendiğinde, öğrencilerin % 38.3 ünün 80–100 arası; % 48.3 ünün 60-79 arası; % 11.7 sinin 40-59 arası ve % 1.7 sinin 20-39 arası notlar aldığı görülmüştür.

Araştırma Soruları

Bu araştırmanın üç ana araştırma sorusu bulunmaktadır.

Araştırma Sorusu 1: Argümantasyon tabanlı bilim öğrenme yaklaşımının geleneksel yöntemlerle karşılaştırıldığında 8. sınıf öğrencilerinin fen başarılarına etkisi nedir?

Araştırma Sorusu 2: Argümantasyon tabanlı bilim öğrenme yaklaşımının geleneksel yöntemlerle karşılaştırıldığında 8. sınıf öğrencilerinin üst bilişlerine etkisi nedir?

Araştırma Sorusu 3: Argümantasyon tabanlı bilim öğrenme yaklaşımının geleneksel yöntemlerle karşılaştırıldığında 8. sınıf öğrencilerinin epistemolojik inançlarına etkisi nedir?

Araştırma Yöntemi

Bu araştırmada nicel çalışma yöntemlerinden yarı–deneysel çalışma yöntemi kullanılmıştır. Yarı-deneysel çalışmalar, raslantısal olmadan tasarlanan müdahaleli çalışmalar olarak tanımlanabilir (Fraenkel & Wallen, 2006). Çalışmada deney grubunda 13 hafta boyunca konular ATBÖ yaklaşımı kullanılarak işlenmiştir. Diğer yandan karşılaştırma grubunda konular geleneksel yöntemlerle anlatılmıştır. Sadece son-test yöntemi kullanılmıştır. Çalışmanın başında uygulanan ön-testler gruplar arasında fark olup olmadığını anlamak için kullanılmıştır.

Veri Toplama Araçları

Çalışmanın verileri araştırmacı tarafından düzenlenen 8. Sınıflar için Fen Başarı Testi, Schraw ve Dennison (1994) tarafından hazırlanıp, Sungur ve Şenler (2008) tarafından Türkçe'ye uyarlanan Üst Bilişsel Farkındalık Ölçeği ve Conley vd. (2004) tarafından hazırlanıp, Özkan (2008) tarafından Türkçe'ye uyarlanan Epistemolojik İnançlar Ölçeği aracılığıyla toplanmıştır.

8. Sınıflar için Fen Başarı Testi

Öğrencilerin başarıları ile ilgili veriler 8. Sınıflar için Fen Başarı Testi aracılığıyla toplanmıştır. Ölçekte "Ses", "Canlılar ve Enerji İlişkileri", "Maddenin Halleri ve Isı" ve "Yaşamımızdaki Elektrik" ünitelerinden sorular bulunmaktadır. Sorular hazırlanırken son 10 yılda çıkmış TEOG, SBS gibi ulusal sınavlar ile PISA, TIMSS gibi uluslararası sınavlardan yararlanılmıştır. Ayrıca, soru oluşturulma sürecinde Marzano ve Kendall (2007) tarafından hazırlanan Bloom'un yenilenmiş taksonomisi göz önüne alınmış ve hazırlanan test ile 150 öğrencinin katıldığı pilot çalışma uygulaması yapılmıştır. Madde analizi sonuçlarına göre 2 sorunun çeldiricilerinde sorun olduğu farkedilmiş ve testten çıkarılmıştır. Testin son hali 30 sorudan oluşmaktadır. Ayrıca testin Cronbach alfa güvenirlik katsayısı 0.87 olarak belirlenmiştir. Pallant' a (2007) göre bu katsayı ölçeğin güvenilir olduğunu göstermektedir.

Üst Bilişsel Farkındalık Ölçeği

Öğrencilerin üst bilişleri ile ilgili veriler Schraw ve Dennison (1994) tarafından hazırlanıp, Sungur ve Şenler (2009) tarafından Türkçe'ye uyarlanan Üst bilişsel Farkındalık Ölçeği kullanılarak toplanmıştır. 52 maddeden oluşan, beşli likert tipi ölçek kendini rapor etmeye dayalıdır. Üst biliş, biliş bilgisi ve bilişin düzenlenmesi olmak üzere iki temel öğeden oluşmaktadır. Biliş bilgisi, bildirimsel bilgi, yordam bilgisi ve duruma dayalı bilgi olmak üzere üçe ayrılırken; bilişin düzenlenmesi planlama, bilgi yönetimi, izleme, hata giderme ve değerlendirme gibi becerilerden oluşmaktadır. Orijinal ölçek üniversite öğrencileri için hazırlanmış olup, ölçeğin 8. sınıf öğrencilerine uygun olup olmadığını anlamak için 200 öğrenciyle pilot çalışma yapılmıştır. Alt boyutlar doğrulayıcı faktör analizi yöntemi ile doğrulanmıştır. Ayrıca testin Cronbach alfa güvenirlik katsayısı 0.95 olarak belirlenmiştir. Pallant' a (2007) göre bu katsayı ölçeğin çok güvenilir olduğunu göstermektedir. Alt boyutların güvenirlik katsayıları ayrı ayrı incelendiğinde bu katsayıların uygun olduğu, ayrıca

Sungur ve Şenler (2009) tarafından rapor edilien katsayılara da yakın olduğu görülmüştür.

Epistemolojik İnançlar Ölçeği

Öğrencilerin epistemolojik inançları ile ilgili veriler Conley vd. (2004) tarafından hazırlanıp, Özkan (2008) tarafından Türkçe'ye uyarlanan Epistemolojik İnançlar Ölçeği kullanılarak toplanmıştır. 26 maddeden oluşan, beşli likert tipi ölçek kendini rapor etmeye dayalıdır. Orijinal ölçek, bilginin kaynağı, bilginin kesinliği, bilginin gelişen doğası ve bilginin doğrulanması olmak üzere 4 alt boyut içermektedir. Türkçe'ye uyarlanmış versiyonunda bilginin kaynağı ve bilginin kesinliği birlikte bir alt boyutu oluşturmuşlardır. Ayrıca 2 madde ölçekle negatif ilişki içerisinde olduğundan analiz dışı bırakılmıştır. Özkan'ın (2008) ilköğretim 7. sınıflarla yaptığı çalışmanın Cronbach alfa güvenirlik katsayısı 0.76 olarak raporlanmıştır. Pallant' a (2007) göre bu katsayı ölçeğin güvenilir olduğunu göstermektedir. Bu nedenle epistemolojik inançlar ölçeği bu çalışmada 3 alt boyut 24 madde ile uygulanmıştır.

Veri Toplama Süreci

Uygulamalı Etik Araştırma Merkezi'nden etik izinler alındıktan sonra uygulama yapılacak okul yönetimi ile görüşüldü ve onlar çalışmanın amacı hakkında bilgilendirilerek onayları alındı. Ayrıca öğrencilerin velilerinden de onaylar alınarak çalışma süreci başladı. Ölçeklerin pilot çalışmaları Ocak 2014 te tamamlandı. Esas çalışma 2014 Şubat ayının son haftasında başlayıp 15 hafta sürdü. Çalışmanın ilk haftasında deney grubuna ATBÖ yaklaşımı hakkında bilgiler verildi ve iki gruba da ön-testler uygulandı. Uygulama 13 hafta devam etmiş olup, son hafta son-testler uygulanmıştır.

Veri Analizi

Araştırmanın verilerinin analizinde SPSS 19 paket programı kullanılmıştır. Üst Bilişsel Farkındalık ve Epistemolojik İnançlar ölçekleri alt boyutlar içerdiği için bu ölçeklerin analizi herbir alt boyut bir bağımlı değişken olarak alınıp çoklu varyans analizi (MANOVA) ile yapılmıştır. Ayrıca, grupların fen başarıları t testi ile kıyaslanmıştır.

Bulgular ve Tartışma

Ön-test sonuçlarında deney ve karşılaştırma grubu arasında öğrencilerin fen başarıları, üst bilişsel farkındalıkları ve epistemolojik inançları yönünden istatistiksel olarak anlamlı bir fark bulunmamıştır. Yani uygulama öncesinde gruplar yukarıda bahsedilen yönlerce birbirine benzerdir. Son-test sonuçları incelendiğinde gruplar arasında (deney grubu lehinde) anlamlı istatistiksel farklar bulunmuştur.

Uygulama sonrasında 8. Sınıflar için Fen Başarı testi sonuçları ATBÖ yaklaşımının öğrencilerin fen başarısı (η^2= .36) üzerine büyük etki değeri yarattığını göstermektedir (Cohen, 1988). Deney grubundaki öğrencilerin ortalaması 26.45 çıkarken, bu ortalama karşılaştırma grubunda 19.72 çıkmıştır. Testin 30 soru olduğu ve bu testin konuların öğrenilme seviyesini ölçtüğü düşünüldüğünde deney grubundaki öğrencilerin konuları daha iyi öğrenmiş olduğu çıkarımı yapılabilir. Bunlara ek olarak ön-test ve uygulama öncesi TEOG sonuçlarına bakılarak deney grubundaki düşük başarılı öğrenciler ve yüksek başarılı öğrenciler arasındaki başarı farkının azaldığı da söylenebilir. Bu sonuçlar alanyazınındaki ATBÖ yaklaşımının öğrencilerin fen başarısını arttırdığını gösteren sonuçlarla paralellik göstermektedir (Greenbowe vd. 2007; Hohenshell & Hand, 2006; Günel vd. 2010; Kıngır vd. 2012). ATBÖ yaklaşımının bu başarısı öğrencilerin kendilerini rahatlıkla ifade edebildikleri, kendi öğrenmelerini yapılandırdıkları, akran öğrenmesi ve geçmiş bilgilerin sorgulatılması yoluyla anlamlı öğrenmelerin gerçekleştiği öğrenme ortamları sunmasıyla açıklanabilir. ATBÖ yaklaşımında öğrenciler bilgiyi sorular sordukları, iddialar oluşturdukları ve bu iddialarını kanıtlarla destekledikleri araştırma-sorgulamaya dayalı bir öğrenme ortamında yapılandırmaktadırlar. Dolayısıyla bu yaklaşım öğrencilerin öğrenme sürecine katılımlarını arttırarak daha etkin bir öğrenme ortamı oluşturulabilmektedir.

Üst Bilişsel Farkındalık ölçeğinin son-test sonuçları ATBÖ yaklaşımının, bildirimsel bilgi (η^2= .29), planlama (η^2 =.23), bilgi yönetimi (η^2= .28) ve hata giderme (η^2=

.24) alt boyutlarında büyük etki değeri; izleme (η^2= .13) ve değerlendirme (η^2= .13) alt boyutlarında orta etki değeri yarattığını göstermektedir (Cohen, 1988). Yordam bilgisi ve duruma dayalı bilgi alt boyutlarının ortalamalarının deney grubunda daha yüksek olduğu gözlense de istatistiksel olarak anlamlı bir fark bulunmamıştır. ATBÖ yaklaşımının doğası düşünüldüğünde bu sonuçlar şaşırtıcı değildir. Birçok araştırmacı üst biliş farkındalığının sınıf içi aktivitelerle gelişebildiğini göstermiştir (Brown & Pressley, 1994; Schraw, 1998; Kipnis & Hofstein, 2008). ATBÖ yaklaşımı da öğrencilerin üst bilişsel becerilerini kullanmaları için fırsat sunmaktadır (van Opstal & Daubenmire, 2014; Wallace & Hand, 2004; Choi, 2008; Akkuş vd. 2007). Örneğin, bu yaklaşımın en önemli elementlerinden biri "büyük düşünce"dir. Büyük düşünce, konunun sonunda öğrencilerin ulaşması planlanan odak nokta olarak tanımlanabilir. Büyük düşüncenin açıkça belirtilmesi, öğrencilerin öğretmenlerinin kendilerinden neyi istediğini anlamalarını sağlayabilir. Böylece öğrencilerin planlama becerileri gelişebilir. Benzer bir şekilde konunun öncesinde ve sonrasında kavram haritasının yapılması öğrencilerde bilgiyi organize etme becerisi oluşturabilir. Karşılaştırma grubunda da laboratuvar uygulamaları yapılmış olup, bu gruptaki öğrenciler de deneyi tamamlama, verileri analiz etme, deneyi değerlendirme ve deneyle ilgili rapor yazma gibi süreçlerden geçmişlerdir. Bu süreçlerde planlama, izleme ve değerlendirme gibi düzenleme becerilerini kullanmışlardır. Ancak bu öğrencilerin düzenleme becerilerinin, deney grubu öğrencilerine göre daha düşük seviyede olduğu gözlenmiştir. Piaget'e göre düzenleme becerileri herzaman bilinçli deneyimler olmayabilir (Brown, 1987). ATBÖ yaklaşımında kullanılan öğrenci rapor şablonu öğrencilere yansıtıcı bir rehber gibi hizmet etmektedir. Bu yansıtıcı rehber açıkça sorduğu sorularla öğrencilerin süreç boyunca kullandıkları düzenleme becerilerinin farkına varmalarını sağlayarak bunları bilinçli birer deneyim haline getirebilir (van Opstal, 2014).

Epistemolojik İnançlar ölçeğinin son-test sonuçları ATBÖ yaklaşımının bilginin doğrulanması (η^2 = .23) ve bilginin gelişen doğası (η^2 = .22) alt boyutlarında büyük etki değeri yarattığını göstermektedir (Cohen, 1988). Diğer yandan bilginin kaynağı ve bilginin kesinliği alt boyutunun ortalamasının deney grubunda daha yüksek olduğu gözlense de istatistiksel olarak anlamlı bir fark bulunmamıştır. ATBÖ yaklaşımının epistemolojik inançlar üzerindeki etkisi doğrudan incelenmemiş olsa da bu olumlu etkiler alanyazındaki konu ile ilgili araştırmalar düşünüldüğünde şaşırtıcı değildir. NRC (2000) raporu, araştırma sorgulama tabanlı öğrenme yaklaşımlarının öğrencilerin bilim hakkında daha sofistike düşünceler geliştirmesine olanak verdiğini göstermektedir. Ayrıca Wu ve Wu (2011) ve Kaynar vd. (2009) yaptıkları çalışmalarla araştırma sorgulama tabanlı öğrenmenin öğrencilerin epistemolojik inançlarında olumlu farklar yarattığını belirtmişlerdir. Araştırma sorgulama tabanlı öğrenmeye benzer olarak ATBÖ uygulamalarında da öğrencilerin araştırılabilir sorular oluşturduğu, öğretici deneyler tasarladıkları, bu deneylerden kanıt topladıkları ve iddialarını bu kanıtlara dayandırdıkları düşünülürse yaklaşımın epistemolojik inançları geliştirmedeki etkisi daha iyi anlaşılabilir.

Sandoval (2005) öğrencilerin bilgiyi sıradan insanlar olarak kendilerinin de üretebildiklerine ya da bu bilgilerin araştırma süresince değişebildiğine şahit olmalarına rağmen bunu profesyonel bilimden ayrı bi yerde tuttuklarını böylece bilginin kaynağı ve bilginin kesinliği ile ilgili düşüncelerinin yapılan uygulamalar sonrasında istenilen şekilde gelişim göstermediğini söylemiştir. Wu ve Wu (2011) ise öğrencilerin epistemolojik inançlarını ders sırasında daha açık ifade edebilecekleri uygulamaların bilginin kaynağı ve bilginin kesinliği ile ilgili inançların gelişmesine katkı sağlayabileceğini belirtmişlerdir.

Araştırmanın Varsayımları

Araştırmanın varsayımları aşağıdaki gibi sıralanabilir:

1. Araştırmada kullanılan ölçekler öğrencilerde hedeflenen etkileri doğru bir şekilde ölçmektedir.
2. Deney grubu öğrencileri karşılaştırma grubuyla etkileşimde bulunmamıştır.
3. Öğrenciler ölçme araçlarındaki soruları bağımsız ve içtenlikle cevaplandırmışlardır.
4. Araştırmacı gruplara yansız davranmıştır.

5. Laboratuvar aktiviteleri süresince tüm grup üyeleri eşit sorumluluk almışlardır.
6. Öğrenciler okul dışı öğrenmelerden etkilenmemişlerdir.
7. Kontrol edilemeyen tüm değişkenler iki grubu da eşit şekilde etkilemiştir.

Araştırmanın Sınırlılıkları

1. Çalışma ses, canlılar ve enerji ilişkileri, maddenin halleri ve ısı ve yaşamımızdaki elektrik konularıyla sınırlıdır.
2. Kolaylık Örnekleme yöntemi kullanıldığı için ve çalışma ulaşılabilir örneklemin çok küçük bir kısmını kapsadığı için çalışmanın sonuçları genellenemez.
3. Bulgular ve yorumlar yapılan istatistiksel ve nitel tekniklerle sınırlıdır.

ATBÖ Yaklaşımının Sınırlılıkları

ATBÖ yaklaşımı uygulamaları sırasında bazı zorluklar gözlenmiştir. Örneğin, öğrenciler ünitelerin büyük düşünceleriyle ilgili kendi araştırma sorularını oluştururken bazen öğretim programı sınırları dışına çıkmışlardır. Norton-Meier vd. (2008) ATBÖ dersleri planlanırken kazanımları esnek tutmak, öğretim programıyla sınırlandırmamak gerektiğinin altını çizmişlerdir. Ancak, Türkiye'de öğretim süreci ortak sınavlarla değerlendirildiğinden ve öğrencilerin iyi lise ve üniversitelerde okumaları bu sınavlara bağlı olduğundan öğretim programına bağlı kalmamak ciddi bir sorun teşkil etmektedir. Yaşanan bir diğer sıkıntı da öğrencilerin kendi bilgilerini yapılandırmaya alışık olmamaları ile alakalıdır. Öğretmen merkezli geleneksel öğrenme yöntemlerine alışkın olan öğrenciler kendilerine bilginin hazır olarak verilmesini beklediklerinden özellikle uygulamanın başlarında kendi sorularını oluşturmakta ciddi zorluklar yaşamışlardır. Bu zorlukların aşılması için öğretmenlerin iyi bir gözlemci ve rehber olması önemlidir. Öğretmenler sordukları sorularla öğrencileri düşünmeye, bazen de farklı düşünmeye yönlendirmeli ve onların doğruya ulaşmalarını sağlamalıdır. Bu durum öğretmenlerin iyi bir alan bilgisinin yanında pedagojik bilgisinin de yüksek olmasıyla mümkün olacaktır. Bunlara ek olarak ATBÖ yaklaşımı uygulamalarında sınıf yönetiminde bazı zorluklar yaşanmaktadır. Öğrenciler grup çalışmaları ve müzakereler sırasında heyecanlanabilmekte ve sınıftaki ses seviyesi yükselebilmektedir. Bu durum geleneksel eğitim öğretim anlayışını benimsemiş idareciler tarafından sorun olarak algılanabilmektedir.

Doğurgalar

Fen bilimleri öğretim programı 2005 yılında yapılandırmacı yaklaşımın temellerinde yeniden tasarlanmıştır. 2013 yılında ise program bir daha gözden geçirilerek, araştırma sorgulama tabanlı yaklaşımların ve argümantasyonun fen eğitimindeki önemi vurgulanmıştır. Buna rağmen ne yazık ki bu durum fen derslerinin işlenişine pek yansımamıştır. Yapılan çalışmalar öğretmenlerin araştırma sorgulama tabanlı öğretim yöntemlerinin uygulamalarında sorun yaşadıklarını göstermektedir. Argümantasyon tabanlı bilim öğrenme yaklaşımı, araştırma sorgulama tabanlı eğitimi öğrenme amaçlı yazma ve okuma aktiviteleri ile zenginleştirip, akran müzakereleri ile birleştirmiştir. Bu yaklaşım öğretmenlere uygulama sırasında onların takip edebilecekleri bir şablon sunduğu için onlara bir rehber olarak uygulama kolaylığı sağlayacaktır.

Bu çalışma ATBÖ yaklaşımının öğrencilerin fen başarısına, üst bilişsel farkındalığına ve epistemolojik inançlarına olumlu etkilerinin olduğunu göstermektedir. Geçmiş çalışmalar da bu yaklaşımın öğrencilerin kavramsal anlama ve kritik düşünme becerilerini, bilimin doğası ile ilgili görüşlerini ve fen dersine karşı tutumlarını olumlu etkilediğini göstermiştir. Bu yüzden öğretmenler, program geliştirme uzmanları ve kitap yazarları ATBÖ yaklaşımının önemi ve uygulamaları konusunda bilgilendirilmelidirler. Soru – iddia – kanıt üçlemesine dayalı daha çok etkinlik geliştirilmeli ve ders kitapları bu etkinliklerle zenginleştirilmelidir. Ayrıca laboratuvarlar gerekli materyallerle düzenlenmeli, öğrencilerin araştırmalarını yapabilmeleri için internet bağlantısı ya da ders kitabına ek kaynak kitaplar sağlanmalıdır.

Bu çalışma ve diğer mevcut çalışmalar öğrencilerin bağımsız öğrenen olmasında üst bilişsel farkındalığın önemini gözler önüne sermektedir. Üst bilişsel beceriler fen eğitiminin en önemli parçalarından biridir. Dolayısıyla, öğretmenler öğrencilerinde üst bilişsel farkındalığı geliştirmek için çalışmalar yapmalılardır.

Fen eğitiminin en önemli amaçlarından biri tüm öğrencileri fen okur-yazarı bireyler olarak yetiştirmektir. Fen okur-yazarı olmak bilginin ve bilmenin doğasını yani epistemolojiyi anlamayı gerektirir. Ayrıca epistemolojik inançların gelişmesi fen başarısında artışı da paralelinde getirmektedir. Bu nedenle öğretmenler bu konuyu daha çok önemsemelidirler.

İleriki Çalışmalar için Öneriler

İleriki çalışmalar için aşağıdaki öneriler sunulabilir:

1. Benzer araştırma konuları farklı yaş grupları, farklı okul türleri ve farklı fen bilimleri konularıyla tekrarlanabilir.
2. Daha uzun süreli çalışmalar yapılabilir.
3. ATBÖ raporları ve sınıf içi tartışmalar incelenebilir.
4. Akran müzakeresinin etkileri niteliksel olarak incelenebilir.
5. ATBÖ uygulamalarında öğrencilerin kendi oluşturdukları bilgileri kaynaklarla karşılaştırmasının epistemolojik inanışlarda bilginin kaynağı ve kesinliği boyutunu nasıl etkilediği araştırılabilir.

APPENDIX K: TEZ FOTOKOPİSİ İZİN FORMU

ENSTİTÜ

Fen Bilimleri Enstitüsü ☐

Sosyal Bilimler Enstitüsü ☐

Uygulamalı Matematik Enstitüsü ☐

Enformatik Enstitüsü ☐

Deniz Bilimleri Enstitüsü ☐

YAZARIN

Soyadı : TUCEL
Adı : SABAHAT TUĞÇE
Bölümü : İlköğretim Fen ve Matematik Alanları Eğitimi

TEZİN ADI: Investigating the effects of science writing heuristic approach on eight grade students' achievement, metacognition and epistemological beliefs

TEZİN TÜRÜ : Yüksek Lisans ☐ Doktora ☐

1. Tezimin tamamından kaynak gösterilmek şartıyla fotokopi alınabilir. ☐
2. Tezimin içindekiler sayfası, özet, indeks sayfalarından ve/veya bir bölümünden kaynak gösterilmek şartıyla fotokopi alınabilir. ☐
3. Tezimden bir bir (1) yıl süreyle fotokopi alınamaz. ☐

TEZİN KÜTÜPHANEYE TESLİM TARİHİ: