Bilişsel Süreç ve İlköğretim Bilim Eğitiminde Öğrenme Aracı Olarak Yazma

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ÖZ. Yazma eylemi dilbilimi, psikoloji ve edebiyat alanlarında pek çok teorik ve emprik çalışmaya konu olmuştur. Bilişsel bir süreç olarak yazma, öğrenme kabul edildiği gibi aynı zamanda öğrenmeyi sağlayan ve destekleyen bir mekanizma olarak algılanarak bilim eğitimi gibi alanların öğretimine adapte edilmiştir. Bilim ve dil eğitimi alanları yazmayı öğrenmede kullanılacak çok güçlü bir öğrenme aracı olarak kabul etmiştir (Keys, 1999). Araştırmacılar bilim eğitiminde özelliklede ilköğretim alanında geleneksel olarak kullanılan ve bilimsel yazmanın mikro ve makro yapılarını öne çıkaran söylemlerden (genre) uzaklaşıp, öğrenciler için anlamlı ve yaratıcı yazma aktivitelerinin kullanılmasını vurgulamışlardır. Bu derleme öğrenme aracı olarak yazma sürecini ve bu aracın ilköğretim seviyesinde bilim eğitiminde kullanımını tartışmaktadır.
Anahtar Kelimeler: Yazma, öğrenme amaçlı yazma, bilimsel okur yazarlık, ilköğretim fen eğitimi

ÖZET

Yazma eyleminin bilişsel ve psikolojik olarak içerdiği süreçler pek çok araştırmacının ilgisini çekmiş ve yine birçok araştırmaya konu olmuştur. Beretier ve Scardamalia (1987) gibi dil bilimci psikologlar yazmayı var olan "bilgiyi söyleme" ve "bilgiyi dönüştürme" modellerini geliştirerek açıklamaya çalışmışlardır. Bilgiyi söyleme modelinde, gerekli olan bilgi uzun sureli hafızadan alınarak yazıya dönüştürülmektedir. Bilgi dönüştürme modeline göre ise bilgi dönüştürmeye aktif bir problem çözümü aracılık etmektedir. Problem çözme esnasında yazarın var olan iki kaynağı aktif olarak etkileşim halindedir. Bunlar, alan bilgisi (content space) ve dil bilgisidir (linguistic space). Var olan kavramlardan hoşnutluğun olmadığı durumlarda bu iki alanın etkileşmesiyle yeni bilgiler hazırlanır ve yazar konu hakkında yeni bir öğreti geliştirir. Sonraki yıllarda Galbraith, (1999) problem çözme modelinin yazma sürecinin içeriğini açıklamada yüzeysel kaldığını iddia etmiştir. Ayrıca problem çözme metaforunun yazma surecinde öğrenme gerçeklemesi durumunu açıklayamadığını savunmuştur. Ona göre, incelenmesi gereken en temel unsurlardan birisi bilginin saklanma-depolanma şeklidir. Bilgi cümleler halinde yığılarak değil, semantic bir ağ ile zihnin her yerinde, diğer olgularla bağdaştırılarak saklanır. Ve her hangi bir bilgiyi çağırdığımızda-aktive ettiğimizde pek çok farklı domain bu aktivasyona karşılık verir. Yazma esnasında ise yazılacak konu, dinleyici kitlesi, yazma formatı, içerik ve pek çok diğer unsurlar aktivasyonun içeriğini ve sınırlarını belirler. Ayrıca, yaratılan her bir aktivasyon sonucu üretilen yazı yeni bir girdi olarak yepyeni aktivasyon döngüleri oluşturur. Sınırlıklar ve farklı aktivasyonlar yeni öğrenmeleri sağlar.

Yazmayı bir öğrenme mekanizması olarak tanımlayan linguistic ve psikoloji alanlarındaki teorik ve empirik çalışmaların etkileri eğitim bilimlerinde de kendini göstermiştir. Pek çok dal yazmayı müfredatının içerisine almıştır, fakat yazmanın amacı konusunda çelişkiler doğmuştur. Örneğin, bilim eğitimi alanındaki bazı araştırmacılar, Halliday ve Martin (1993), bilim eğitiminde yazmanın bilimsel söylemler (rapor tutma, gözlem kayıtları vb.) içerisinde gerçekleşmesini savunmuşlardır. Öte yandan, Alvermann (2004), Gee (2004), Prain ve Hand (2005), and Yore ve Treagust (2006) gibi araştırmacılar yazmanın geleneksel sınırların dışında bir formatta olup, hem ilköğretim öğrencilerinin günlük dilleri ile bilimsel dili bağdaştıracak yapıya sahip olması gerektiğini savunmuşlar, hem de geleneksel olmayan yazma aktivitelerinin kullanılmasının bilimsel kavramları öğrenmede faydalı bir metot olduğunu vurgulamışlardır. Bu görüşün temsilcileri yazarak öğrenme aktiviteleri öğrencilerin kabul gören standart bilimsel bilgilere erişmelerine yüreklendiren, öğrencilerin epistemolojik inançlarını, ve akıl yürütme stratejilerini bilimin doğası iskeleti etrafında vücuda getiren ve öğrencilerin bilimsel kavramları öğrenmesinde yukarıda sözü geçen öğeleri entegre eden bir araç olarak benimsemişler ve bu alanda çalışmalarda bulunmuşlardır.

Dünyanın pek çok ülkesinde ilköğretim bilim eğitimi dâhil, müfredatın bir parçası olan öğrenme amaçlı yazma ülkemizde henüz yeterince gündeme alınmamıştır. Gerek müfredatın içeriği gerekse bilim eğitimi araştırmalarının gündemini meşgul etmeyen öğrenme amaçlı yazma aktiviteleri bizler için keşfedilmeyi bekleyen yeni olgulardır. Türk eğitim sisteminde hedeflenen amaçlardan biri olan "bilimsel okuryazarlığı geliştirme" ve anlamlı bilim öğrenmeyi destekleme adına öğrenme amaçlı yazma araştırmaları ülkemiz araştırmacılarına yeni ufuklar açabilir.

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Writing as a Cognitive Process and Learning Tool in Elementary Science Education

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ABSTRACT. The action of writing has been subject of several empirical and theoretical studies in the areas of linguistic, psychology and literacy. Not only writing as a cognitive process is considered to be leaning, but also it has been adopted and used as learning and scaffolding mechanism by different disciplines such as science education. Research on language and learning in the science content area has emphasized the use of writing as a powerful learning tool (Keys, 1999b). Moving away from teaching traditional scientific genres, which emphasize the need for students to learn micro and macro structures of the genres of science writing to be able to understand science, researchers have focused more on expressive and creative writing that promotes meaningful learning in science. Especially in the area of elementary science education there has been growing number of reform movements and research studies that emphasize the significance of writing as a learning tool.

Key words: Writing, Writing to learn, science literacy, primary science education

INTRODUCTION

Cognitive process models have attempted to identify the cognitive activities that involved in writing (Bereiter & Scardamalia, 1987; Flower & Hayes, 1980). These models tend to view writing as a problem solving activity and also distinguish between expert and novice writers (Rijlaarsdam, Couziijn, Janssen, Braaksma, & Kieft, 2006). As a result of these models, Bereiter and Scardamalia (1987) suggested two different views of writing: knowledge telling (in which students simply repeat back information they have on a particular topic) and knowledge transformation (in which student writing is driven more by rhetorical constraints). On the other hand, writing from a composition point of view is typically considered the interaction of the processes of the author generating, structuring, translating, and revising his or her own ideas and the author attempting to communicate those idea. (Bereiter & Scardamalia, 1987; Galbraith, 1999; Howard & Barton, 1986). While there is a massive body of research has been conducted to investigate cognitive aspect of writing there is also grooving body of literature that investigates "learning to write" that focuses on the factors involved in student acquisition of writing skills and what can be done in educational settings to promote this acquisition (Rijlaarsdam et al., 2006). Hillocks (1986) provides an exhaustive discussion of the multitude of factors involved with this area of research.

Research in the education is currently focused on establishing the theoretical underpinnings of why writing facilitates this type of learning and what happens cognitively that leads to increased learning. As this research base grows, one new area of discussion is how science education practitioners can design meaningful and effective writing activities and what the characteristics of these activities should be. This involves exploring a number of task factors in relation to the writing activities in several domains such as science education.

Writing employed in science classrooms, especially in the elementary and middle school levels, however, has been traditionally focused only on the communication aspect of writing and this communication is generally to the teacher for evaluative purposes (Monhardt, 1996). Writing activities designed for use in elementary science classrooms based on writing-to-learn strategies, conversely, attempt to focus on the use of writing as a tool to promote conceptual change in the author as a result of writing (Holliday, Yore, & Alvermann, 1994). Science educators and researchers agree that the goal of writing-to-learn activities is the creation of learning situations and environments in school settings that

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allow for meaningful writing, the encouragement of critical thinking and the evolution of conceptual understanding (Holliday et al., 1994). The purpose of this paper is two folded; first to establish theoretical framework of cognitive processes during the writing which leads learning, second, to discuss application of "writing-to-learn" approach into science education domain by giving concrete frameworks that may possibly be used in the elementary and middle school science classrooms.

COGNITIVE PROCESS OF WRITING

Writing is a sophisticated task that requires the application of several cognitive processes. The complexity of writing is associated with the nature of the task, the writer's goal, and the syntactic and grammatical rules required by the tasks (Denis Alamargot & Chanquoy, 2001). Added to these demands is the need for students to relate with their audience and to formulate and present relevant ideas. All of these factors combine through the written word to produce a satisfactory text. The writer generally must make a number of drafts, corrections, deletions, and additions to the text after considering writing cues such as goals, state of writing, and topic to produce the final product. Such translation of thoughts into a written format involves a complex cognitive mechanism, and, as a consequence, diverse models to explain the process have been proposed in both the psychology and the linguistic disciplines (Bereiter & Scardamalia, 1987; Galbraith, 1999; Hayes & Flower, 1980, 1987; Klein, 1999).

The different models of written composition, called *blueprints* by Alamargot and Chanquoy (2001), allow researchers to focus on different dimensions of writing while retaining consideration for the complexity of whole cognitive action. The common feature of these blueprints is that they tend to propose an analytic definition, or map, of the writing process in which the processes and sub-processes, and definitions and arrangements of them, are articulated by providing rules, constraints, and limitations. Even though numerous experimental research studies guided by different models have been conducted, there has not been a clear formulation of the complex cognitive mechanism of writing (Alamargot & Chanquoy, 2001; Klein, 1999).

Hayes and Flower (1980) attempted to explain the writing process by adopting a cognitive approach in which writing is perceived as a set of mental processes that are not only rigidly graded but also are embedded in nature (Hand, 2004). Furthermore, in their model, writing is perceived as a confirmed and multifaceted activity since it requires writers to process and implement an adequate amount of knowledge through several mental activities (Alamargot & Chanquoy, 2001). In his extensive review of writing models Hand (2004) identified four foundation stones necessary to understanding Hayes and Flower's model:

1. The process of writing is best understood as a set of distinctive thinking processes that writers orchestrate or organize during the act of composing.
2. These processes have a hierarchical, highly embedded organization in which any given process can be embedded within any other.
3. The act of composing itself is a goal-directed thinking process, guided by the writer's own growing network of goals.
4. Writers create their own goals in two key ways: by generating both high-level goals and supporting sub-goals which embody the writer's developing sense of purpose, and then, at times, by changing major goals or even establishing entirely new ones based on what has been learned in the act of writing (p. 366).

The model has three main components: task environment, the writer's long-term memory, and the general writing process. Hayes and Flower have defined each of these as: (a) task environment; where all outside factors, such as topic, audience, motivation, and text produced so far, can influence writing and must be considered; (b) the writer's long-term memory, in which the writer's conceptual, pragmatic, linguistic, and lexical knowledge are stored and can be used to guide and complete the task; and (c) the general writing process, which refers to the process of translating writer's knowledge of the topic into linguistic form, which consists of four essential parts–planning, translating, reviewing, and monitoring.

The planning process includes generating ideas from the writer's long-term memory, organizing the ideas according to the given task, and creating goals to evaluate the written text. Translation comprises turning retrieved ideas from long-term memory into a text format, influenced by goals already put in place. Reviewing scrutinizes the quality of the text by reading and editing. The important feature of these processes is that they are not linear cognitive operations that occur in an ordered fashion; instead, they are recursive and concurrent. That is, at any given moment planning, translating, and revisiting can occur in a different order during the writing process (Tynjala, Mason, & Lonka, 2001).

The model Hayes and Flower proposed attempted to incorporate the information, knowledge, and cognitive processing required for writing. Writing was not considered as a product-based, linear activity; instead, writing was referred to as a cognitive process based on a means to monitor the control of planning, writing, and editing at any moment during writing (Galbraith, 1999). In other words, writing was perceived as a goal-driven activity wherein, to accomplish writing task, a writer needs to balance components of the task environment with his or her content knowledge in the environment to be presented, and, thus, the overall result of interactions among those environments operates as a learning tool (Hand, 2004). Finally, the model proposed is reviewed as a problem-solving metaphor, whereby writing is controlled by the writer's general problem-solving skills, rhetorical knowledge, and content knowledge (Galbraith, 1999; Hayes & Flower, 1980).

While Hayes and Flower's model was not adequate enough to explain the particular procedures, functions, and relationship among sub-procedures or the differences between expert and novice writers, their model was the first attempt at creating a framework of the writing process (Alamargot & Chanquoy, 2001). Extending Hayes and Flower's model, Bereiter and Scardamalia (1987) proposed a more defined version of the problem-solving process in writing. What is more, they proposed two types of writing: "knowledge telling-psychology of the nature" and "knowledge transforming- psychology of problematic," recognizing the second type of writing as a learning mechanism (p. 5).

Writing as a knowledge-telling process involves the use of naturally gained (through social interaction) language capability and skills, whereas knowledge transformation through writing encompasses studied ability and skills. By studied skills Bereiter and Scardamalia (1987) meant that, unlike a more naturally developed ability such as casual reading and talking, studied skills involve conscious, strategic control over parts of process such as in critical reading and oratory. The knowledge telling process is employed by mostly children and novice writers and the process entails putting down everything that writer knows about the topic, what Hayes and Flower (1980) called "Get it down as you think" (p. 20). Bereiter and Scardamalia argued that when an audience is not present in the conversation as is the case in writing, children and novice writers encounter the problem of what to say and how to say it during the text production process. While they are constrained by the absence of immediate feedback, they need to use a limited number of cues such as content retrieval from long-term memory, topic, discourse schema, and the text already produced. In other words, "the knowledge-telling model is a model of how discourse productions can go on, using only these sources of cues" and the quality of text produced in this fashion is affected largely by the writers' content knowledge and level of activation in their long-term memory (p. 7).

There are three essential components in the knowledge-telling model. The first component involves mental representation of the assignment, whereby the writer creates the mental representation of the assignment that allows him or her to define the text topic and function. Also, mental representation of the assignment guides the whole rhetorical writing activity. The second component refers to the two types of knowledge stored in the long-term memory, content knowledge and discourse knowledge, both of which need to be articulated. The content knowledge refers to the topic and is what the writer knows related to the topic, and the discourse knowledge is the nature of the task, such as the linguistic, lexical, grammatical, narrative, or argumentative structures that are necessary for producing a written text (Bereiter & Scardamalia, 1987).

The third component in the knowledge-telling model is the process of knowledge telling, which has a close relationship with the other two components (mental representation of the assignment and content and rhetorical knowledge). Knowledge telling presents writing as a display resulting from pre-existing

knowledge about the assignment and knowledge of the topic stored in long-term memory, and it is not conceptualized as a process that can modify either the assignment or content knowledge during the act of writing. In summary, knowledge telling is essentially a "think-say" method, in that ideas are retrieved directly from memory in response to a topic and then translated into text. The condition of the succession of the text is attributed to ideas stored in the memory, similar to the Hayes and Flower model. On the other hand, the *knowledge-transforming* model conceptualizes writing as an act that stimulates thinking; thus, mental representation of the assignment and knowledge of the topic can be modified through the act of writing.

The knowledge-transforming model suggests that writing at the expert level can be a complex problem-solving activity, although it first requires the writer to move through a knowledge-telling phase comparable to that required for knowledge-transforming activities in Hayes and Flower's model. The additional components required for knowledge to be modified involve problem-analyzing and goal-setting activities, which allow the writer to understand the task. The knowledge-transforming model also involves an interaction between the content problem space and rhetorical problem space that allows the writer to explore the content setting and rhetorical setting, that is, respectively, what to tell and to whom and how to tell it. Also, the model proposed by Bereiter and Scardamalia (1987) suggests that there is a possible interaction among content knowledge, the content problem space, discourse knowledge, and the rhetorical problem space that can transform and modify the writer's thought. More specifically, there is a dynamic relationship between where content is stored, thought about, and worked out, and the rhetorical space where goals for the text are worked out, which provides the stimulus for reflection in writing and problem solving (Keys, 1999).

In the knowledge-transforming model, it is assumed that the retrieval and translation of ideas is mediated by active problem solving. However, writing not only is taking information from memory or translating this information. Writing also involves working out new content when existing content does not satisfy goals, and, when realized, writing allows further development of the writer's understandings of the topic (Galbraith, 1999). The importance of writers understanding content may be realized in two ways. First, when already-existing knowledge is not enough to complete the task, the writer has to develop new understandings. Second, the new content, born as a result of dissatisfaction with existing content, is now a new construction of knowledge rather than simply a reflection of old knowledge (Galbraith, 1999).

In brief, while this model recognizes that not all writing can lead to learning, as Langer and Applebee's (1987) found in their empirical study, the model proposes an important structure to illuminate the writing process and pathways to recognize writing as a learning tool. Yet, the way Bereiter and Scardamalia captured the thinking and learning mechanism during the process of writing was criticized by other researchers as being simplistic and unable to capture the unpredictability of thinking (Hand, 2004).

Rather than viewing writing using a problem-solving metaphor as in the knowledge transforming model, cognitive psychologists Galbraith and Torrance (1999) have suggested that writing should be viewed as a text-production model called a romantic position. They have proposed a knowledge constitution model to analyze the process of text production (Denise Alamargot & Andriessen, 2002). The fundamental conflict between the knowledge-transforming or problem-solving model and the knowledge constitution model is that the former accepts writing as text production. In other words, the problem-solving model assumes knowledge is stored in a uniform way so no difference exists between the searching and retrieval processes, which are used during problem solving and text production. In contrast, the knowledge constitution model asserts that the knowledge encoded in sentences is represented within a distributed network of conceptual relationships.

Moreover, in the knowledge constitution model ideas are synthesized by constraint satisfactions within this network, rather than simply being retrieved as is (Galbraith, 1999). The overall synthesis of an idea to satisfaction is affected by two factors: first, the constraint satisfaction within the disposition, which is responsible for the formation of the message, and, second, the constraint satisfaction within the linguistic network, which is responsible for the expression of the message in words.

The writer's conceptual knowledge is embodied in the connections between the units within their disposition (content knowledge base) and cannot be accessed directly. Instead, to make their understanding explicit, writers have to articulate their dispositional response to the topic, but this cannot happen in a single utterance. To capture the understanding as a whole, the writer must continue to synthesize the dispositional response as it unfolds. This means that the writer must constitute thought, obliquely and unpredictably, over a series of cycles. At the end of each cycle, a product, the written text, which may consist of only a phrase, or a few words or sentences, allows writer to feed back through the system again where different activations take place to produce further writing (Hand, 2004). Through each cycle less activation occurs within the writer's content knowledge base. The resulting dialect is a stable and satisfied product that requires no more activation. This final product is different than what was originally stored in the writer's content knowledge base since throughout the production process some meanings are omitted and some are added according to constraint satisfactions within the disposition linguistic network.

WRITING-TO-LEARN IN SCIENCE EDUCATION AND IN THE ELEMATARY-MIDDLE SCHOOL LEVELS

Being able to speak, read, and write about science and to unify concepts of science, the nature of science, and the relationship among science, technology, society, and environment are targets for both contemporary and interactive constructivist science teaching and learning (National Research Council, 1996; Project 2061 (American Association for the Advancement of Science), 1993; Yore, Bisanz, & Hand, 2003). The view that individuals create meaning and knowledge by interacting in their environment and by reflecting on and making sense of these interactions is the accepted interactive constructivist position that forms the basis for the writing-to-learn science movement (Brian Hand & Prain, 2002). Studies of writing-to-learn generally involve using different writing tasks within investigative science to prompt construction of knowledge in active learning environments, whereby students construct personal meanings within the classroom community (Rivard & Straw, 2000).

Teachers who provide opportunities for students to articulate, defend, and explain their own ideas within the social context of the classroom change the classroom environment from a teacher-oriented and text-dominated environment to a more student-oriented environment, in which language is used by students (Brian Hand & Prain, 1996). The importance of the language, especially written language for science learning, has been emphasized and discussed by many scholars (Halliday & Martin, 1993; Brian Hand & Prain, 1996; Brian Hand, Prain, & Wallace, 2002; Keys, 1999a, 1999b, 2000; Sutton, 1992; Yore et al., 2003). Various cognitive writing models (Bereiter & Scardamalia, 1987; Galbraith, 1999; Hayes & Flower, 1980), which have been described earlier in this paper, are the basis for research studies in writing-to-learn in science especially in elementary and middle school science areas.

Different positions have been adopted by scholars regarding the value of using writing-to-learn strategies in helping young pupils understand science. The main conflict between the positions lies in the purpose of using writing in science. Halliday and Martin (1993) have argued that the implementation of traditional writing in science is necessary because students need to use proper technical scientific language and types of genre to learn science. For Halliday and Martin, one has to learn the micro and macro structures of the genres of science writing to be able to understand science. However, Prain and Hand (1996) proposed that students should be encouraged to write their understanding of science concepts in a variety of ways using their own language. By adopting student-oriented views of learning, Keys, Hand, Prain, and Collins (1999) have emphasized that students need experiences with a variety of writing genres to communicate ideas. Consequently, students construct their own science conceptions, through interacting with other students, materials, and the teacher in the classroom context under the teacher's guidance.

Comparing and contrasting others' writing, rewording others' ideas in their own words, and speculating about possible explanations, provides students opportunities to sort out what they understand

(Vaughan Prain & Hand, 1996). Moreover, meaningful science learning has similarities with the methods used by scientists in practice (Yore, Hand, & Prain, 2002). Keys (1999b) argued that there is an important connection between language conventions in science that scientists use and the everyday language of students that is personally meaningful. She used quotes from Lemke (1994) to point out this crucial connection:

> I think the most important issue here is to understand why science registers show the grammatical and other linguistic peculiarities that they do [and] what specific functions they serve. I suspect that it is when learners see a need to perform these functions, when the functions make sense to them (e.g., classification), that they will be able to adopt the linguistic means of doing so that has evolved historically in modern European culture.

The issue raised by Lemke, using writing as a tool for meaningful science learning elementary and middle school levels, brings about some critical questions: How can one learn to read, write, and speak the language of science?, What are the protocols and expectations for reporting one's research?, How can we communicate our ideas effectively to experts, scientists in other fields, and laypeople?, and How can we promote effective science learning by using investigative science methods and by using writing-to-learn or by using any possible combination of investigative science methods and writing-for-learning in science? Using language of science and partial answer to such questions addressed by standards (National Research Council, 1996);

> The language and practices evident in the classroom are an important element of doing inquiries. Students need opportunities to present their abilities and understanding and to use the knowledge and language of science to communicate scientific explanations and ideas. Writing, labeling drawings, completing concept maps, developing spreadsheets, and designing computer graphics should be a part of the science education. These should be presented in a way that allows students to receive constructive feedback on the quality of thought and expression and the accuracy of scientific explanations (p. 144-45).

Keys et al. (1999) argued that in addition to informal writing genres, such as journal writing, question reflection, cartoons, and narratives, writing laboratory reports should be considered an effective science learning tool. The authors proposed the Science Writing Heuristic (SWH) as a tool to guide teachers and students in order to implement writing to learn activities blended in inquiry based science teaching. The SWH approach has a template for each of its two audiences. In the teacher template, the teacher uses a series of writing, reading, and small- and large-group discussion activities to support students in meaningful thinking. Thus, the teacher template illustrates the necessary pedagogy to support student learning. In the student template, students are encouraged to investigate their own question(s) about the activity and use scientific methods during investigations; however, they are encouraged to use their own language to share their findings. Figures 1 and 2 give templates for students and the teacher. Student's template for the SWH approach illustrates students' thinking stages and writing shaped during the inquiry activities. On the other hand, teacher template illustrates teacher's preparation stages as well as guideless for cornerstones of the implementation. Teacher's template stresses to implement language activities such as reading and writing during the implementation of inquiry based approach.

Several empirical studies have been carried out to investigate the influence of the SWH approach on the learning process in both qualitative and quantitative aspects (or dimensions) across elementary, middle and high school levels. Studies by Hand, Prain, and Hohenshell (2001), and Keys et al. (1999) showed that the implementation of the SWH approach had an impact on students' use of metacognition and reflection to understand knowledge, students' abilities to generate meaning from data in relation to specific knowledge, students' abilities to extend science ideas, and students' understanding of the nature of science. In addition to explicit evidence from the use of the SWH approach for meaningful learning in science in terms of the reshaping of the traditional laboratory report to more productive activities that

require more cognitive and meta-cognitive activities through the use of writing activities, Prain and Hand (1996) and Hand and Prain (2002) assert the need for broadened implementation of writing-to-learn strategies in different grade levels.

A Model for Writing for Learning in Science proposed by Prain and Hand (1996) (see Figure 3) is designed to guide teachers in planning writing tasks for elementary and secondary science topics. The crucial elements of the model include a theoretical base in that there are strong interactions between the demands of different writing tasks, subject-topic-task, and student learning outcomes; and a practical base in that primary school science teachers need to develop their understanding of writing-to-learn and which types of writing should be used (Hand & Prain, 2002). This model is proposed to help science teachers to integrate writing activities in their teaching practices and learning environments. Model provides a framework that several components of the writing such as audience, method of text production, and purpose can be evaluated and considered when writing to learn activities are planned or implemented. Further, this model is also valuable for researchers since it maps out the possible variables that could be manipulated in research settings to find out the impact of particular writing in learning science.

In brief, to improve students' conceptual understanding of science, educators need to focus on students' conceptions of "what language is," rather than on "what science is," by using diverse types of writing in the classroom environment (Sutton, 1993, p. 1224). Implementing different types of writings for different purposes, different audiences, and different science contexts from beginning of the unit to the end will promote primary students' conceptual understanding of science. However, more research studies are needed to explore what type of writing serves for which type of conceptual understanding and to investigate the most effective implementation of the these non-traditional writings in elementary and middle school science context (Sutton, 1993).

1-	Beginning ideas – What are my questions?
2-	Tests – What did I do?
3-	Observations – What did I see?
4-	Claims – What can I claim?
5-	Evidences – How do I know? Why I am making these claims?
6-	Reading – How do my ideas compare with others?
7-	Reflection – How have my ideas changes?

Figure 1. The Science Writing Heuristic-Student 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 interpretation in small group (For example making a group chart).
6-	Negotiation phase III- comparing science ideas to textbooks or other printed recourses (For example, writing group notes in response to focus questions).
7-	Negotiation phase IV- individual reflection on writing (For example, creating a presentation such as a poster report for larger audience).
8-	Exploration of post instruction understanding through concept mapping.

Figure 2. The Science Writing Heuristic-Teacher Template

Topic — What are the main ideas?
- key concepts
- links between ideas
- examples

Purpose — What is my purpose in writing?
- to explore ideas
- to clarify my understanding
- to devise a plan
- to show I know the topic
- to revise for a test
- to show I can apply what I know to a new situation
- to persuade others about my views on the topic

Writing in Science

Audience — Who am I writing for?
- other students in my year level
- younger students
- textbook readers
- teachers
- consumers
- parents
- visitors to the school

Type — What type of writing will I use?
- narrative
- brochure
- journal
- travelogue
- concept map
- poetry
- explanation
- diagram
  - instructions
  - report
  - letter
  - poster
  - script

Method of Text Production — How will I produce this writing?
- on my own
- in pairs
- in groups
- different groups to work on different parts
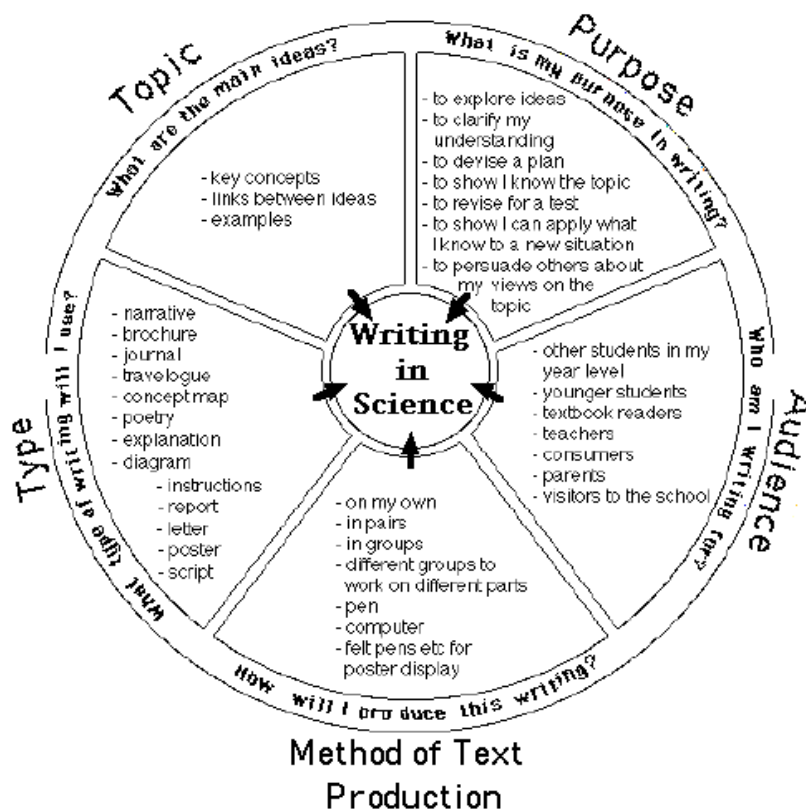- pen
- computer
- felt pens etc for poster display

Figure 3. Model for Writing-to-Learn. Writing Barrel developed by Prain and Hand (1996).

CONCULUSSIONS AND IMPLICATIONS

The literature review for cognitive process of writing and its current stage of science classroom use revealed some interesting results. First, writing is considered as learning mechanism by many researchers in the linguistic, psychology and literacy areas. Being able to understand demands and procedures of writing can help us to use it effectively in the educational setting. However, there are always conflicts and controversies when moving from theory to practice. This issue becomes apparent in the area of science education. While, some researchers such as Halliday and Martin (1993) and Osborne and Wellington (2001) have argued that writing should be in the form of traditional scientific genre to promote learning science, the others such as Alvermann (2004), Gee (2004), Prain and Hand (2005), and Yore and Treagust (2006) have suggested using writing in the "non-traditional" form. To elaborate former view Yore and Treagust (2006) have suggested that "a three-language (home language, instructional language, science language) problem exists for most science language learners (ScLL) involves moving across discourse communities of their family, school, and science." To overcome this, Gee (2004, p 13) argues for students to acquire "academic language within specific social practices" but suggests that science instruction in the primary level does not deal well with promoting such opportunities for students. Writing

in non-traditional format as suggested by Alvermann (2004) can help to connect these multiple literacies exist and help students develop conceptual understanding of science.

By adopting the former view of writing in learning primary level science, there are several research studies conducted in different grade levels and cultural settings (Boscolo & Mason, 2001; Gunel, Hand, & Prain, 2007; Brian Hand et al., 2002; Klein, 2000). Those studies have pointed out the benefit of using writing as a learning tool in different grade levels and countries such as US, Italy, Australia, and UK. However, research studies in Turkish elementary educational setting are rather limited if not any. Not only, the Turkish National Curriculum does not put emphasis on the reform movements such as "writing across to curriculum" to integrate literacy, science and other subjects through writing, but there is also gap in the Turkish elementary science education literature that investigates impact of writing in learning science.

The author of this article suggest that one step in developing stronger science education agenda for Turkey is to pay attention to the area of science literacy where writing is used as a learning tool. Adopting and developing strategies such as Writing Barrel or the Science Writing Heuristic into Turkish educational setting could help not only to improve students understanding of science concepts in the elementary setting but also to empower Turkish Science Education Community to compete in the international arena.

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