AMERICAN UNIVERSITY OF BEIRUT

THE EFFECT OF ARGUMENTATIVE WRITING IN SCIENCE ON CONCEPTUAL UNDERSTANDING, UNDERSTANDING OF NOS AND SELF EFFICACY

by
MAHA EMILE NAJJAR

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by
MAHA EMILE NAJJAR

Approved by:

Dr. Saouma BouJaoude, Professor
Department of Education
Advisor

For Dr. Ghazi Ghaith

Dr. Ghazi Ghaith, Professor
Department of Education
Member of Committee

Dr. Vivian Khamis, Professor
Department of Education
Member of Committee

Date of thesis defense: Jan, 22, 2016

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AN ABSTRACT OF THE THESIS OF

Maha Emile Najjar for Master of Arts
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The science curricula of the 21st century focus on providing students with the opportunity to become scientifically literate, to be able to engage in scientific explanations built on evidence, and to be able to apply their conceptual understanding of science while learning and communicating about everyday issues. In the Lebanese context, the medium of science instruction is a foreign second language. In the case of English as the second language, a three-language problem challenges science learners as they move from one community to another: Family, school, and science with three languages to use: Mother language or Arabic, language of instruction or English, and the language of science. This three-language problem prevents students from gaining the full benefit of experiencing inquiry, and negatively affects their engagement and achievement in science. Researchers have identified the evidence of "enhanced conceptual learning gains" when students are involved in writing tasks that demand from them an elaboration of their understanding and reasoning with rich scaffolding of their writing during inquiry. . In addition they have recognized the benefits for embedding language in science instruction and for the development of literacy skills like reading and writing which enhance the learner's verbal and cognitive abilities, and the learner's motivational variables like *self-efficacy*. The purpose of this study was to investigate the effect of scaffolding of students' writing of arguments through modeling and demonstration during inquiry on conceptual understanding, understating of NOS, and self-efficacy... Participants were students of two sections of grade 8, an experimental class and a comparison class, in a private school that follows the Lebanese curriculum. Students were guided through inquiry and scaffolding of their argumentative writing. The experimental class followed three phases of instruction and testing: 1) Scaffolding of argumentative writing during English arts classes with pre-testing of students' conceptual understanding in chemistry and biology, their understanding of Nature of Science NOS, and their self-efficacy, 2) Scaffolding of argumentative writing during science inquiry, 3) Post-testing at the end of inquiry. The comparison class learned argumentative writing in English arts classes, and the same chemistry and biology lessons through inquiry and writing explanations, but without scaffolding, and then they were post-tested using the same tests. Finally, the learning outcomes of the experimental class were compared to those of the control class on conceptual understanding, in addition to understanding Nature of Science NOS) and improved self-efficacy. The results indicated a moderately significant effect of scaffolding of argumentative writing on conceptual understanding in biology but not on

chemistry. In addition, there were no significant effects of scaffolding on students' understanding of NOS and their self-efficacy for science learning.

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Chapter I

Introduction

The opportunities for engaging students in scientific explanations, to apply their conceptual understanding and become scientifically literate are frequently challenged by a three- language problem (home language, instructional language and science language). This problem complicates the efforts to enhance science learning. In this respect, although there is widespread theoretical and empirical evidence indicating that embedding language instruction and tasks in ongoing science inquiries can enhance science literacy, but additional research is needed to develop and document language tasks and instruction in science that are linked to students' science learning and literacy (Yore & Treagust, 2006).

Embedding language in science instruction perhaps dates back to the theoretical argument about the value of writing by Emig (1977). This argument was built upon the implications of the work of psychologists like Vygotsky (1962), Bruner (1971), and Luria (1971). Emig considered that writing is an instrument of thought, and that it has unique verbal functions, with features that correspond with powerful learning strategies. Particularly, both writing and learning strategies benefit from multiple representations, synthesis, analysis, and feedback from review and evaluation. In addition, both involve review, personal engagement and personal connections (Emig, 1977). Later, Applebee (1984) examined the efficacy of writing to learn in a review of literature, with the aim of examining the trend of Writing across the Curriculum (WAC), and whether it is a possible strategy to help students develop higher order intellectual skills. As a conclusion, writing to learn was found to have the potential for helping students construct knowledge, use strategies, and understand rhetorical structures and background knowledge during writing, better than during reading. Asa conclusion, the review could not prove that writing contributes significantly to students' reasoning skills. On the contrary, in another review of the literature, ten years later, Rivard (1994), concluded, in agreement with Hayes' (1987) Organizing Demand Theory, that writing is effective as a result of the demands it places on the learners, and that writing in science is articulation, or a process of putting thoughts into words on paper, which is different from communication or exchange of information (Rivard, 1994).This articulation has been the subject of discourse in research and theory over the years until now, and its development has witnessed many contributing factors, particularly those related to the relationship of argumentative writing with constructivism, metacognitive awareness, conceptual understanding, and the new conception of nature of science NOS, in addition to the promising effect of argumentative writing on student's self-efficacy in science learning.

Educational psychology moved towards constructivism through Wittrock's (1974, 2010) generative learning model. This model is based on the idea that learners bring their prior knowledge and experiences to the learning process and are capable of using their prior learning to generate new perceptions. According to this model, writing tasks in science should promote active construction of knowledge by involving learners in decision making and problem solving, as they explore credibility of evidence and rival claims. Thus, the enhancement of argumentative writing, as a "central feature" of science, provides access for students into a powerful language of science. The reason for this power is that, as learners write an argument, they come to understand scientific reasoning through asking questions, exploring evidence and data, and connecting them to claims (Hand, Lawrence & Yore, 1999; Yore et al. 2004).

On the other hand, according to Scardamalia's and Bereiter’s (1989) theory of metacognition during writing, writers are conscious of what goes on in their minds, particularly when they are involved in problem solving. In agreement, empirical evidence confirms the role of metacognition and confirms the resulting conceptual understanding for students in grades 5 and 6 during their involvement in argumentative writing (Klein & Rose, 2010). Similarly, Keys (2000) showed that eighth grade students become expert writers who can produce sophisticated rhetoric goals and show evidence of problem solving during writing, as they use problem solving to generate content by moving back and forth between composing and reading text. Apparently, the demand placed on those students to generate claims from data during writing emphasizes revision and rhetorical planning and enhances knowledge transformation, and. Similarly, Keys, (2000) indicates that building an argument enhances science learning as it leads students to sequence and organize their writing in advance in order to generate content in the form of claims, supporting evidence, and hypotheses for their reports It is remarkable that if students' familiarity with argumentative writing is enhanced, they are challenged and motivated to construct knowledge, to engage in science learning, to understand the argumentative nature of science and to achieve conceptual understanding, rather than being discouraged by language difficulties (Bangert-Drowns, Hurley, & Wilkinson 2004; Hand, Wallace, & Yang, 2004; Klein & Samuels, 2010; Klein & Rose, 2010; Yore, et al., 2004).

Since science progresses through dispute and challenge of earlier understandings and through refutation of theories and conflicting explanation of evidence, then argumentation is a basic feature of science (Kuhn, 1996), while in science education, argumentation is essential for the development of new knowledge (Duschl & Osborne, 2002). For this reason, upon reviewing the history of knowledge building, Scardamalia and Bereiter (2012) conclude that construction of knowledge depends on considering real and improvable ideas with rich diversity that aim to motivate students to develop long-range plans, solve authentic problems, and evaluate progress. Such a successful knowledge construction agrees with contemporary views of NOS, and with research which has shown that using curricular interventions that build on constructivist perspectives result in successful change in students' views about scientific knowledge, from considering science as a passive and faithful copy of the world that is derived through observing nature, to a desired view that inquiry means a careful construction of explanations based on evidence, reflection and evaluation (Carey, et al., 1989).

This view of inquiry agrees with Toulmin's (1958) model of argumentation, which is an appropriate guide for students to construct arguments by using the four components of an argument: The *claim* advanced by the writer to assert the advantage of what she or he is establishing, the *evidence* or *data* supporting the claim, and the *warrant* or justification used by the writer in connecting claim to evidence, and the *rebuttal* or the circumstances under which the claims would not be correct. One variation to Toulmin's model includes the *alternative solution* proposed by the writer in addition to the *countered rebuttal* or the arguer's position of recognizing the rebuttal while not accepting it (Crammond, 1998; Golder & Coirier 1994; Kuhn & Udell, 2003).

Research on argumentation and understanding NOS has shown that explicit teaching of the skills of argumentation and discussion of NOS with students proved to be effective in making grade 9 students understand NOS (Khishfe & Lederman, 2007). Moreover, grade 11 students' counterargument had a strong correlation with their understanding of the subjective, tentative, and inferential aspects of NOS, because counterarguments seem to alert students to the subjective and empirical nature of science (Khishfe, 2012). Similarly, explicit teaching of both NOS and argumentation skills in grade 7 proved to be effective in optimizing students' understanding of NOS and meaningful learning in a socioscientific context (Khishfe, 2014). Consequently, when argumentative writing tasks are infused into science instruction, they can contribute to understanding of NOS, and to deeper conceptual understanding (Yore et al., 2004)

Research has also shown that writing to learn is effective in some cases but not in others (Bangert-Drowns, Hurley & Wilkinson, 2004). This ambiguity in the results of writing to learn was explained according to the functionalist approach as a result of the nature of the writing task which "invites" students to think, and shapes how they think and how they learn. In other words, it was suggested that "most instances of writing to learn could best be conceptualized in terms of "*situated cognition*" (Klein & Rose, 2010, p 426). This means that argumentative writing tasks are effective if they support students in utilizing ideas from multiple sources, and if they result in more causal structures and more connections from various sources (Wiley, 1997; Wiley & Voss, 1996, Wiley & Voss, 1999). Actually, source documents were found to affect students' argumentative texts more than prior knowledge (Klein & Rose, 2010; Klein & Samuels, 2010). Besides, non-traditional and authentic writing tasks implanted within science units allow students to develop rich understanding of science (McDermott, & Hand, 2010).

From a different perspective, during inquiry teaching, scaffolding writing tasks that involve and guide students in constructing written explanations, and in connecting claim to evidence, increases students' conceptual understanding (Ruiz-Primo, Li, Tsai & Schneider 2010). Similarly, scaffolding students' use of evidence and reasoning in their justification of claims supports students' learning gains (McNeill & Krajcik, 2009). Furthermore, scaffolding students' writing by engaging them in asking questions, learning about methods for generating data, and using models and theories to interpret and explain data, ultimately leads to their understanding of NOS (Sandoval & Reiser 2004).

As an end result, scaffolding and modeling create favorable social interventions that affect classroom environments and learners' personal beliefs. Therefore, according to Bandura's (1986) social cognitive theory, such environments that encourage students' writing, affect their behaviors by making them feel more efficacious to write and succeed. Eventually, students' favorable feelings motivate them to work harder on a difficult task, and perhaps on an uncertain task, so they regulate their behavior. The improved cognitive processing during argumentative writing, and the improved engagement in science learning which result from the instructional practices of modeling during scaffolding of students' argumentative writing, spread out the benefits of scaffolding to the development of students' self-efficacy, and self-regulation (Schunk, 2003; Schunk & Zimmerman, 2007; Pajares, Britner & Valiante, 2000).

In conclusion, students' conceptual understanding, and understanding of NOS, in addition to their self-efficacy for science learning, may benefit from expert mentoring that can scaffold their written arguments.

Statement of the Problem

In the Lebanese context, the medium of science instruction is a foreign language, either English or French. Hence, when the medium of science instruction is English, we expect students to face the challenge of learning science while moving among three discourse communities of their Home, school and science with three languages: Mother language or Arabic, language of instruction or English, and the language of science. This three-language problem may prevent students from gaining the full benefit of experiencing inquiry, and may negatively affect their engagement and achievement in science.

Purpose of the Research

It is reasonable to assume that instruction in the argument genre, along with the suitable materials and content, based in inquiry, can scaffold students' written arguments in intermediate school, and thus improve their conceptual understanding , their understanding of NOS, and self-efficacy for science learning. For those reasons, the purpose of this study was to investigate the effects of instruction aiming at scaffolding argumentative writing during science inquiry on intermediate level school students' conceptual understanding of biology and chemistry, understanding of NOS, and self-efficacy in the Lebanese context. .

Research questions

In particular, the study will attempt to answer the following research questions:

1. What is the effect of scaffolding intermediate school students' argumentative writing in science on their conceptual understanding?
2. What is the effect of implementing argumentative writing in science on students' understanding of NOS?
3. What is the effect of implementing argumentative writing in science on their self-efficacy for science learning?

Significance of the Study

The results of this research may contribute to both theory and practice in science education. On the one hand, it attempted to apply the pedagogical strategies for implementing argumentative writing from constructivist perspectives of knowledge building, and thus it may contribute to verifying the influence of scaffolding students' argumentative writing on conceptual understating of science, NOS, and self-efficacy. On the other hand, it attempted to use innovative ideas to enhance the Lebanese curriculum and to transform informative texts into ideas for inquiry and argumentation in order to stimulate conceptual understanding and understanding NOS. Besides, the illustration of the modeling and scaffolding of argumentative writing in Lebanese curricula might stimulate curriculum designers and textbook writers to include similar resources as those used in this study, in addition to using argumentative texts. In fact, students are not likely to be exposed to argumentative texts in their textbooks, because of the structure of scientific language in textbooks which conveys a confusing image of science as the exact truth, rather than being investigative, and argumentative (Sutton, 1998).

In this study, there was an attempt to use resources that act as scaffolds for inquiry, by encouraging teachers to help students construct arguments to enrich their conceptual understanding of science, improve their understanding of NOS, and to enhance their self-efficacy for science learning.

CHAPTER II

Review of Literature

Writing and Learning

Writing differs from other verbal functions like reading, talking, and listening, in many distinctive features which correspond with learning strategies. Emig (1977) describes how writing is unique in providing certain attributes of powerful learning strategies. Emig builds her arguments about the role of writing as heuristic, on implications of the work of psychologists like Vygotsky (1962), Bruner (1971), and Luria (1971). The summary of that work shows the unique value of writing for learning through similarities between some attributes of writing and some learning strategies. As a result, both writing and learning strategies benefit from multi-representational and integrative processes, seek self-provided feedback in review and evaluation, establish synthetic and analytic connections, and make generative conceptual groupings. Emig explains that the common attributes of writing and learning strategies are the engagement and personal commitment they involve. Besides, writing has the same pace of learning because it uses analysis and synthesis, thus allowing for personal connections and review which make writing an instrument of thought. Finally, Emig (1977) calls for starting inquiry about writing by experimental and speculative research, to describe this correspondence.

Currently, writing in science is recognized as the means for engagement in scientific understanding and the medium for the construction of this understanding. However, there are many conflicting arguments about the purpose and the means for engaging students in writing to learn in science. Therefore, there is a need for empirical research to inform educators about the contexts for writing tasks, the quality of learning and the particular instruction that can support this learning. In this respect, literacy education experts, focus on the issues and efforts that help them understand how science literacy goals can be achieved by students' understanding of Nature of Science (NOS), in addition to inquiry, and argumentation, and other forms of representation that distinguish science as a discipline (Hand & Prain, 2006). Within this focus of their interest, science literacy researchers tend to specialize in research on reading and writing in science learning rather than on other forms of representation in science, which has lead to a convergence of understandings in this field between researchers in language and in science education. Therefore, a major issue resulting from this convergence is how to contribute "to better understanding of the big ideas of science", and how to identify contextual and pedagogic factors to build an environment that can manipulate students' resources and teachers' efforts to support a sound pedagogy in the classroom in order to achieve science literacy (Hand & Prain, 2006).

Theoretical and Empirical Background for Writing in Science

The contribution of written language to intellectual development was the center of concern and discussion in a review of literature on writing and reasoning by Applebee (1984). Applebee examined whether writing to learn is a possible strategy to help students develop higher order intellectual skills, at a time when the efficacy of the trend of Writing across the Curriculum (WAC) was the subject of debate and evaluation. The review indicates that writing is an important part of constructing knowledge, since empirical evidence from research points to the potential of writing to learn in science. For example, case studies have shown that students were more aware of the use of rhetorical structures and the use of strategies and background knowledge during writing than during reading. However, the conclusion was less optimistic since Applebee (1984) found that the proposed argument that writing activities can contribute significantly to the development of higher level reasoning skills is not sure, because embedding writing activities and skills in school subjects does not seem to make school graduates more thoughtful and rational, and that this argument is complex and needs a research base in order to understand the various functions of writing in developing reasoning skills. Besides, Applebee called for the development of models of writing that build on topic knowledge, in addition to a study of the relationship between the writing process and the goals of writing.

The empirical research base kept expanding, and ten years later the same question was still lingering with another review of the literature completed by Rivard (1994) with the goal of coming up with a conceptual framework for writing to learn in science. According to Rivard, there is a link between writing and thinking, since the act of writing, by its very nature, may enhance thinking according to some researchers and theorists because, for the purpose of communication, the written word needs to be an explicit discursive tool in order to refine ideas, and shape thought (Rivard, 1994). Thus, Rivard agreed with Hayes (1987) in his Organizing Demand Theory, in that the effects of writing are a result of the demands it places on the learners and he called for more qualitative and quantitative research in a variety of contexts to be able to generalize findings and to guide teacher practices in the use of effective writing strategies. However, Rivard’s review concluded with an emphasis on writing in science as articulation or the process of putting thoughts into words on paper, and as different from communication or exchange of information (Rivard, 1994).This articulation has been the subject of discourse in research and theory over the years until now, and its development has witnessed many contributing factors, particularly those related to the relationship of argumentative writing to constructivism, metacognitive awareness, conceptual understanding, and the new conception of nature of science NOS, in addition to the promising effect of argumentative writing on student's self efficacy in science learning.

Constructivist Perspectives on Writing to Learn in Science

In his seminal writings, Wittrock (1974, 2010) shifted educational psychology towards constructivism through his generative learning model based on the idea that learners bring their prior knowledge and experiences to the learning process and are capable of using their prior learning to generate new perceptions. Therefore, instruction should arrange and plan for learners to construct knowledge by facilitating “meaningful processing, comprehension and long-term memory” (p. 44). Such constructivist models result in writing tasks that are different from the traditional writing, as Hand, Lawrence and Prain (1999) conclude in their framework for interpreting and evaluating the reading-science learning-writing connection. These writing tasks involve learners in active construction of knowledge, decision making, and problem solving, as they explore credibility of evidence and rival claims**.**

Writing in science serves to generate new knowledge because of the demand on the learner to organize the science content knowledge, and because of the cognitive activity and the improved cognitive processing during writing and knowledge transformation (Yore et al. 2004; Hand et al., 1999). In other words, writing becomes a cognitive mechanism that places demands on the learner in order to focus, clarify thought, stimulate metacognitive awareness and facilitate learning of scientific ideas (Scardamalia, & Bereiter, 1989)

The Theory of Metacognitive Awareness during Writing

Scardamalia's and Bereiter's (1989) theory of metacognition during writing considers that reading and many other cognitive processes may proceed without much conscious awareness or metacognition of the process. Nevertheless, writing involves metacognition or awareness of what goes on in the mind, particularly when the writer is involved with problem solving (Scardamalia & Bereiter, 1989). Specifically, a central idea in Scardamalia and Bereiter's theory is that writing falls on a continuum, and is affected by dialectic between two problem spaces: The content problem space, and the rhetoric problem space. This strategic use of language can be described as a metacognitive awareness in science writing, that converts metacognitive awareness into self regulation and actual writing (Yore & Treagust, 2006).

Empirical Evidence of Metacognition during Writing. Scardamalia & Bereiter's (1989) model of learning during writing has been illustrated and confirmed in a study whereby students in grades 5 and 6 in experimental classes were guided to acquire the *conception of writing as learning.* These students showed significantly greater learning during writing, after going through explicit writing instruction in argumentative and explanation genres. In addition these students were involved with frequent writing in content area subjects, and constructive use of sources. These steps enhanced students' intrinsic motivation to write, and confirmed the efficacy of learning during writing as a result of metacognitive awareness (Klein & Rose, 2010).

In agreement with this theory of metacognitive awareness, and with this perspective of the effect of writing on reasoning, research has contributed to an understanding of the function of writing in science in contemporary studies of the actions and views of scientists about the language they use in their investigations and communications. Research on two scientists indicated that they assessed and regulated their science inquiries and research reports, as a result of the comments they received. Besides, the two scientists in the study believed that both science inquiry and text clarity changed as a result of writing and revising the text (Yore, Florence, Pearson & Weaver, 2006). These findings contribute to the effect of metacognitive awareness that results from an improved cognitive processing or metacognition during writing, and support metacognition as an important factor in constructive knowledge building. This argument supports the creation of an interactive–constructivist model described by Yore and Treagust (2006) as being an interface that connects long-term and short-term memory while constructing knowledge.

In conclusion, writing in science serves to generate new knowledge because of the demand on the learner to organize the science content knowledge, and because of the cognitive activity and the improved cognitive processing during writing and knowledge transformation (Yore et al., 2004).

The Relationship between Argumentative Writing and Conceptual Understanding

Argumentative writing is a "central feature" of science and its enhancement provides access for students into a powerful language of science. The reason for this power is that, as learners write an argument, they come to understand scientific reasoning through asking questions, exploring evidence and data and connecting them to claims (Yore et al., 2004). However, positive results are insured when students can write argumentative texts, and when they are familiar with this genre (Bangert-Drowns, Hurley, & Wilkinson 2004; Wallace, Hand, & Prain, 2004). Consequently, if this scientific genre is enhanced, then it challenges and motivates learners to construct knowledge, to engage in science learning, and to achieve conceptual understanding, rather than be discouraged by language difficulties.

In general, the empirical evidence of learning during writing indicates that conceptual understanding is the ultimate result when students are involved with writing to learn strategies. In particular, a secondary analysis of six studies of students in grades 7-11, indicates that students working with writing to learn strategies that incorporate changing the mode of representation, have a greater advantage in acquiring conceptual understanding than students working with traditional strategies that support replication of knowledge (Gunel, Hand & Prain, 2009). Similarly, writing supports eighth graders' retention of new simple and integrated knowledge in science by enhancing basic learning strategies in science like refining and consolidating new ideas with prior knowledge, thus enhancing conceptual understanding (Rivard & Straw, 2000). On the other hand, Keys (2000) showed that we can teach eighth grade students to become expert writers who can produce sophisticated rhetoric goals. In fact, those students showed evidence of problem solving during writing, as they moved back and forth between composing and reading text to generate content by problem solving. Apparently, the demand placed on the students to generate claims from data during writing, is a process that emphasizes revision and rhetorical planning. Thus, rhetorical planning lead those students to sequence, organize, and plan their writing in advance, which stimulated their ability to generate content for their reports in the form of claims, supporting evidence, and hypotheses. As a result, this content facilitated students' science learning, and supported the knowledge transforming model, in that the content informs writing goals, and stimulates science learning. Hence, the rhetorical goals for building an argument stimulate rhetorical planning, production of content, and science learning (Keys, 2000). It is reasonable that such ideas and tasks that involve argumentation can be manipulated and designed to stimulate science learning by using the suitable pedagogical principles in order to promote students' conceptual understanding, in addition to developing familiarity with the argumentative nature of science (Yore et al., 2004).

Argumentative Writing and the New Conception of Nature of Science NOS

In science education, argumentation is a justified requirement for the development of new knowledge (Duschl & Osborn, 2002). The reason is that the contemporary view of nature of science (NOS) includes argumentation as a basic feature of science since science progresses through dispute, challenge of earlier understandings, and through refutation of theories and conflicting explanation of evidence (Kuhn, 1996). The nature of science derived from this contemporary view is that science is empirical, inferential, theory-laden, tentative, and socially embedded (Abd-El-Khalick, Bell & Lederman, 1998). If science is tentative and theory-laden, then learners are encouraged to move away from the opinion that experts are correct, towards an epistemological position in which they are expected to develop an evaluative conception of science in order to be able to acquire life-long learning, and in order to participate in argumentative discourse and ongoing debates about social issues associated with the application of science.

In conclusion, the contemporary view of NOS promotes an epistemic view of knowledge, in which reasoning is embedded in an evaluative examination of scientific knowledge resulting from inquiry. As a result, this reasoning affects the dimensions of scientific literacy, and changes the way writing is used in science classrooms. So, writing in science becomes a means for encouraging learners to get involved in critical thinking strategies, in order to generate alternative causal hypotheses. In fact, these thinking strategies are consistent with argumentative writing tasks that enhance understanding NOS by demanding reflection, consolidation, elaboration, and reprocessing of ideas, in addition to the formulation of hypotheses, interpretations, syntheses and persuasion which enhance higher order thinking and help students construct deeper understanding of science concepts (Yore, Bisanz & Hand, 2003).

The contemporary View of NOS affects modern science education and scientific literacy. Modern science education identifies the need to articulate students' learning and familiarity with inquiry and argumentation around what the discipline considers to be an authentic scientific practice. As a result, we can make use of important parallels between components of scientific literacy and the three contemporary images of science: Science as logical reasoning, theory change, and practice, in order to enhance science learning (Ford, 2006). Consequently, suitable conceptions of science teaching and learning that agree with contemporary reform of curricula consider writing in science as a mental activity that involves cognitive processes (Bereiter & Scardamalia, 1987). These mental activities express the generative character of argumentative writing, and at the same time agree with the contemporary view of the nature of science NOS (Holliday, Yore, & Alverman, 1999).

As a conclusion, the construction of knowledge seems to be a common purpose of inquiry and writing in science, because writing in science has marked great steps in the history of science, and it is an important feature and a basis for the growth of both the ontological and epistemological aspects of scientific inquiry. Besides, writing has contributed to the philosophical, psychological, and epistemological dimensions of scientific knowledge and nature of science. For instance, one of the functions of writing arguments built on textual sources is to establish a constructive process that demands novel connections and more conceptual connections with both the text and the writer's knowledge, as contrasted to superficial connections with the texts under consideration (Bereiter and Scardamalia, 1987).

The contemporary view of NOS and successful writing tasks. Scardamalia and Bereiter (2012) summarize the history of knowledge building, and reach a conclusion about pedagogical principles that guide the choice of type of ideas to advance innovation in science education. They indicate that successful knowledge building depends on considering real ideas and authentic problems, improvable ideas, ideas with rich diversity, ideas that aim to motivate students to develop long-range plans, to follow goals and to evaluate progress. Besides, knowledge building depends on ideas that lead to rising above the current best practices, in order to contribute to enrichment of community knowledge, engagement in innovation, respect and understanding of authoritative sources, and dealing with the dissatisfaction with the present state of affairs (Scardamalia & Bereiter, 2012). These pedagogical principles agree with contemporary views of NOS, and with research which has shown that using curricular interventions that build on constructivist perspectives result in successful change in students' views about scientific knowledge, from considering science as a passive and faithful copy of the world that is derived through observing nature to a desired view that inquiry means a careful construction of explanations based on evidence, reflection and evaluation (Carey, et al., 1989).

The results of two conferences have contributed to better understanding of theoretical and pedagogical issues of language and science, and harmonized the views of science literacy experts. One of the emerging ideas of these conferences is that if we want to encourage science literacy, there needs to be successful combinations of tasks that “maximize learning”, in addition to modeling of scientific practices, and a use of language in the classrooms in the same ways language is used by scientists to construct knowledge (Hand & Prain, 2006). Principally, this understanding is reflected in the Science Writing Heuristic (SWH) approach and in other approaches that aim to scaffold students in writing arguments with an important teacher role in helping students to transform knowledge and to generate knowledge.

The Role of the Teacher in Promoting Argumentative Writing

The SWH is a student centered, argument-based approach that supports students learning through inquiry by supplying them with a template which guides them through laboratory work that engages them in argumentative writing tasks about their inquiry. On the other hand, the teacher is guided by a teacher template for implementing the approach. Empirical evidence indicates that the SWH approach contributes to assisting students in grade, 3, 5 and 7 in constructing reasonable arguments that connect claims to evidence (Choi, Notebaert, Diaz, & Hand, 2010). Besides, the SWH approach contributes to significantly higher achievement in chemistry for grade 9 students (Kingir, Geban, & Gunel, 2012), is a favorable experience that involves students in scientific inquiry as scientists do, and contributes to higher students' self-efficacy in science learning, in addition to enhanced achievement especially for females (Caukin, 2010). This enhanced achievement by females was also recognized in another study in which students who wrote a summary report, following their engagement with the SWH, performed better on conceptual questions than a control group writing conventional laboratory reports. Furthermore, these students discerned the difference in thinking needed in both types of writing, with better performance by females (Hohenshell & Hand, 2006). However, the success of this approach was found to be dependent on teacher efforts in adapting, redirecting, and responding to students' needs. Although this approach depends mainly on student self-direction, but this needs to be balanced with mentoring (Shelly et al., 2010).

In agreement with Hohenshell and Hand (2006), and according to a study by Hand and Prain (2002) that investigated teachers' concerns in implementing the SWH in science classrooms, these teachers' concerns seem to focus on three central issues: Planning, setup, and their changing role in the classroom. Therefore, one of the conclusions about the SWH approach is that the teacher has a key role in a basically student-centered approach that stresses argumentative writing tasks for learning. This conclusion underscores instruction that demands more influence from the teacher in guiding and scaffolding of argumentative writing in science teaching.

Toulmin's Model of Argumentation in Relation to Understanding NOS

Argumentation is an important tool for the growth of scientific knowledge, and is necessary for a sound understanding of NOS since through argumentation students come to understand that claims are challenged by new evidence and possible refutation. This understanding is an important prerequisite for understanding NOS (Kuhn, 1993). Toulmin's (1958) model of argumentation represents a model for guiding students as they learn how to write arguments and at the same time helps in developing guidelines for evaluating the quality of the arguments that students write (Simon, 2008). This model considers that the structure of an argument consists of four components: The *claim* advanced by the writer to assert the advantage of what she or he is establishing, the *evidence* or *data* supporting the claim, and the *warrant* or justification used by the writer in connecting claim to evidence. However, one variation to Toulmin's model included the *alternative solution* proposed by the writer in addition to the *countered rebuttal* or the arguer's position of recognizing the rebuttal while not accepting it (Crammond, 1998; Golder & Coirier 1994; Kuhn & Udell, 2003).

Khishfe (2012) conducted research with grade 11 students on the relationship of argumentation skills and understanding of NOS within a controversial socioscientific context. Results indicated that there is a strong correlation between counterargument and understanding of three aspects of NOS, specifically the subjective, tentative, and inferential aspects of NOS. Specifically, it seems that counterarguments alert students to alternative views which in turn help them to understand the subjective nature of science. Besides, when students generate their counterarguments by using evidence, they understand the empirical nature of science (Khishfe, 2014)

Earlier research about intervention in the form of explicit teaching of the skills of argumentation has shown promising results. In this respect, explicit approaches including discussion of NOS in grade 9, proved to be more effective in improving students' understanding of NOS, as a result of the intervention (Khishfe & Lederman, 2007). Moreover, students in grade 7 have shown a developmental variation from naive to intermediate, to more informed views of NOS, as a result of explicit discussion and argumentation of the aspects of NOS (Khishfe, 2008). Furthermore, explicit intervention in teaching both NOS, and argumentation skills proved to be effective in grade 7 (Khishfe, 2014). These studies have consistently shown that interventions that explicitly introduce argumentation and NOS have produced positive results.

These positive results agree with the review by Yore et al., (2003), in that when argumentative writing tasks are infused into science instruction, they can contribute to understanding of NOS, and to deeper conceptual understanding.

Tasks that demand connections of ideas from various sources. Scardamalia's and Bereiter's (2012) principles recommend the use of rich diversity of ideas with epistemic agency. In agreement, some studies have shown that when students were allowed to write by using multiple sources, their historical essays gave the best transformation, and showed the best inference verification. Therefore, writing argumentative texts by utilizing ideas from multiple sources results in more connections from various sources and more causal structure (Wiley, 1997; Wiley & Voss, 1996, Wiley & Voss, 1999). This is also true in science where source documents positively affected students' writing of argumentative texts, and also positively affected their science learning to a greater extent than the effect of their prior knowledge (Klein & Rose, 2012; Klein & Samuels, 2012).

Tasks that use writing as an epistemological tool for learning. Writing can be used as an epistemological tool, as in the case of addressing an audience other than the teacher, incorporating different modal representations in writing texts, and translating science knowledge into everyday language. Thus, results of research using secondary reanalysis methodology of students' responses in qualitative studies over ten years, indicated the benefits of such non-traditional and authentic writing tasks because students developed rich understanding of science when these tasks were implanted within science units (McDermott, & Hand, 2010).

Tasks that scaffold students in connecting claim, evidence, and justification. Research has shown that students' writing of scientific explanations is superior to merely talking about them because they require these students to think critically and construct new knowledge (Sandoval & Reiser, 2004; Klein, 2004; Rivard & Straw, 2000). It is also evident that writing explanations is a challenging experience so scaffolding the construction of written explanations is rewarding in terms of students' conceptual understanding during inquiry teaching. For instance, scaffolding of students' writing can be done by using strategies that support the learning environment like using prompts with sufficient level of guidance, while systematically analyzing and scoring the quality of students' written notebook explanations. This approach uses designed supports or prompts to help students in writing explanations using claim, and supporting evidence, in addition to a reasoning or justification that links the claim to the evidence. Results of research on this approach showed that it helped students to reach high levels of understanding (Ruiz-Primo, Li, Tsai & Schneider 2010). Conversely, when teachers simplify the application and explanation of scientific inquiry, by just demanding from students to write explanations, students show lower learning gains. These results suggest that students' success in writing arguments does not depend only on understanding the content, but rather on scaffolding, and on classroom practices that include multiple opportunities and goals to engage in writing arguments.

In addition, the success in writing arguments also depends on scaffolding students' use of evidence and reasoning in their justification of claims and in the construction of explanations, so they achieve greater learning gains (McNeill & Krajcik, 2009). However, in another study, fading the support, or providing less support over time, was found to better equip students to engage in writing explanations in the absence of scaffolding (McNeill, Lizotte, Krajcik, & Marx, 2006). Furthermore, scaffolding of students' writing by engaging them in Explanation Constructor software improved their understanding of NOS because it developed their "epistemological commitments" like asking questions, learning about methods for generating data, and using models and theories to interpret and explain data (Sandoval & Reiser 2004).

As a conclusion, there is theoretical and empirical evidence in this review of literature to point out some outstanding functions of argumentative writing tasks in science. Essentially, argumentative writing improves cognitive processing, and metacognitive awareness, in addition to problem solving and construction of knowledge, as a result of the knowledge transformation involved during writing (Scardamalia & Bereiter, 1989; Yore et al., 2004).

On the other hand, these functions of writing in science seem to extend the interaction of writing to two key variables that are both cognitive and motivational: Self-efficacy, and self-regulation. Specifically, the interaction of argumentative writing with these two variables is also the result of the improved cognitive processing during argumentative writing, and the improved engagement in science learning which results from the instructional practices of modeling during scaffolding of students' argumentative writing (Schunk & Zimmerman, 2007).

Effects of Scaffolding of Argumentative Writing on Students' Self-Efficacy in Science

Self-efficacy is the learner's self-perceived capabilities that interfere with what task, effort, persistence, and achievement the learner chooses. On the other hand, *self-regulation* includes self-generated thoughts and feelings that determine how actions are planned by the learner in order to acquire skills and knowledge. Self-efficacy has critical influences on both reading and writing, because it allows students to engage in difficult tasks that affect students' verbal abilities (Schunk & Zimmerman, 2007)

Modeling argumentative writing

The social cognitive theory according to Bandura (1986, 2001) considers that human actions are influenced by a series of *reciprocal interactions* of personal factors, environmental events and behavioral patterns. For instance, self-efficacy is such a personal factor, while instruction is an environmental factor, and enhanced effort and hard work are behavioral patterns. If the environment favors and promotes personal feelings of success and motivation, then the learner works harder. This success, in turn, contributes to the learner's enhanced self-efficacy. On the other hand, self regulation is the process that promotes the learner's participation and success and supports the ability to continue learning and controlling the environment by seeking help, so that, modeling in particular is crucial in helping learners to develop self regulation, which helps the learner to develop self-efficacy for learning (Schunk & Zimmerman, 2007). On the contrary, self-efficacy for learning science was found to be lower for high school Taiwanese students who had the view that scientific knowledge is uncertain. Knowing that those students' views are advanced epistemic beliefs, this unexpected result was explained by the researchers as a cultural interaction that affected their self-efficacy, which needs more qualitative research to clarify (Tsai, Jessie, Liang & Lin, 2011).

It is possible to consider scaffolding and modeling as favourable social interventions that influence classroom environments, and learners' personal beliefs. Such an environment that encourages and scaffolds students' writing, affects their behaviors by making them feel more efficacious to write and succeed. Eventually, students' favorable feelings motivate them to work harder on a difficult task, and perhaps on an uncertain task, so they regulate their behavior. As a result, according to Bandura's (1986) social cognitive theory, the two motivational variables of *self-efficacy* and *self-regulation* show reciprocal interaction with instruction, and allow students to benefit from modeling of reading and writing (Pajares, Britner & Valiante, 2000; Schunk, 2003). During modeling, students' self-regulation follows three stages conceptualized by Zimmerman (1998) to be: The forethought phase, the performance control phase, and the self-reflection phase. In the forethought phase, learners observe and rely on social sources, like the model or teacher to set their goals. Then, in the performance control stage, learners begin to use learning strategies and feedback to act and progress. Finally, in the self-reflection stage, learners rely on their perception of progress for personal evaluation of their performance in order to adjust their strategies. These phases postulate four levels of development that occur as a result of modeling: First level, or observation of skill from modeled and verbal instruction with cognitive acquisition of the skill; second level of emulation, or demonstration of the skill with the help of feedback and social guidance.; Third, the learner demonstrates the skill independently, so this level represents self-controlled internalization of skill; Fourth, in the self-regulated level of development, the learner adapts the skill to changes in personal and contextual conditions as a result of motivation and self-efficacy (Schunk & Zimmerman, 2007).

Schunk and Zimmerman (2007) summarize the research intervention that supports the idea that self-efficacy and self-regulation have critical influences on reading and writing achievement. As a result, scaffolding of students' writing, through modeling, rigorous instruction, and teacher feedback, actually results in developing students' self-efficacy.

Consequently, self-efficacy leads to self-regulation and better achievement. This summary concludes that modeling of writing builds self-regulatory and academic skills, and raises self-efficacy. Besides, the summary highlights the recent emphasis on writing and reading as very essential literacy skills, and supports the contemporary views of embedding language in science instruction to support scientific literacy.

Conclusions

Writing is a medium through which students can construct meaningful knowledge and communicate their thoughts and understanding within an environment that encourages student agency. Therefore, when scaffolding of argumentative writing is implemented in the science classroom, we may visualize an effective science classroom environment that provides learners with various opportunities for a constructive experience: An opportunity to learn about argumentative writing through modeling and guidance that foster their self-efficacy, and self-regulation during writing; an opportunity to understand NOS while manipulating claim, evidence and justification; an opportunity to construct knowledge while using multiple resources and various modal representations, and an opportunity to construct explanations about real ideas and authentic problems that are meaningful for them.

Such a classroom environment may enhance scientific literacy through student-centered, active, and constructive writing experiences that stimulates students' metacognition and their involvement in science, thus boosting their perceived science self-efficacy, and enhancing their conceptual understanding and engagement in science learning. Eventually, students involved in argumentative writing may come to realize that science is a human construction of knowledge, which may guide them to recognize the tentative nature of science.

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CHAPTER III

Methodology

Research Design

This chapter describes the research deign of this study, basically a quasi-experimental design, with two non-equivalent groups the treatment group and the control group. The sample, questionnaires, tests, stages of implementation and steps of inquiry cycle, teacher qualifications, coordination and teacher training, in addition to scaffolding of argumentative writing in science, for the treatment group.

This study aimed at exploring the effects of instruction that scaffolds Grade 8 students' argumentative writing during inquiry in a private school in Tripoli, Lebanon. Specifically, the aim was to detect evidence of learning in the form of higher conceptual understanding of science and NOS, in addition to the increase in students' self-efficacy for science learning. This study followed a quasi-experimental design with two non-equivalent groups, a treatment class and a control class. There were only two sections of Grade 8 in that school, and these sections were assigned randomly to the treatment and control classes by flipping a coin. The school was chosen because it was available to the researcher being a science teacher and coordinator for many years in the school.

Rationale for the Research Design

First, research has confirmed the benefits of instruction that aims to enhance students' argument-writing, in terms of science achievement, and understanding of NOS

(Bell &Linn, 2000; Driver et al., 2000; McNeill et al., 2006). Besides, research has shown that argumentative writing is consistent with knowledge transformation where "data provides a source of knowledge from which students can make inferences, while genre writing provides rhetorical goals for such inferences" (Klein & Rose, 2010, p 455). Therefore, the research design of this study attempted to benefit from Klein's and Rose's (2010) research built on an adaptation of the cognitive model of Bereiter and Scardamalia (1987) which considers that writing is a problem solving process in which learning occurs during the writer's internal cognitive processes. Moreover, the research design adapted Toulmin's (1958) argumentation pattern illustrated as Toulmin's Argumentation Pattern (TAP) in a study by Erduran, Simon, and Osborn (2004) in addition to the available inquiry lesson plans developed in their research project for the chemistry activity about a burning candle (APPENDIX II)

Second, the study attempted to benefit from cognitive theories that agree with intertextuality since intertextuality enhances learning benefits from external textual and non-textual sources (Flower & Hayes, 1980; Spivey, 1997). Therefore, this study made use of the research design of those studies that have confirmed the importance of source documents in affecting students' writing and learning as a result of intertextuality, whereby students benefit from argumentative writing as an analytic writing task that leads them to think deeply, and to reach conceptual understanding (Newell, 2006; Klein & Rose, 2010; Klein & Samuels, 2010). Specifically, such research has confirmed that students' learning of the argument genre helped them in selecting information for their arguments. In this respect, "the number of science propositions from sources, correlated significantly with both text quality and learning during writing" (Klein & Samuels, 2010, p 209).

Phases of Implementation

The research design proposed for this study involved three phases: Scaffolding of argumentative writing within English language arts classes in the first phase, inquiry and scaffolding argument writing in chemistry and biology in the second phase, and argument writing and testing in the third phase (refer to Table 1). Therefore, argument instruction was the independent variable while conceptual understanding of science, understanding of NOS, and science self-efficacy were the dependent variables. The three phases of the study are described below and in Table 1.

Table 1

Research Design

Phases	Treatment Group	Control Group
1st phase: scaffolding of argumentative writing	Pretesting of argumentative writing, understanding NOS, and self-efficacy for science learning, and pretesting for science learning	Pretesting of argumentative writing, understanding NOS, and self-efficacy for science learning.
	Implementation and scaffolding of argumentative writing, by English teacher.	Regular language arts instruction by English teacher, including persuasive writing,
2nd phase: Inquiry and scaffolding of argumentative writing in science	Five-week implementation of argumentative writing about inquiry science topics from chemistry and biology curricula, with science teachers' support, and feedback	Inquiry activities in chemistry and biology with regular writing demands using inquiry science topics from chemistry and biology curricula.
3rd phase: Argument writing and testing	• Students' writing of one argument in each of chemistry and biology, using multiple sources of documents at the end of inquiry. • Post-test of understanding NOS • Post-test of science knowledge • Post-test of science self-efficacy	• Regular writing demands on inquiry topics in both chemistry and biology. • Post-test of understanding NOS • Post-test of science knowledge • Post-test of science self-efficacy

First phase: Scaffolding of argumentative writing by English language teacher. Scaffolding of argumentative writing involved explanation of genre structure, and modeling by the English teacher in both the treatment and the control classes, following the approach in *First Steps Writing Resource* (Raison, Rivalland, & Derewianka, 1994). This resource was a useful document designed in Western Australia as a resource for teachers with teaching and learning activities of six common genres in educational settings, including expositions or arguments with a constructivist model of learning. The resources (APPENDIX I) included in this study represent an adaptation of the lesson plans, the activities, the stages for implementation, the typical context in which the genre is used, its components, its grammar and lexis, in addition to a rubric for evaluating argument texts that students produce were built according to this resource In this respect, research on this constructivist model of learning has shown that students who participated in this specific argument-writing instruction produced argument texts of better quality, and used their knowledge of the argument genre in selecting information, and in connecting ideas from the provided source documents. Eventually, scaffolding of experimental classes contributed to students' science learning and to enhancing their understanding of NOS (Klein & Samuels, 2010).

Second phase: Inquiry and scaffolding of argumentative writing in science. The inquiry phase involved instruction by two science teachers, a biology teacher and a chemistry teacher who teach both the treatment and the control classes. Besides, the activities in this phase aimed at implementing argumentation by following a learning cycle with a five-step sequence of activities: Engage, Explore, Explain, Elaborate, and Evaluate. This model was developed by Biological Science Curriculum Study (BSCS) to improve instruction and enhance learning (Bybee, Taylor, Gardner, Van Scotter, Powel, Westbrook, & Landes, 2006).

Engagement. This step connects learners' past and present learning experiences, by initiating students' curiosity, exposing their prior conceptions, and focusing their thinking and anticipation about the new learning outcomes.

Exploration. This step allows learners to use prior knowledge to explore possible questions and provides them with a common base of activities to help them generate new ideas. The resources for exploration in biology inquiry, and those for the third stage of the chemistry inquiry are available in (APPENDIX II)

Explanation. This step allows learners to verbalize their understanding and focuses their thinking on the concepts they were exploring, while the teacher introduces the concepts, processes and skills directly in order to help them reach a deeper understanding.

Elaboration. This step provides learners with additional challenging activities that help them apply and extend their conceptual understanding.

Evaluation. This step encourages learners to assess their understanding, and also allows teachers to evaluate learners' progress.

The inquiry lessons in chemistry dealt with application of earlier knowledge of the periodic table, deducing the formula of binary and ternary compounds, using knowledge of the naming rules, and at the same time, writing the names of given formulas by recognizing the constituting parts in a formula (APPENDIX III). On the other hand, the inquiry lessons in biology dealt with heredity and built upon concepts learned in Grade7 (APPENDIX IV).

Scaffolding of argumentative writing was implemented in the treatment class, by the biology and chemistry teachers, during the inquiry lessons provided in chemistry and biology. Each teacher modeled, explained and guided students in writing arguments, following the same model of argumentation by Toulmin (1958). Consequently, the aim was intensive implementation of argumentative writing in order to motivate students to consider writing an argument as a way of learning, and to enhance students' self-efficacy for writing and for science learning.

Third Phase: Argumentative Writing, and Post-Testing. Students participated in argument writing, during one inquiry. Students in the treatment class were given a portfolio of documents to use in writing one argument in chemistry about a burning candle (APPENDIX II). On the other hand, students in the treatment class were given scaffold 3 to write an argument about inheriting dimples in biology. This phase was followed by post-testing students to determine the effect of the treatment in terms of conceptual understanding, understanding NOS, and self-efficacy for science learning.

Participants

Students. Participants were 28 males and 24 females (a total of 52 students) in Grade 8, with an average age of 14 years, in a private school in which the language of instruction of science is English. Besides, students in this school represent the urban population in Tripoli and surrounding areas with well-known high levels of success in official exams. Besides, students mostly came from middle class socioeconomic background, and from a mixed cultural milieu.

Teachers' experience. There were three teachers with an age range of 40-48, involved in this study, an English language teacher, a chemistry teacher, and a biology teacher. The English language teacher has a BA in English Language and a Teaching Diploma (TD) with more than 20 years of experience. Besides, the chemistry teacher has a BS in chemistry and TD in science teaching and an experience of more than 15 years of teaching chemistry. The biology teacher has a BS in Biology, and a TD in science teaching with an experience of 20 years of teaching biology. Besides, all teachers have attended various training workshops aimed at professional development.

Sample and Sampling Procedure

Students in this school are usually placed at the beginning of the school year into different sections by the teachers with the intention of having a heterogeneous distribution in terms of academic achievement for all sections of a class level. Teachers usually use overall average in the previous school year for this classification, while insuring to place equal numbers of males and females in each percentile rank. There were only two sections of Grade 8, so one section was randomly assigned to be the treatment class, while the other was the control class, by flipping a coin.

Instructional Intervention

Teacher Training. Teacher training was done through frequent meetings with the teachers to explain the aims of the study, the significance of inquiry, the role of argumentative writing and to examine the success of implementation, in addition to some recommendations on how to encourage students to use evidence to support their claims. Consequently, the meetings made it possible to help teachers raise questions that helped to improve implementation by discussing the pitfalls in the activities and the validity of the tests. Therefore, training took place during a preparatory session for all teachers about argumentative writing, and about Toulmin's model for an argument, while discussing the persuasive writing instruction, and the related *First Steps Writing Resource* (*Raison et al., 1994)* with the English language teacher and the science teachers In addition all teachers received a copy of the part of that resource related to persuasive writing, in addition to a chart and an explanation of Toulmin’s model of argumentation. Moreover there was a preparatory session for science teachers about the 5E cycle of inquiry during the coordination meetings.

***Coordination with the English language teacher*.** There were three meetings with the English language teachers every week during her implementation. During the first meeting, the English teacher was familiarized with the study and the approach to teaching argumentative writing, and she was supplied with a copy of *First Steps Writing Resource* by (Raison, et al., (1994). Then, during subsequent meetings, efforts were directed towards discussing the objectives, the method of implementation, the argumentative texts, the graphic organizers, and the tests using it as a resource, In addition, there was a discussion of the evaluation of written arguments according to the rubric presented in *First Steps Writing Resource*.

Coordination with the science teachers. There was one hour meeting with the science teachers every week during the study. First, science teachers were supplied with

First steps writing Resource, the objectives, the lesson plans, and the scaffolding for argumentative writing. Then, science teachers were encouraged to adopt the implementation of argumentative writing, and to use this genre in science teaching, by discussing with them the importance of the view of science as an argument. Moreover, there was a discussion of the stages of implementation and the role of the teacher in promoting inquiry according to the BSCS learning cycle with a five-step sequence or 5E of activities: Engage, Explore, Explain, Elaborate, and Evaluate. This model was discussed with both science teachers, and each step in the lesson plan was explained and discussed with the teacher before implementation in order to encourage teacher involvement in the study.

English language arts instruction on argumentative writing. Instruction on the argument genre was done by the English language teacher during the first two weeks of the study. First, the English language teacher provided students in both the treatment and control classes with argument genre education by analyzing model texts to familiarize students with the genre, then composing in front of the class while thinking aloud, which was followed by *guided writing* using a graphic organizer as an external prompt with teacher guidance and comments. Thus, students were guided to reach a stage where they wrote argumentative texts independently, and the teacher evaluated students' understanding of the argument genre, using a definition and an example of an argument. Finally, the teacher determined students' understanding of this genre, by giving them a test. This test contained brief questions about what constitutes an argument, in addition to the writing of an argument that builds on external prompts for the sake of evaluating students' ability to write the argument. The evaluation of written arguments followed the rubric presented in *First Steps Writing Resource* (Raison, et al., 1994).

Science instruction in the treatment class. Over a five-week period, students in the treatment class learned regular chemistry and biology curriculum content, through the five-step sequence of activities: Engage, Explore, Explain, Elaborate, and Evaluate. Therefore, the teachers guided the treatment class through instruction to learn and use argument scaffolds, followed by writing the related argumentative text while teaching their regular curricular content. The scaffolds helped to structure students' writing of an argument. At the end of each scaffold, the biology and the chemistry teachers modeled and showed the parts of an argument, explicitly, by composing in front of the class like: Claim-evidence-warrant, claim-evidence-warrant-backing, claim-evidence-rebuttal. Consequently, the treatment group participated in argument writing guided by teachers' support, feedback, and scaffolding according to Toulmin's Argumentation Pattern (TAP) for an interval of about 10-15 minutes, during each period that included the fifth step of inquiry or *Evaluate*, in both chemistry and biology classes over the five-week period of the study. Hence, there were two periods for each of chemistry and biology, with about 8-10 periods covered by the lesson plans in chemistry (Appendix III), and similarly by the lesson plan in biology (Appendix IV).

Science instruction in the control class. During the study, and over a five-week period, students in the control class participated in the traditional writing tasks including explanations, and listened to oral arguments explained by the teacher, but without implicit teaching of argumentative writing. Therefore, contrary to the treatment class, the control class students were not given any hints or feedback from the teacher, on how to use arguments and how to improve their writing, but, at the same time they learned their regular chemistry and biology curriculum through the five-step sequence of inquiry common to both the control and the treatment classes: Engage, Explore, Explain, Elaborate, and Evaluate. Therefore, there were three lesson plans in chemistry (Appendix III), and three lesson plans in biology (Appendix IV).

Scaffolding argumentative writing in the treatment class. During the course of this study we developed the biology and chemistry curriculum content during a five-week period in a way to adapt it to inquiry. Teachers' traditional plans were modified, to integrate argumentative writing skills and inquiry while covering the regular chemistry and biology curriculum in the second stage. Moreover, students in the treatment class used scaffolds in the form of handouts that guided reasoning, and transformed the science classroom in a way to include a stronger focus on argumentation by including evidence, claims, warrants backings and rebuttals in students' and teachers' explanations. Such handouts were filled in by students, with teacher's help and reasoning, and were used in writing the arguments (Appendix V). Besides, students in the treatment class independently constructed one argument, in each of chemistry and biology in the third phase of the study. Consequently, according to the "Knowledge Transforming Model", it was intended that students would be able to develop metacognition during this writing task about the basic concepts they learned before and during the study.

Instruments

Four instruments were used to collect the data in this study: A five-point Likert scale questionnaire for students' motivation and self-efficacy, a five point Likert-scale instrument to evaluate students' understanding of NOS, and two tests of conceptual understanding. The two tests of conceptual understanding were: A teacher and researcher-prepared chemistry multiple-choice test (Appendix VI) and a researcher and teacher-prepared multiple choice biology test (Appendix VII)

Tests of conceptual understanding. The researcher prepared an achievement test in each of chemistry and biology to use as pre-test and post-test, to measure conceptual understanding of science concepts before and after scaffolding of argumentative writing and inquiry. Therefore, the standard scores on this test represented students' science achievement in terms of initial conceptual understanding of background concepts, and their conceptual understanding after the treatment. Besides, these tests were multiple choice tests that covered the concepts in the national curriculum, and included items at the different levels of Bloom's taxonomy to insure that they measured conceptual understating and not only memorization. Moreover, the validity of the tests was insured by asking the classroom teachers and university science education faculty members to examine the alignment of the tests with the content and the levels of Bloom's taxonomy.

The chemistry test of conceptual understanding. In chemistry, the test was a multiple choice test with 30 items that determined understanding of background knowledge of the concepts that students had learned during the first and second terms in grade 8 about solids, liquids, gases, mixtures, elements, compounds, atoms, molecules the periodic table, chemical and physical properties, in addition to ionic and covalent bonding in chemistry for Grade 8. The items were written according to the objectives of the national curriculum and some items were adapted from Grade 8 exams that are available online like California Standards Test.

The biology test of conceptual understanding. In biology, the test of conceptual understanding covered the concepts of "Reproduction and Genetics" and the concepts of "Transmission of hereditary characteristics" that students had covered in the previous years during grades 5, 6 and 7. The test included 25 multiple choice items written according to the objectives of the national curriculum, and following Bloom's taxonomy to assess conceptual understanding.

The validity of the test of conceptual understanding. The researcher prepared the test, by writing the multiple choice items in order to measure achievement according to the Lebanese curriculum, with 60% of the items at the comprehension level or above, and 40% of the items at the knowledge level. Therefore, the validity of the test was insured through a process of analysis of the items with the teacher, in order to make sure the items measured conceptual understanding according to Bloom's taxonomy for concepts required by the Lebanese curriculum. First, Bloom's taxonomy was discussed with the teacher who was provided with a copy of Bloom's taxonomy and a copy of the test. Then, the teacher and the researcher classify five items together while they discussed their level, so that total agreement about these five items insured the same understanding by both. Then, each of the researcher and teacher independently classified 5 items and then met to discuss their classification in order to insure total agreement. Finally, the same procedure of classification was followed for the rest of the items, until total agreement was achieved for all items. Any disagreements regarding classification of the items were resolved by consulting a university science education faculty member.

The questionnaire of Students' Views of Nature of Science (SVNOS). This questionnaire includes seven subscales (Appendix VIII) and uses a five-point Likert-scale format with 1 = strongly disagree, 2 = disagree, 3 = no opinion, 4 = agree, and 5 = strongly agree. This questionnaire was developed by Lin, Goh, Chai and Tsi (2013) in order to examine grade 7 and grade 8 students' views of NOS in Singapore. The researchers included in this questionnaire various scales and items from other instruments that assess understanding of NOS like those by Lederman (2002), Tsai and Liu (2005), and Conley et al. (2004). Thus, SVNOS was used to survey students' views of Nature of Science in Singapore, with a sample of 359 students in Grade 7 and Grade 8. In addition , confirmatory factor analysis (CFA) test suggested by Deng et al. (2011) confirmed the reliability, validity and structure of SVNOS instrument, and resulted in retaining its final form with seven scales that assess students' views of seven aspects of NOS on a five-point Likert scale. These seven aspects with composite reliability coefficients that exceeded the cut-off value of 0.60, while the CR values were respectively: (0.77, 0.87, 0.87, 0.88, 0.82, 0.92, 0.93). The scales are: (1) the creative nature of science (CREA) with , (2) the role of social negotiation (NEG), (3) the theory-laden notion of scientific exploration (THEO), (4) the cultural impacts on science (CUL), (5) the changing/tentative nature of science knowledge (CHG), (6) the non-objective nature of science (NOBJ), and (7) the justification of scientific ideas (JUS) (Lin, Goh, Chai &Tsi, 2013). The questionnaire was pilot-tested with a number of Grade 9 and Grade 10 students to insure that it is appropriate for use with Lebanese students.

Student Motivation towards Science Learning Questionnaire (SMTSL). Students in both classes were also pretested for their science self-efficacy using the self-efficacy scale (Cronbach's Alpha = 0.78) which was adopted from the Student Motivation towards Science Learning Questionnaire (SMTSL) developed by Tuan, Chin, and Shieh (2005). This questionnaire (Appendix IX) contains six subscales with Cronbach's Alpha ranging from 0.7 to 0.89, and Cronbach alpha for the entire questionnaire was 0.89: "Self-Efficacy, Active Learning Strategies, Science Learning Value, Performance Goal, Achievement Goal, and Learning Environment Stimulation". The development of this instrument involved 1407 randomly selected students in junior high school in Taiwan, where the results of implementing the questionnaire significantly correlated ($p < 0.01$) with related students' variables like science attitudes and current science achievement tests, The questionnaire was pilot-tested with a number of Grade 9 and Grade 10 students to insure that it was appropriate for use with Lebanese students.

Data Analysis

The study used a quasi-experimental design with two groups, with 24 students in the treatment class, and 28 students in the control class, so the total number of students who participated in the study was 52 students. Therefore, in order to reduce bias, both the treatment and control classes took the pre-tests and post-tests. Then, quantitative data was obtained from the conceptual understanding pre- and post-tests in chemistry and biology, in addition to scores on the SMTSL, and the SVNOS instruments. Consequently, analysis of covariance (ANCOVA) was used to determine if there were significant differences between the two groups on the conceptual understanding tests, the self-efficacy scale of SMTSL questionnaire, and the SVNOS questionnaire. The covariates were the pre-test scores while the dependent variables were the biology and chemistry post-test scores. In addition to ANCOVA, the statistical tests used were descriptive statistics to calculate means, maximum, minimum, and standard deviations, reliability tests to calculate Cronbach's Alpha for the four tests (Tests of Conceptual Understanding of Biology and Chemistry, Students' Views of Nature of Science (SVNOS), AND Student Motivation Towards Science Learning Questionnaire) Levene's test for equality of variance..

CHAPTER IV

RESULTS

In this chapter we present the answers to the three research questions which will be organized in three parts, specifically dealing with the effect of scaffolding of intermediate level (specifically Grade 8) students' argumentative writing on conceptual understanding in chemistry and biology, on self-efficacy, and on understanding NOS. It is to note that, students in both the experimental and the control classes were pre-tested and post-tested on their conceptual understanding in chemistry, biology, on their understanding of NOS, and on self- efficacy. Moreover, students in both the experimental and control classes received instruction on how to write arguments in English classes, in addition to instruction based on constructivist perspectives and inquiry in both chemistry and biology, but only the experimental class students received scaffolding of their argumentative writing during chemistry and biology classes. The covariates used in the analysis were the biology, chemistry, NOS and self- efficacy pre-tests while the dependent variables were the biology, chemistry, NOS and self- efficacy post-tests. In order to maximize the power of the statistical tests to detect the scaffolding or treatment effects, an ANCOVA test was used to control for pre-treatment differences between the two classes.

Table 2 presents the total means, standard deviations, and minimum and maximum scores of all the variables used in the study. Table 3 presents mean pre-test and mean post-test scores for self-efficacy, conceptual understanding of chemistry, conceptual understanding of biology, and understanding NOS by group.

Table 2

Minimum, Maximum , Mean Scores and Standard Deviations on Pre-Tests and Post-Tests

Test	***N***	**Minimum**	**Maximum**	**Mean**	***SD***
PRESE total score	53	16.00	35.00	26.87	5.82
POSTSE total score	53	18.00	35.00	28.34	4.60
PRECH total score	53	4.00	17.00	10.49	3.11
POSTCH total score	52	2.00	17.00	10.85	3.57
PREBIO total score	53	1.00	12.00	7.17	2.54
POSTBIO total score	53	2.00	12.00	7.42	2.49
PRENOS total score	53	93.00	142.00	114.90	11.51
POSTNOS total	53	84.00	141.00	111.85	13.99

PRE stands for pre-test, POST stands for post-test, SE = Self efficacy score from SMTSL questionnaire, CH= Chemistry conceptual understanding score, BIO = Biology conceptual understanding score, and NOS = student views of Nature of Science from SVNOS questionnaire.

Table 3

Mean Pretest and Mean Post-Test Scores by Group

			Pre-Test		Post-Test	
Group	**Test**	***N***	**Mean**	***SD***	**Mean**	***SD***
Treatment	SE	25	28.21	5.52	29.04	4.95
Control	SE	28	26.07	5.78	28.00	4.16
Treatment	CH	24	10.95	2.81	11.33	4.26
Control	CH	28	10.21	3.35	10.43	2.87
Treatment	BIO	25	7.04	2.64	8.08	2.83
Control	BIO	28	7.18	2.48	6.89	2.10
Treatment	NOS	25	115.08	11.23	111.04	14.72
Control	NOS	28	114.84	12.14	112.93	13.65

SE = Self efficacy score from SMTSL questionnaire, CH= Chemistry conceptual understanding score, BIO = Biology conceptual understanding score, and NOS = student views of Nature of Science from SVNOS questionnaire.

The covariates

The covariates in the ANCOVA test appearing in the model are evaluated at the values of estimated total means for pre-tests; these covariates are used to compute the Post-test adjusted means as presented in Table 4.

Table 4

Estimated marginal means for Post-Tests

Test	Group	[a]Estimated Pre-Test Mean	Post-Test Adjusted Mean	Std. Error	Lower Bound	Upper Bound
POSTSE	Treatment	26.87	28.61	.82	26.98	30.29
	control		28.26	.77	26.70	29.81
POSTBIO	Treatment	7.17	8.01	.41	7.18	8.84
	Control		6.89	.39	6.10	7.68
POSTCH	Treatment	10.55	11.06	.60	9.86	12.26
	Control		10.66	.55	9.55	11.77
POTSNOS	Treatment	114.90	110.59	2.21	106.16	115.03
	Control		112.97	2.09	108.78	117.16

Note. [a]Estimated Pre-Test Mean used in computing the covariates in the model.

Test Reliability

Test reliability for all pre-tests and post-tests was measured by computing Cronbach's alpha which determines the extent of the consistency of an individual's scores across different items on a test. This measure of reliability helps us to avoid the occurrence of measurement error, and supports the consistency of test items in measuring what they are intended to measure. Table 5 presents the reliability statistics for the treatment group, while Table 6 presents the reliability statistics of the control group.

Table 6 indicates that all the pre-tests and post-tests for the treatment group show acceptable reliability coefficients with Cronbach's alpha values greater than 0.55 which is acceptable in social sciences. However in chemistry, although Cronbach's alpha = .51 is still acceptable but it is lower than that computed for the other tests, since the chemistry test includes a variety of measures testing for understanding of atomic structure, periodic table, chemical and physical properties, in addition to chemical and physical change.

Table 5

Reliability Statistics for all Pre-Tests and Post-Tests for the Treatment Group

					***Cronbach's Alpha**	
Test	***N* (Students)**	**Valid**	**%**	***N*(Items)**	**Pre-Test**	**Post-Test**
SE	25	25	100%	7	.74	.77
CH	25	24	96%	20	.51	.79
BIO	25	25	100%	14	.70	.70
NOS	25	25	100%	33	.70	.81

Note: The same test was used as pre-test and post-test

SE=Self-efficacy, CH=Chemistry conceptual understanding, BIO=Biology conceptual understanding, NOS =Nature of Science views.

Table 6

Reliability Statistics for all Pre-Tests and Post-Tests for the Control Group

					*Cronbach's Alpha	
Test	***N* (Students)**	**Valid**	**%**	***N* (Items)**	**Pre-Test**	**Post-Test**
SE	28	28	100%	7	.74	.56
CH	25	24	96%	20	.63	.48
BIO	28	28	100%	14	.61	.51
NOS	28	27	96.4%	33	.73	.80

Note. The same test was used as pre-test and post-test.
SE=Self-efficacy, CH=Chemistry Conceptual understanding, BIO=Biology conceptual understanding, NOS =Nature of Science views.

Equality of variance

Equality of variance is a necessary assumption for conducting ANCOVA. In this study, Levene's test for equal variances is used to examine whether the variance of the dependent variable is equal for both groups. Variances are assumed to be equal when Levene's test yields a significance level $p > .05$. Table 7 presents the results for Levene's test for equality of variance for all the dependent variables, and it shows there is equality of variance for three dependent variables or post-tests, for POSTNOS ($p = .88 > .05$) , POSTBIO p=20 > .05), and POSTSE ($p = .54 > .05$). However, for chemistry post-test ($p = .014$) < .05, so equal variances cannot be assumed. This means that it is not possible to conduct ANCOVA for chemistry scores for the group as dependent variable.

Table 7 also reports the values of partial eta squared η^2, which is the curvilinear correlation used to indicate the proportion of explained variance after the individual differences have been eliminated from the partial total variance. It indicates observed power of probability that a significant difference between groups will occur when the same sample size is drawn from a population having the same effect size as in this study. The values of partial eta squared indicate a weak effect for all post-test scores.

Table 7

Levene's Test of Equality of Error Variances[a]

Dependent variable	***F***	***df1***	***df2***	****Sig.***	***Partial Eta Squared***
[a]POSTCH	6.56	1	50	.014	.007
[a]POSTBIO	1.72	1	51	.20	.078
[a]POSTNOS	.026	1	51	.88	.016
[a]POSTSE	.37	1	51	.54	.002

$^*p > .05$

[a] Design: Intercept + Pre-test sum + Group
Note. POSTCH= Chemistry post-test, POSTBIO = Biology post-test, POSTNOS = NOS post-test, POSTSE = Self-efficacy post-test.

Students' Conceptual Understanding in Chemistry and Biology

In order to answer the first research question (What is the effect of scaffolding intermediate school students' argumentative writing in science on their conceptual understanding?), we implemented a constructivist 5-step inquiry learning cycle with scaffolding of students' argumentative writing, and modeling by the chemistry and biology teachers for the treatment group. The tests of conceptual understanding of chemistry and biology were administered for both the treatment and control groups, as pre-tests before instruction, and as post-tests again at the end of the inquiry cycle.

Students' conceptual understanding in chemistry. To answer the research question (What is the effect of scaffolding intermediate school students' argumentative writing in chemistry on their conceptual understanding in chemistry?), we used the chemistry test of conceptual understanding as a pre-test and a post-test with a maximum score of 20. The treatment group scored a mean 11.33 out of 20 on the post-test, while the control group scored a mean of 10.43 out of 20 (Table8).

Table 8

Mean, Maximum and standard Deviation for Chemistry Post-Test Score as Dependent Variable by Group

Treatment or Control	**Mean**	**Maximum**	***SD***	***N***
Treatment	11.33	17.00	4.26	24
Control	10.43	16.00	2.87	28
Total	10.85	17.00	3.57	52

Note. Maximum score on Chemistry test of conceptual understanding = 20

The univariate analysis of covariance with the chemistry post-test score *POSTCH* as the dependent variable and the chemistry pre-test score *PRECH* as the covariate are presented in Table 9. The results show no significant effects of implementation of scaffolding on conceptual understanding of chemistry for the treatment group since F =0.24 was not significant (p = .62 > .05).

Table 9

Tests of Between-Subjects Effects with POSTCH Score as Dependent Variable and PRECH Score as Covariate

Source	**Type III Sum of Squares**	***df***	**Mean Square**	***F***	****Sig.***
Group	2.07	1	2.07	.24	.62
Error	416.50	49	8.50		
Total	6768.00	52			
Corrected Total	650.77	51			

*P > .05

Student' conceptual understanding in biology. To answer the research question (What is the effect of scaffolding intermediate school students' argumentative writing in biology on their conceptual understanding in biology?) we used the biology test of conceptual understanding as a pre-test and a post-test with a maximum score of 15. The treatment group scored a mean 8.00 out of 15 on the post-test, while the control group scored a mean of 6.90 out of 15 on the post-test (Table 10).

Table 10

Mean, Maximum and Standard Deviation for POSTBIO Score as Dependent Variable by Group

Treatment or Control	**Mean**	**Maximum**	***SD***	***N***
Treatment	8.00	12.00	2.80	25
Control	6.90	11.00	2.10	28
Total	7.41	12.00	2.49	53

Note: Maximum score on biology test of conceptual understanding =15
POSTBIO = Post-Test score on biology conceptual understanding

The results of the univariate analysis of covariance, with the biology post-test score *POSTBIO* as the dependent variable and the biology pre-test score *PREBIO* as the covariate, show a significant effect of implementation of scaffolding on the treatment group conceptual understanding of biology since F = 3.87 and p= 0.05 was significant at 0.05 level (Table 11).

Table 11

Tests of Between-Subjects Effects with POSTBIO Score as Dependent Variable and PREBIO Score as Covariate

Source	**Type III Sum**	***df***	**Mean**	***F***	****Sig.***
Group	16.57	1	16.57	3.87	.05
Error	213.93	50	4.28		
Total	3237.00	53			
Corrected Total	322.87	52			

*p = .05
PREBIO = Pre-Test score on biology conceptual understanding, POSTBIO = Post-Test score on biology conceptual understanding

Students' Understanding of NOS

In order to answer the second research question (What is the effect of implementing argumentative writing in science on students' understanding of NOS?), the SVNOS questionnaire was used as a pre-test and a post-test. The maximum score that students could get was 165, with a mean score of the treatment group of 110.64 out of a maximum of 165, while the control group scored a mean of 112.93 out of a maximum of 165 (Table 12).

Table 12

Number of Students Mean, maximum, and Standard Deviation for POSTNOS Scores by Group

Treatment or Control	**Mean**	**Maximum**	***SD***	***N***
Treatment	110.64	141.00	14.55	25
Control	112.93	138.00	13.65	28
Total	111.85	141.00	13.99	53

Note: Maximum score on SVNOS Questionnaire= 165.
POSTNOS = Post-Test Score for views of NOS on SVNOS questionnaire.

A univariate analysis of covariance was computed with the pre-test as a covariate and the post-test as the dependent variable.The results presented in Table 13 show that there was no significant effect of implementing argumentative writing on the treatment group students' score on SVNOS questionnaire, since F = 0.61 was not significant (p = 0.44 > 0.05)

Table 13

Tests of Between-Subjects Effects for the Dependent Variable POSTNOS Total Score with PRENOS as the Covariate

Source	**Type III Sum of Squares**	***df***	**Mean Square**	***F***	***Sig****
Group	74.57	1	74.57	.61	.44
Error	6089.87	50	121.80		
Total	673220.00	53			
Corrected Total	10178.80	52			

*p > .05
PRENOS = Pre-test score on views of nature of science, POSTNOS = Post-test score on views of nature of science.

Students' Self-Efficacy

In order to answer the third research question (What is the effect of implementing argumentative writing in science on students' self efficacy?), the self-efficacy scale of the SMTSL questionnaire was used as a pre-test and a post-test. The maximum score that students could get was 35, where the mean score of the treatment group was 28.72 out of a maximum of 35.00, while the control group scored a mean of 28.00 out of a maximum of 35.00 (Table14).

Table l4

Mean, Maximum and Standard Deviation for POSTSE Score as Dependent Variable by Group

Treatment or Control	**Mean**	**Maximum**	***SD***	***N***
Treatment	28.72	35.00	5.10	25
Control	28.00	35.00	4.16	28
Total	28.34	35.00	4.60	53

Note: Maximum score on Self-Efficacy scale of SMTSL questionnaire = 35, POSTSE = Post-Test score on self-efficacy

The univariate analysis of covariance with the self-efficacy post-test score POSTSE as the dependent variable and the biology pre-test score PRESE as the covariate are presented in Table15. The results did not show a significant effect of implementation of scaffolding on the treatment group self-efficacy, since F = .01 and p= 0.91 was not significant at .05 level.

Table 15

Tests of Between-Subjects Effects POSTSE Score as Dependent Variable and PRESE Score as Covariate

Source	**Type III Sum of Squares**	***df***	**Mean Square**	***F***	***Sig.**
Group	.24	1	.24	.01	.91
Error	886.59	50	17.73		
Total	43666.00	53			
Corrected Total	1099.89	52			

*p > .05

In conclusion, the effect of scaffolding grade 8 students' argumentative writing within inquiry constructivist instruction is significantly effective on conceptual understanding of biology, but it is not significantly effective on conceptual understanding of chemistry. On the other hand, students' understanding of NOS, and students' self efficacy were not significantly affected by scaffolding of their argumentative writing.

CHAPTER V

Discussion

This chapter presents the findings and their interpretation in light of the theoretical framework and the cognitive model applied in the research design in addition to related research findings. It is organized in four sections. The first three sections discuss the findings for the three research questions about the effect of scaffolding of argumentative writing on students' conceptual understanding in science, students' understanding of NOS, and students' self-efficacy for science learning. The fourth section presents the limitations of the study and the implications for theory and practice.

Effectiveness of Scaffolding Argumentative Writing on Conceptual understanding of Science

Theoretically, this study is an attempt to use writing as learning and problem solving, according to the model developed by Scardamalia and Bereiter (1989).Therefore, the writing tasks involved a dialectic between solving rhetoric problems and solving content problems, in order to construct knowledge, achieve metacognition, and develop an epistemic view of knowledge.

Furthermore, the literature review in this study confirmed an effective role of knowledge construction as a result of scaffolding of students' argumentative writing during inquiry as students connect claims, evidence and reasoning. For that reason, the research design in this study included scaffolds that prompted students to use hints about the content knowledge in the text of the scaffolds, so they function as context-specific scaffolds and are thus expected to support students' learning gains (McNeill & Krajcik, 2009). The literature also confirmed the results of implementing this model in the form of conceptual understanding of science, understanding of NOS, and an improved self-efficacy for science learning (Bell &Linn, 2000; Driver et al., 2000; McNeill et al., 2006).

The results showed a significant effect of implementation of scaffolding on conceptual understanding for the treatment group, in biology but not in chemistry. Knowing that both the biology tasks and the chemistry tasks express the dialectic between solving a rhetoric problem and solving a content problem, it is reasonable to examine the difference in the nature and context of the writing tasks expressed in the scaffolds, and to draw a comparison between chemistry and biology regarding the effects of argumentative writing and instruction. Furthermore, there is a need to examine the effect of the inherent difficulty in chemistry which challenges both chemistry teachers and students (Johnstone, 1991; Nakhleh, 1992).

Contextual factors in middle school science. In general, the results of this study indicate that the effect of argumentative writing on conceptual understanding in science fit in with earlier research on writing-to learn strategies applied at the intermediate school level. Specifically, the meta-analysis conducted by Bangert-Drowns et al. (2004) of research findings covering school-based writing-to-learn interventions from 48 controlled doctoral dissertation studies from elementary to college level, and for various subjects including history, English, mathematics and science found that across various contexts, subjects and grade levels, writing-to-learn was effective in some cases but not in others. The researchers' conclusion of that meta-analysis was that writing can enhance learning but this depends on contextual factors like the intensity and the nature of the writing task, and the ability of the students to benefit from writing interventions. Some of those factors that predicted reduced effects of writing-to-learn are dynamic obstacles to scaffolding of argumentative writing in the present study. While excluding longer writing assignments, those factors include language difficulties, need for more familiarity with argumentative writing, and implementation in grades 6-8. Specifically, Bangert-Drowns et al. (2004) indicate that in 4 out of 6 studies of writing to learn implementation from grades 6-8, yield a significantly lower average effect size than the outcomes of other writing to learn studies. They explained that the reason for lower effectiveness in grades 6-8 seems to be the result of the transition of learners, from children into young adults, an age at which the transition neutralizes the efforts of writing to learn interventions. Although argumentative writing is not age-dependent, as indicated by a study in which the researchers develop a learning progression for argumentation and scaffolding, but rather "is related to student understandings of the classroom norms of whether and how participation in argumentative discourse is expected and the complexity and support provided by the instructional context" (Berland & McNeill, 2010, p. 790). As a result, students need more assistance and more exposure to writing during this transitional stage in order to reflect on their writing, and in order to achieve metacognition.

In agreement, other studies indicate that when middle school students are not provided with support in constructing explanations they have difficulty in connecting evidence to claims and justification. This practice needs reasoning or logic and is the most difficult type of reasoning that middle school students face (McNeill & Krajcik, 2008;

McNeill, Lizotte, Krajcik & Marx, 2006). In addition to this difficulty that middle school students encounter during argumentative writing**,** there are particular difficulties in this study resulting from the complex context in which students are involved in argumentation in each of chemistry and biology.

The contextual factors in chemistry tasks. Chemistry is a field of science that incorporates a multitude of connections among a variety of concepts and relations among concepts. For instance, in the inquiry lessons in this study there are associations of knowledge of periodic table, chemical properties of elements, groups, periods, compounds, symbols, formulas, metals, non-metals, ionic and covalent bonding, , etc... Such a context is neither supportive of rehearsal nor elaboration due to the abstract level at which chemistry as a science operates, that is to say the macro, the micro, and the symbolic levels (Johnstone, 1982), so that integrating these levels and shifting from one level to another and relating among them is necessary for good understanding (Jaber & BouJaoude, 2012). Cconsequently, during the five weeks of the study, the efforts were focused, during inquiry and argumentative writing, on helping students construct knowledge rather than memorize what they need to know from science textbooks, in an attempt to enhance their conceptual understanding and to correct their relational learning. However, incorporating this approach into the scaffolds in chemistry needs more instructional time to take effect and needs to start at an earlier stage when students are just beginning to learn the basic concepts, so they construct knowledge and build the correct relational understanding.

The contextual factors in biology tasks. The biology scaffolds focus on one topic and one type of argument for the inheritance of certain human observable characteristics, reported to be related to a single gene with two alleles, one responsible for a dominant trait and the other for a recessive trait. The scaffold helps students to connect a claim about inheritance to the given evidence through a justification using laws of heredity. In other words, students use the parents' characteristics as evidence to write a claim in order to predict the genetic outcome and inheritance of traits for the children of those parents.

In biology, and in contrast to the multitude of levels and the variation in chemistry topics in each problem solving application, it is possible to notice that the writing tasks do not differ much from the beginning to the end of the inquiry in biology, with the same conditions for inheritance and the same laws that can be applied on every new trait. A specific context, at such a complex stage of learning chemistry as described earlier, is rather difficult to apply in ten periods over a short time of five weeks, due to the multitude of relations, contexts, and macro-micro-symbolic levels in every problem solving application of one scaffold. Therefore, chemistry scaffolds may be less specific and less successful than those in biology. Perhaps, this is due to the prompts being difficult to use in synthesizing all the knowledge, so more scaffolds are needed to effect a significant change. In this study, the scaffolds included hints or cognitive prompts that are embedded in reasoning to prompt learners to associate content knowledge with the scientific explanation, and this is related to a significant effect of argumentative writing. In similar contexts, Wang (2015) indicates that for 7th grade students, during inquiry and problem solving, cognitive prompts facilitate integration of knowledge from the inquiry with the synthesized information in the scaffolds, and also enhance learning with better outcomes in the posttest on content knowledge.

The specific context of the scaffolds in biology allows students to gain conceptual understanding with a better chance to reflect on their writing and to benefit from the writing tasks as these tasks become more familiar to them. The results of this study fit in with research by McNeill and Krajcik, (2008) in that middle school students have difficulties in constructing explanations, but when provided with support, they succeed in using evidence and reasoning.

Instructional factors in the effectiveness of argumentative writing in chemistry and biology. In contrast to chemistry tasks, writing tasks in biology were more focused without much variation, and thus could serve as a way for enhancing conceptual understanding, rehearsal and metacognition The variety of applications and the nature of the tasks in chemistry did not allow students to rehearse as they did in biology. In addition, rehearsal was required by the teacher as a preparation for the school exams. During coordination with the two science teachers, the biology teacher explained that she gave students all the arguments to study and rehearse for both formative and summative evaluation. She further explained that she wanted them to assimilate the biology argument, and explicitly explained argumentation as a scientific practice. This approach, intends to stress assimilation of arguments that connect claim to evidence and reasoning, and eventually satisfies one goal for using argumentative writing, since this requirement acts like an incentive for students to value and benefit from the cumulative effects of the writing tasks, by learning their content.

Research in a study by Berland, and Krajcik (2008) confirms the important role that teachers play while supporting students in consolidating scientific explanations during inquiry. The results suggest that teachers' practices vary and affect students' learning differently. Teachers' instructional practices vary for the components of defining, modeling of scientific explanation, and connecting the scientific explanation to everyday life, for each part of the explanation: Claim, evidence, and reasoning. Teachers who defined and modeled the rationale for scientific explanation explicitly had the most significant effect on their students' learning of explanation.

It is to note that, in the Lebanese context, rehearsal is a study habit that is often encouraged by some teachers of Grade 8 with a traditional classroom environment, because they think that it helps students at this level to prepare for the Lebanese Intermediate School Certificate (known as the Brevet) official exams that take place at the end of next grade level, or grade 9. In these official exams, rote learning and rehearsal of a major part of the science subject matter is a safety measure for many teachers by which they secure the success of the majority of students' achievement because these exams encourage rote learning by repeating a common part of the exam (about 40%) in the same format and with similar requirements every year. Such study habit as rote learning is a shallow strategy that does not guarantee conceptual understanding, but has interacted with the scaffolding of argumentative writing, because teachers encourage it in order to support the success of a larger number of students in Brevet official exams, due to benefits they exploit from the structure of that exam in which connection of claims to evidence and justification is not required in a large percent of the score. For that reason, chemistry teachers trying to face students' difficulty of chemistry, resort to such methods and ignore the evidence-based explanations, and even if the reasoning is required, it has changed, in the school and the

Brevet official exams, to a rigid mechanical repetition of a form of writing without understanding of the rationale.

One of the conclusions in this study is that the success of scaffolding of middle school students' argumentative writing in achieving its goals is determined by many factors like the science subject matter, the nature of the writing task and the specific language of the scaffolds, how much rehearsal and reflection the scaffolding is allowed during writing and during school exams, and how much value students are educated to give to the arguments. In addition, ability of students to benefit from argumentative writing seems to be related to teachers' explicit modeling of parts of an argument, and explanation of the roles of claims, evidence and basically of the reasoning that connects them.

The Effect of Argumentative Writing on Students' Views of NOS

As mentioned earlier in this discussion, this study is an attempt to use writing as learning and problem solving, in order to develop an epistemic view of knowledge according to the model developed by Bereiter and Scardamalia (1989), so the study follows the recommendations for infusing science instruction with argumentative writing tasks in order to improve understanding of NOS. However, the results do not show a significant effect of scaffolding on the views of NOS of the treatment group. This may fit in with existing research by Khishfe (2014) on the relation, and possible interaction, between argumentation skills and understanding NOS, in that explicit teaching of NOS along with argumentation skills is more effective in improving students' understanding of NOS.

The rigid school schedule for each of the science topics, with two periods per week for each, makes it time demanding for the teacher to take more class time away from the curriculum demands, to explain sufficiently NOS. Discussion with the teachers about this point during coordination revealed two trends. First, the explicit introduction and use of the rationale by the biology teacher who chose to explain the rationale of the scientific explanation, and included this rationale in school exams and further explained Toulmin's structure of an argument while stressing its relation to science inquiry. This explanation seemed to have added an extra element to the scaffolding and thus supported students' conceptual understanding, as it related evidence, claim and justification. The second trend was expressed by the chemistry teacher who found that explanation time consuming, to the extent that using the cognitive scaffolds became procedural. In addition, although the rationale was an integral part of naming formulas or writing a formula in the exam, writing an explanation was not required by either the school exams or the official exams.

Social interaction would facilitate the transformation of students' understanding of NOS through explicit teaching and discussion of NOS (Khishfe & Lederman, 2007). But since the model of scaffolding argumentative writing was implemented in a traditional classroom environment, it might not have strongly promoted the benefits of social interaction which is necessary to enhance students' understanding while persuading others. On the contrary, students' construction of arguments and their participation in discourse about NOS, as essential practices during inquiry, seemed to have been inhibited and hindered by the traditional classroom interactions, which persisted - regardless of attempts at planning for an interactive inquiry cycle - due to the limitations in the teaching schedule and the limitations of the curriculum choice of topics. Most likely, students' understanding of what constitutes evidence in the particular domain in which they were writing did not transfer to an understanding of NOS. The writing tasks in chemistry were restricted by the topics and their abstract content. It is to note that benefits from writing tasks are obtained when those tasks promote argumentation skills along with explicit teaching of NOS within a socioscientific context (Khishfe & Lederman, 2007). Besides, explicit and reflective discussions following inquiry-based laboratory activities improve students' NOS views (Yacoubian & BouJaoude, 2010).

The Effect of Argumentative Writing on Students' Self-Efficacy

In this study we expected that encouraging and scaffolding of students' writing to affect personal beliefs and behavior by making students feel more efficacious to write and succeed. Students' feelings of success and motivation makes them put in more effort and work harder on a difficult task, so their behavior changes. During the instructional practices of modeling and during scaffolding of students' argumentative writing there are two key cognitive factors subject to debate: The improved cognitive processing and the improved engagement in science learning are theoretical factors, expected to affect the interaction of argumentative writing with self-efficacy and self-regulation (Schunk & Zimmerman, 2007). However, there was no significant effect of those instructional practices on the treatment class students' self-efficacy for science learning. Logically, since students' self-efficacy was not affected, then the environment created in this study was not able to improve their success. One of the reasons for no significant effect of scaffolding and modeling of argumentative writing is that it did not promise any reward for students' participation and did not boost what interests them most, in this case their grades that had fallen down in mid-year exams (before the start of the study), which seemed to have affected their self-efficacy scores at the beginning of the study.

Empirical evidence indicates that even those students with high self-efficacy rely on the perceived value and utility of a task and their self-efficacy is not likely to change if the tasks will not lead to positive outcomes (Schunk & Zimmerman, 2007). Therefore, in a traditional classroom environment especially after a difficult mid-year exam, the time at which the study started, five weeks of argumentative writing and scaffolding, there is not enough intervention to improve students' low self-efficacy in science because students face the daily difficulty of the school science tests. Successive difficulties are a likely pattern that ran parallel to the study and may have played down the expected positive effects of modeling and scaffolding. A favourable class environment gives students adequate time to study and also supports their success. This is not feasible within the five weeks of the study in Grade 8, under the continuous flow of formative and summative testing intended to put a student's nose to the grindstone, with the excuse of preparation for a tough official exam at the end of the next school year in Grade 9. Under such conditions, all forms of scaffolding, modeling and support are implicated by inherent difficulties in the sciences, and by threats of impending failure that continue to outweigh the effects of scaffolding and modeling on students' self-efficacy

Limitations of the Study

In this study, the same science teacher taught both the treatment group and the control group. In this case, there is a possibility for the teacher to transfer some features of the scaffolding of argumentative writing, and the resulting arguments themselves unintentionally to the control group. Besides teachers had to involve students in critical thinking during inquiry, and students in the control class listened to oral arguments from the science teachers, so this might have affected the results of the study. So, inquiry and oral arguments might have minimized the difference between the two groups and may thus lead us to see there is no significant effect of the treatment. Besides, instructional time limitations might have influenced research results: Explicit teaching of NOS was not done because it requires time, but it was rather that the goal of the intervention was to “induce” an understanding of NOS derived from argumentative writing.

The model used in this study did not achieve its goal of enhancing students' understanding of NOS during the five weeks of the study. If students were given the opportunity to participate in discourse and if the research design included more time for the teacher to explain the reasoning and for students to reflect on aspects of NOS, then perhaps students understanding of NOS might have improved. However, it seems that the traditional teacher-centered classroom culture prevailed leading to lack of improvement in NOS understanding (McNeill & Krajcik, 2008; Kuhn & Reiser, 2005).

There are other limitations in this study, beyond those from the curriculum, instructional time and teacher attitude towards implementation of scaffolding. It is the lack of knowledge about metacognitive learning that results from the treatment. Since most of the design is built around a metacognitive model of learning, we were able to recognize the immediate effects on students' performance which can be described as "situated learning", but we did not investigate the distant effects of this model on metacognitive changes in students' thinking and understanding NOS.

Recommendations for Future Research

Perhaps using a socioscientific issue would be a better context and a more inquiry-oriented topic that can be satisfy more than one requirement: First, it may facilitate students' experience in public negotiation to clarify their ideas and elaborate their thinking in connecting inquiry to NOS. Second, it supplies more active engagement, and more student talk in a topic that could be more meaningful to them. Third, this topic could be more relevant to teacher running of discussion and argumentation than one that traditionally teachers implement as a teacher-centered activity or lecture.

Future research might be able to encourage curriculum designers, especially in the Lebanese context, to add this important feature of inquiry and argumentation in chemistry and to structure scaffolding in the context of scientific explanation and argumentation in chemistry over a longer instructional time and in the early stages of learning chemistry, because understanding and writing good arguments is not age-dependent as some researchers showed (Berland & McNeill, 2010). Using cognitive scaffolds as those in the present study might motivate an integration of inquiry in science teaching, and create a need for teacher intervention, even in a traditional classroom environment. This teacher intervention is crucial in enhancing students' learning gains when the teacher specifically takes the role of explaining the rationale and reasoning in the scaffolds, because this seems to be the most rewarding in students' post-test achievement (Mcneill & Krajcik, 2008).

Appendix I

English Language Plans and Resources

Persuasive Writing Lesson Plans

Lesson 1: Building student awareness of writing to persuade/ Turning in stage
English lesson Plan/ 3periods, 50 minutes each
Supporting students at the various stages of implementation of argumentative writing included in "First steps writing resources" (Riason et al., 2007)

TURNING IN STAGE Teaching points	Task
• Focus on building student awareness of writing to persuade by teaching students language features and organizational frameworks using the procedures: 1. Sample text display: talking about the purpose of persuading or making an argument, by: • Identifying the possible intended audience. • Drawing attention to the text organisation: Thesis-arguments or assertions-conclusions or summary. 2. Highlighting the type of language used: Nouns and pronouns that represent abstract ideas-Technical terms-using timeless present tense in describing opinions-signal words that show cause and effect, compare and contrast, problem and solution, and conclusions-using formal objective style without first person pronouns-converting verbs to nouns to make it seem a more objective argument. 3. Reading to students and reading with students, with an explanation of the features of the persuasive text, in order to provide students with the opportunities to discuss the texts and to evaluate critically how real authors achieve their purpose.	• Invite students to discuss an issue in the presented texts: "Crime and Punishment"? • Ask students to express their position "for, or "against" life sentence of life imprisonment or death for murderers. • Let students explain what they think the situation is, and what they feel the outcome should be. • Encourage students' responses to questions like: *who else thinks...? Who doesn't agree with...? Who has a different thought about....?* • Model and compose the text in front of the class. Finally give the text to students with labeled parts as a model persuasive essay. • Encourage students to provide evidence to support their opinions. • Give students the text with labeled introduction stating the position to be taken, argument for and against life imprisonment, and a final conclusion.

Lesson 2: Building student understanding of purpose, organisation, structure and language features of writing to persuade/Beginning and Developing stage

English lesson Plan/ 2 periods, 50 minutes each

Supporting students at the various stages of implementation of argumentative writing adapted from "First steps writing resources" (Riason et al., 2007)

BEGINNING STAGE

Teaching points	Task
Guiding students through modeling and explaining to: 1. Develop a definite point of view before attempting to write the text 2. Write an introduction that states the position to be taken 3. Locate and collate evidence to support an argument. 4. Structure sentences that include justification of opinions, e.g. I think …, because… 5. Select vocabulary to create a particular effect 6. Use linking words about problem and solution or cause and effect 7. Use language that represents fact and opinion, e.g. It is reported rather than I think.	Students are involved through guided practice to understand the purpose, organisation, structure, and language features of persuasive writing. The texts and activities are the following: 1. *Flip Side.* Teacher provides students with an issue for problem solving and one side of the argument, and then she asks them to use the presented information to compose a list of arguments representing the other point of view. 2. *Text Response.* Teacher asks students to write opinions about characters, actions or events in a literary text:"TV Turn-Off Week", and then she asks them to provide justification for their opinion. Students' opinions should be based on evidence in the text, as well as on their personal experience. 3. *Rate It.* Teacher invites students to use a rating scale to rank their level of reaction to an issue, e.g. strongly agree, agree, undecided, disagree, and strongly disagree. Then she requires that they read a text on that issue; when they finish, she will have them review their rating to see if it needs to be changed. Finally teacher discusses the information that caused students to change their opinions, and to cite examples from the text.

Lesson 3: Building student understanding of purpose, organisation, structure and language features of writing to persuade/Beginning and Developing stage

English lesson Plan/ 4 periods, 50 minutes each

Supporting students at the various stages of implementation of argumentative writing adapted from "First steps writing resources" (Riason et al., 2007)

DEVELOPING STAGE

Teaching points	Task
Guiding students through modeling and explaining to 1. Write an introductory definition or statement 2. Include reasons that explain why or how 3. Use precise and factual subject specific-terms, e.g. Igneous, volcanic; create a glossary when necessary. 4. Use objective language that includes some passive Verbs, e.g. is collected, was harvested use the appropriate tense	• *Across Learning Areas.* Teacher provides opportunities across learning areas for students to compose texts used to explain. • Society: Protecting the natural environment, freedom of stating your beliefs, better laws. • Health: Smoking Students are involved through guided practice to write by giving them: 1. Writing prompt: Write an opinion about an issue that strongly interests you. 2. Purpose: To persuade or help others understand an opinion. 3. Audience: your classmates and friends, members of your community. 4. A chart, "Basics in a box" as a guideline about what a successful opinion statement should be.

Lesson 4: Supporting Students at the Consolidating and Extending Stages of Persuasive Writing

English lesson Plan/ 3 periods, 50 minutes each

Supporting students at the various stages of implementation of argumentative writing adapted from "First steps writing resources" (Riason et al., 2007)

Extending and consolidating Stage

Teaching points	Task
Students are guided through the construction of persuasive texts by modeling and sharing and using previous stages in terms of focus and understanding of organisation, structure and language features. 1. Reinforce arguments by including diagrams, tables and statistical data 2. Present an argument that includes a number of perspectives, 3. Generalise information to substantiate an argument, e.g. Smoking is dangerous 4. Influence the reader to take a particular point of view, e.g. Present more arguments for one side than the other, quote authorities, use technical language, include data and statistical analysis 5. Conclude the text in an appropriate way, e.g. With a recommendation, a summary, a final or overall argument, reiteration of writer's belief 6. Use signal words to guide the reader through the reasoning behind the argument, e.g. Firstly, however, on the other hand	1. *Who's the Audience?* Provide several texts written to persuade; have students review the texts, and then ask them to identify the possible audience for each text. Have students highlight those words or phrases that alerted them to the possible target audience. 2. *Across Learning Areas* Provide opportunities across learning areas for students to compose texts used to persuade, e.g. • Should students' textbooks be replaced by tablets or notebooks, computers or laptops? • Should smoking be banned in Public Restaurants? Write a persuasive essay to convince people in your community of your opinion.

Model Persuasive Essay 1: Crime and Punishment

The purpose of this persuasive essay is to convince you to agree with my point of view about crime and punishment. I will give reasons to support my opinion that murderers should be sentenced to life imprisonment instead of death penalty. Introduction

One reason I support life sentence for murder is that death is not the worst punishment. It is worse to have to sit in jail for the rest of one's life. Life imprisonment is hard. Prisoners never get to do what they want. All they can do is think about their crimes. They know that they will never be able to get out of prison. Therefore, life imprisonment is an effective punishment. Body

Another reason is that sometimes people change. Some people commit murder when they are addicted to drugs or have other bad influences in their lives. With time, people can change in jail. Many convicted criminals start studying or learn about religion when they are in jail. Some of them start to really think about what they did wrong. They even try to help other prisoners by teaching or counseling them. However, change is not possible if they are dead. Body

Finally, I would like to confirm that life in prison is so effective. Also I hope that you are convinced to oppose capital punishment and support life sentences. Conclusion

Model Persuasive Essay 2: TV Turn-Off Week

Assignment: Write a letter to the editor of your school newspaper with suggestions for solving a problem.

Dear Editor I think that watching TV has bad effects on people, especially kids my age. Let's help solve the problem by having TY Turn-Off Week. I suggest that all families in our school district follow these steps: take a large sheet of paper and draw a big circle with a large X in the middle of it. Tape the paper across your TV screen. Slip your remote control into a bag. Unplug your TV set for a week. Why is my proposal such a good idea? Here are three reasons for going a week without TV.	States the problem
First, too many students in King Middle School are becoming couch potatoes. They sit on their sofas and stare at their TV sets for a few hours every day. Meanwhile they are munching on junk food like potato chips and candy. They don't get enough exercise, and gain weight. TV Turn-Off Week would force kids to get off their sofas and possibly get some exercise. They might try spending more time going to visit friends, playing games, taking walks, or riding bikes. Second, some kids watch TV as a substitute for talking to their families, or having friends. My cousin Raymond, for example, has conversations with characters on the TV shows. He likes to tell them what to do or say. Raymond totally tunes out everyone else. His mom can call "Raymond, Raymond" in a loud voice, but Raymond doesn't answer because he's so involved watching TV. TV Turn-Off Week would encourage kids like my cousin to have relationships with real people instead of TV characters. He would probably feel less lonely too. Third, watching too much TV can make some kids have behavior problems at school and home. During an assembly, last month, the principal at King Middle School asked us to stop watching violent TV shows. He told us that TV violence gives certain kids wrong ideas. TV characters who use violence seem strong and powerful. Kids who like to pretend being such TV characters can get trapped in a fantasy world. The principal asked us to stop watching violent TV shows. A TV Turn-Off Week could help kids find better ways to use their imagination.	Gets background, explaining why it is a problem, and what causes it
Don't be a couch potato. Don't use TV as a substitute for friendship or family relationship. Don't let TV violence twist your imagination. Let's break the TV habit for just seven days by having a TV Turn-Off Week	Ends by encouraging the reader to try the solution

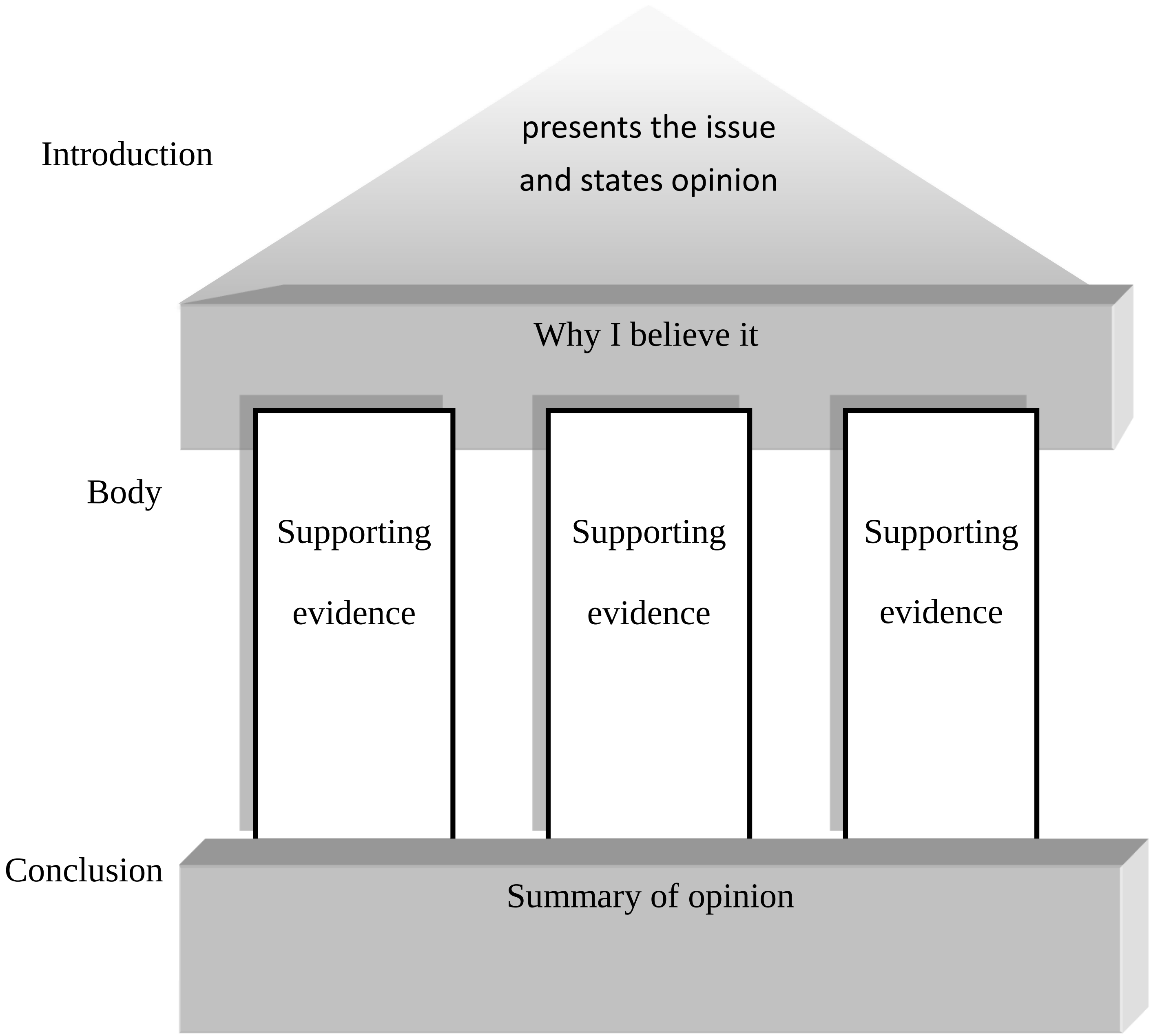
Graphic Organizer: Chart for a Persuasive Essay

Use the graphic organizer below to write an essay of 4 paragraphs to convince others to agree with you.

Introduction 3-4 sentences	• Give an opinion about a serious issue. • give general details to support it. • Write a thesis statement.
Body 5-6 sentences	• Give a fact or a reason to support your opinion. • Give enough evidence and explanations to your reasons.
Body 5-6 sentences	• Give the strongest reason and its evidence and explanations last.
Conclusion 3 sentences	• End with a strong restatement of your opinion. Give a motivating sentence to take an action.

A chart, "Basics in a box"

Opinion statement at a glance



Appendix II

1. Biology Inquiry Resources-Exploration Phase

First Resource: An Inventory of my Traits

This Activity is downloaded from an online module by Genetic Science Learning Center at http://learn.genetics.utah.edu. It helps students recognize their observable hereditary traits, work in small groups, record their traits into the inventory, observe how their traits and those of others in the group differ. Then students record their observations into data tables, and bar graphs that give the results for the least and most common traits in the group. It is included as a downloaded pdf document as a resource in this study at the following link:

Second Resource: Pea Soup Activity

This activity was adapted from an online source. It was simplified for grade 8 students understanding and English language level. It was obtained from http://www.sonic.net/~nbs/projects/anthro201/disc/

Activity: Mendel's Experiments-Explore. Read the handout given to you under the title:

Mendel's Discoveries. This document was adapted from an online document: http://www.sonic.net/~nbs/projects/anthro201/disc/

Work in pairs to read the handout given to you and answer the related questions below under the title: Mendel's Discoveries.

1. What traits of pea plants did Mendel describe in his experiments, and into what categories did he classify those traits?

2. On what evidence did Mendel build his conclusions about dominant and recessive traits?
3. Mendel worked on controlling his experiments in order to be able to make correct conclusions. What precautions did he take?
4. What new findings contributed to a better understanding of Mendel's observations and discoveries about splitting and blending of traits?

Mendel's Discoveries

Johann Gregor Mendel (1822-1884) lived from age 21 at a monastery where he studied theology, mathematics and natural sciences. He became interested in gardening, and started to experiment with the pollination and breeding of the common pea plant. The results of his experiments became known after his death at the beginning of the 19th century. Mendel studied mainly seven traits in pea plants, presented in the table below.

	Trait:	Dominant	Recessive
1.	Form of ripe seed	Smooth	Wrinkled
2.	Color of seed albumen	Yellow	Green
3.	Color of seed coat	Grey	White
4.	Form of ripe pods	Inflated	Constricted
5.	Color of unripe pods	Green	Yellow
6.	Position of flowers	Axial	Terminal
7.	Length of stem	Tall	Dwarf

In his experiments, and during the flowering period, Mendel protected the flowers from the accidental contact with foreign pollen. Such accidental contact would lead to totally different conclusions. He ended up making 287 crosses between 70 different purebred plants.

Mendel made some striking observations. He observed that when two purebred plants with variation of a trait (green pods x yellow pods) were crossed one trait was masked in the first generation (yellow pods), but it would appear again in the second generation. This led him to say that the green variation is dominant, while the yellow variation is recessive. In addition, the yellow was only masked in the first generation since it was transferred to the second generation. Therefore, Mendel concluded that when two plants breed, the variations of their traits are combined, and that this combination of traits can only be explained by assuming that, for each trait, there is space for two pieces of "information" to describe the variation. Nowadays we call these pieces of information alleles.

The first filial generation results from crossing purebred green peas or homozygous GG, and purebred yellow peas or homozygous gg. Therefore, we draw this variation using a Punnet square.

First filial F1

	G	G	100% Gg
g	Gg	Gg	hybrid
g	Gg	Gg	Green peas

Second filial F2 results from crossing the hybrid green peas or heterozygous Gg

	G	g	50% Gg hybrid green peas
G	GG	Gg	25% pure green peas 25% pure yellow peas
g	Gg	Gg	

At the time when Mendel explained his findings as "pieces of information", science could only reach that stage. However, with new developments in technology and optical instruments like the microscope, scientists started to observe proof of Mendel's work. For instance, Boveri and Hertwig observed proof of Mendel's "splitting and blending" of pieces of information, when they witnessed chromosomes halving during cell division. Moreover, Henking further noticed that chromosomes can also determine the sex of a new individual.

These new discoveries gave birth to the science of genetics. Nowadays, with a vast amount of knowledge, science has the ability to use antibiotic-making bacteria, and to determine hereditary diseases, and how they are passed along from generation to generation.

Chemistry Inquiry Resource-Third Stage

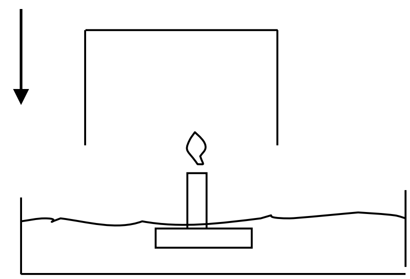
Act 1. A Burning Candle was developed by the researchers in the study by Erduran et al., (2004) and is adapted and used in stage 3 of this study.

Aims	– Use the combustion in a burning candle to provide a context for students to generate arguments. – Collect evidence of combustion from the demonstration.
Learning goals	The learning goal is provide an opportunity for students to: – Think about evidence of burning. – Make an explanation of what happens during burning. – Think about and evaluate arguments of others.
Teaching points	– Prerequisite understanding of oxygen as a needed component in combustion. – Alternative predictions provide the context for argumentation. – Carbon dioxide is a product of combustion and it displaces oxygen gas within the cup. – Water rises to displace oxygen gas that was removed. – Why didn't the released carbon dioxide displace the oxygen and prevent water from moving up? – Exploring evidence and justification of students' points of view.
Teaching sequence	– Elicit students' hypotheses before the demonstration. – Ask students to work in pairs to write their predictions into the activity sheet. – Direct students to work in pairs or fours to compare their predictions. – Let students in a group write an *argument* to explain their predictions, and make the textual resources about solubility of gases and indicators available to students to use as they write their arguments. – List the predictions on the board. – Demonstrate the experiment, and let students observe and write their observations. – Let one student in each group present the argument. – Conduct a discussion with each group and direct them to present their rebuttals of the arguments of other groups.

Background Notes	–	Carbon dioxide is the product of combustion. It is soluble in water. When it dissolves it leaves fewer molecules in the space above the water, so the atmospheric pressure on the surface increases and the water rises. This effect would be intensified with the burning of two candles.

A Burning Candle

What will happen when the candle is covered?



What do you think will happen?

Why do you think this will happen?

What happens when it is demonstrated?

Explain why you think what you observed happens.

First Inquiry Resource Document-A burning candle-Third phase

Solubility of gases

Solubility is the mass of a solute that dissolves in a volume of solvent under normal conditions of temperature and pressure. For example, many gases from the atmosphere dissolve in water and support the life of organisms that live in water.

The solubility of gas in water depends on the type of gas, and on the temperature of water. Therefore, different gases dissolve in water at different rates. The solubility of a gas also depends on the temperature at which it is dissolving. When the temperature of water decreases, the solubility of gases increases. For example, carbonated drinks consist of a gas, carbon dioxide CO_2, dissolved in water. When carbon dioxide dissolves in water, the resulting solution is an acidic solution of carbonic acid $H_2CO_{3\,(}$aq), which is an acid, and has a sour taste. The sour taste is weaker when the temperature of the carbonated drink rises outside a fridge. The table below shows the solubility rates of three common gases in the atmosphere. *Solubility in Grams of gas dissolved in 100 ml of water when the total pressure above the solution is 1 atmosphere.*

Name and formula of gas	Solubility
Carbon dioxide CO_2	0.169 g/ml
Nitrogen gas N_2	0.0019 g/ml
Oxygen gas O_2	0.0043 g/ml

Carbon dioxide is almost 39 times more soluble than oxygen and 88 times more soluble than Nitrogen gas. The low solubility of oxygen gas allows it to dissolve in water and support life of organisms in water, but also this low solubility allows oxygen to exist in the atmosphere under normal temperature and pressure, so this is also suitable for life on land. Imagine what would have happened if oxygen had a much greater solubility in water.

Second Inquiry Resource Document-A burning candle-Third phase

Indicators

What is an acid-base indicator?

An acid -base indicator is a dye (colored substance) composed of a large organic molecule that changes color according to the medium in which it is dissolved. For instance, when Litmus is dissolved in an acid, it turns red, but when it is dissolved in a base it turns blue. Litmus turns red when the concentration of H^+ ions increases, but it turns blue when the concentration of H^+ decreases.

Note: The change in color has to do with the confinement (imprisonment) of electrons in the molecule of indicator when the concentration of Hydrogen ions H^+ in solution changes.

Table of some common indicators and their colors

Indicator	Color in acidic solution	Color in basic solution
Litmus solution	Red	Blue
Phenolphthalein	Colorless	Fuchsia
Methyl orange	Red	Yellow

Appendix III

Chemistry Lesson Plans and Objectives

Lesson 1: Binary compound of a metal and a non-metal
Chemistry lesson Plan/ 3 periods, 50 minutes each
Using the 5Es of BSCS instructional model during minds on activities

Step	Teaching points	Task
Engage	Handout: Periodic Table of the elements. Some people say that the periodic table is a masterpiece of organized chemical information. Do you agree? Why?	Discussion and teacher directed argument to concentrate on properties of the elements and how those with the same chemical properties are arranged in the same column or group
Explore	Students are told to search the periodic table for a metal available in table salt. Then exploration of the compound sodium chloride begins.	Teacher writes the name and formula and directs students to find similar formulas of elements in group I with elements in group VII. Teacher writes the formulas on the board and writes the corresponding name while asking students to supply this information and the related justification.
Explain	Teacher and students collaborate to explain the naming rule for metallic halides,	• Students write the naming rule for a metal and halogen compound as • Metal + halogen→ "name of metal + halide" • NaCl is Sodium chloride
Elaborate	Students state the naming rule and then the teacher directs their attention to other metals in group II and requires that they explain how bonding occurs when they combine with halogens	• Metal + Non-metal → "name of metal + name of non-metal + ide" • Include scaffold 1 as an elaboration on the concept and as a resource document
Evaluate	Students perform the task of writing names of some compounds using the rule for a binary compound of metal and non-metal	• Name the following, , MgF_2 Na_2O Na_3S KI Al_2O_3 $BaCl_2$ $AlCl_3$ Li Br, Na_3S Al_2O_3 MgF_2 $AlCl_3$

Lesson 2: Binary compound of hydrogen and non-metal
Chemistry lesson Plan/2 periods, 50 minutes each
Using the 5Es of BSCS instructional model during minds on activities

Step	Teaching points	Task
Engage	Handout: Periodic table of the elements Teacher directs student to think about: • Properties of the element hydrogen. • Electrons that hydrogen shares with other non, -metals to form a stable configuration of the outermost energy level	• Some questions follow the discussion about hydrogen as a non-metal of group I • Students' answers are directed to the five compounds of hydrogen and other non-metals water, hydrogen peroxide, ammonia methane and phosphine (H_2O H_2O_2 NH_3 CH_4 PH_3) • The teacher writes the names and formulas on the board, and says they represent exceptions to the rule studied earlier of metal and non-metal binary compound, so what is the rule?
Explore	Teacher directs students to explore the hydrogen and non-metal, in examples like HCl, HI, HF, HBr	Students explore the possibilities for naming the compounds as in the previous example of metal and non-metal, start naming them hydrogen chloride, etc....
Explain	The teacher explains that these compounds of a hydrogen and a halogen are gases and which can dissolve in water to give an acidic solution	Students are encouraged to write the name of the gas HCl (g) as hydrogen chloride , and the name of the aqueous solution of HCl (aq) as hydrochloric acid
Elaborate	Students start to elaborate using the information and state the rule	Hydrogen +non-metal_ide if gaseous Hydrogen +non-metal_ic acid if it is an aqueous solution.
Evaluate	Teacher evaluates students over lesson 1 and 2, using the periodic table as a resource, by asking them to name the formulas of some compounds, or to give the formulas when given the names	Give the formula for each of the following compounds: Hydrochloric acid, hydrogen iodide, hydrogen bromide, hydrofluoric acid.

Lesson 3: Binary compound of a metal and hydrogen
Chemistry lesson Plan/2 period, 50 minutes each
Using the 5Es of BSCS instructional model during minds on activities

Step	Teaching points	Task
Engage	Handout: Periodic Table of the elements. What kind of element is hydrogen? Would hydrogen atom gain an electron during a reaction with a metal?	Discussion and teacher directed argument to concentrate on properties of the element Hydrogen as a non-metal.
Explore	Students explore the evidence sheet given as a preparation for modeling of argumentative writing	Students focus on examining the formula of calcium hydride as an ionic compound.
Explain	The teacher models and explains while asking students to connect evidence to claims or ideas, then she composes and writes the argument in front of the class, stressing the use of connectives like: Because, since, therefore, so, hence, etc...	What is the formula of the compound calcium hydride? Using the evidence sheet, the class fills in the sheet and then participates actively in answering and in writing the whole argument after they fill in the ideas related to the evidence.
Elaborate	Students state the naming rule and then the teacher directs their attention to other metals in group II and requires that they explain how bonding occurs when they combine with halogens	• Metal + hydrogen → "name of metal + hydride"
Evaluate	Students perform the task of writing names of some compounds using the rule for a binary compound of metal and hydrogen.	• Name the following, , Na H KH Li H Ba H_2 SrH_2 Cs H

Lesson 4: Binary compound of two non-metals
Chemistry lesson Plan/ 3 periods
Using the 5Es of BSCS instructional model during minds on activities

<table>
<tr><th>Step</th><th>Teaching points</th><th>Task</th></tr>
<tr><td>Engage</td><td>Handout: Periodic Table of the elements.
There are fewer non-metals than metals in the periodic table, but these non-metals bond together in various ways and produce a huge number of compounds. Can you think of two different compounds made up from the same elements?</td><td>Students concentrate on the elements they identify as non-metals and may be able to mention compounds CO and CO_2, in addition to water, hydrogen peroxide, and hydrogen chloride.</td></tr>
<tr><td>Explore</td><td>Teacher gives students some examples to explore and try to name according to the example CO and CO_2</td><td>Students explore prefixes that indicate a number of atoms in the formula like:<table><tr><td>2
di</td><td>3
tri</td><td>4
tetra</td><td>5
penta</td><td>6
hexa</td></tr></table>
Students try to write the formula for three compounds: dinitrogen dioxide, and dinitrogen pentaoxide, and dinitrogen trioxide.</td></tr>
<tr><td>Explain</td><td>Teacher and students collaborate to explain the naming rule for a formula of two non- metals:</td><td>Students write the naming rule for two non-metals
Name = (amount of 1st non-metal + name of non-metal) + (amount of second non-metal
+ name of 2nd non-metal)</td></tr>
<tr><td>Elaborate</td><td>Students state the naming rule and then the teacher directs their attention to other metals in group II and requires that they explain how bonding occurs when they combine with halogens
Students perform the task of writing names of some compounds using the rule for a binary compound of metal and non-metal.</td><td>Name the following

MgF_2 Na_2O Na_3S KI Al_2O_3
$BaCl_2$ $AlCl_3$ Li Br, Na_3S Al_2O_3</td></tr>
</table>

Evaluate Third Phase Inquiry	• Chemistry Inquiry Resource-Third Stage-A burning candle • Demonstration and directing discussion within groups by teacher.	• Students use the first and second Inquiry Resource Document-A burning candle-Third phase, fill out the activity sheet about the burning candle, APPENDIX II • Post-testing: conceptual understanding in chemistry, understanding NOS, and self-efficacy for science learning

Appendix IV

Biology Lesson Plans and Objectives

Lesson 1:Heredity and genetics
Biology lesson Plan/ 6 periods
Using the 5Es of BSCS instructional model during minds on activities

	Teaching Points	Task
Engage	Teacher initiates the learning process allowing students to read the story of Mendel and his work in a document as handout with a set of 7 hereditary traits that he studied.	Students are engaged in answering a question during discussion: What traits did we inherit from our parents?
Explore	Using "An Inventory of my Traits" (p.5), the teacher directs attention to special observable human traits like widow's peak trait, earlobes attachment, tongue rolling, dimples, freckles, handedness, naturally curly hair, allergies, hand clasping, and colorblindness. This activity was downloaded from: http://teach.genetics.utah.edu	• Students work in groups and focus on exploring those traits in each individual in the group, by filling an inventory of those traits for the group. • Students in each group describe their findings in front of the class Finally, students add their values for the frequency of each trait in class on a bar graph
Explain	• Teacher explains which traits are dominant, which are recessive, which are related to one gene, or to more than one gene, and which traits are sex-linked traits. • She focuses students' attention on the scientific terms and she guides students to a deeper understanding. • She explains each term while connecting it to students' understanding and experience during exploration.	Students take notes about the important scientific terms: heredity, inherited traits, genetics, chromosomes, gene, recessive gene, dominant gene, representation of a gene in cases of pure homozygous and hybrid heterozygous genes.

Elaborate	• In the treatment class the teacher models, composes in front of the class and writes an argument in which she shows the predictions, by going through connection of evidence to claims and justification with biology evidence sheets in three scaffolds: 1. Scaffold 1: Inheriting freckles /teacher support 2. Scaffold 2: Inheriting hairline shape /teacher support 3. Scaffold 3:Inheriting dimples/ final stage or evaluation • Students in the control class apply their understanding in a new situation by solving problems, on inheriting dimples, diabetes, and hair color. They answer specific questions that follow the traditional method followed by teachers in preparing for the Brevet National Exam for grade 9.	• All students in the treatment class participate in filling in an Evidence sheet, with teacher help and directions, as the teacher models and she writes an argument in which she shows the predictions, using a scaffold for argumentative writing. • Students in the control class represent the genes for certain traits like color of eyes, and solve exercises on heredity using traditional methods of writing and representation related to Brevet National Exam.
Evaluate	Teacher assesses students' progress/independent student writing of an argument using scaffold 3	Students take a formative test.

Objectives of background learning on heredity and genetics

Students are able to:

1. Identify a trait as an observable characteristic passed from parent to offspring.
2. Recognize that an equal number of traits is passed along from each parent.
3. Recognize that some traits are more common in a population than others.
4. Identify DNA as the genetic material that is responsible for transferring traits.
5. Explain that a part of the molecule of DNA that carries specific characteristic.
6. Distinguish between sexual and asexual reproduction.
7. Explain that chromosomes come in pairs, with one set from each parent in the case of living things that have sexual reproduction.
8. Recall that each species has a specific and constant number of chromosomes.
9. Recall that genes come in pairs one on each of a homologous pair of chromosomes.
10. Explain that a human body cell has 46 chromosomes, or 23 pairs, with 22 autosomal pairs, and a pair of sex chromosomes, either xx in females or xy in males.
11. Compare number and type of chromosomes in human gametes.
12. Recall that the gene may have various forms called alleles of the gene.
13. Distinguish variations in hereditary traits in the offspring as resulting from combinations in the traits from parents, which make the individual unique.
14. Recognize that the variation in a trait that supports adaptation would help the survival of the organism.
15. Define an allele as an alternative form of a gene with the same position on the homologous chromosomes.
16. Apply the definition of an allele in labeling a pair of alleles on a diagram of the homologous chromosomes.

Objectives of Lesson 1:Heredity and Genetics

Students will be able to:

1. Differentiate between dominant and recessive traits using evidence in data and in descriptive text.

2. Identify patterns in data and relate them to Mendel's models of heredity.

3. Relate the Punnet square factorial analysis of hereditary traits to inheritance of alleles of the same gene.

4. Explain simple dominance, using empirical evidence.

5. Describe conclusions based on empirical evidence of hereditary traits in problem solving situations

6. Recognize that the results of Punnet square factorial analysis of hereditary traits are applicable to a large population and that in a small family the results might not be exactly the same as that in a large population.

7. Write an argument that connects claims to evidence and warrants, about predictions of heredity for a trait in a case for problem solving.

Appendix V

The Scaffolds in Chemistry and Biology

Note: Only the evidence part in the scaffolds is supplied to students, so that the teacher models and explains the writing of the claims and how they connect to the evidence through a warrant.

Scaffold 1-Lesson 1

Writing the correct formula for magnesium oxide

The argument can be written while explaining it orally and asking questions that are central to argumentation, because they demand that students move from evidence to explanation. The teacher selects evidence, and moves to the claims and ideas by explaining and filling in under claims in the table. She stresses the use of connectives like because, so, therefore, hence etc...

Problem: A piece of magnesium ribbon was burned in air to produce magnesium oxide. Knowing that Magnesium is Alkaline Earth metal, oxygen is a diatomic gaseous non-metal element then the word equation for this reaction is: Magnesium + Oxygen $\rightarrow$ magnesium oxide Write the formula of magnesium oxide and justify, using the evidence sheet below. Then write your argument.

<u>Evidence Sheet</u>

Evidence	Claims or ideas and justification
Magnesium is a metal and oxygen is a non-metal	A metal and a non-metal react to form an ionic compound (warrant)
Magnesium is a metal of group II	It forms Mg^{2+} cations when it reacts with non-metals.
Oxygen is a non-metal of group VI	It forms the anion O^{2-} when it reacts with metals
Word equation: Magnesium + Oxygen $\rightarrow$ magnesium oxide	
Magnesium cation Mg^{2+} + oxide anion O^{2-} $\rightarrow$ magnesium oxide $Mg^{2+}O^{2-}$ or MgO	

Chemistry Scaffold 2-Lesson 3

What is the formula of the compound calcium hydride?

The teacher models and explains while asking students to connect evidence to claims or idea, the she composes and writes the argument in front of the class, stressing the use of connectives like: Because, since, therefore, so, hence, etc...

1. Deduce the formula of the compound calcium hydride in the table below, and write an argument to justify your answer, using the evidence sheet.

Evidence sheet

Metallic Hydrides are ionic compounds made up of metal cations and hydrogen anions

Evidence	claims or ideas and justification
Calcium is a metal	Reacts by losing electrons to form cations
Calcium belongs to group II of alkaline earth metals	Calcium forms Ca^{2+} Cations
Hydrogen is a non-metal and hydride means H^-	Hydrogen reacts with a metal by gaining one electron to form the anion H^-
Calcium hydride is an ionic compound, Calcium hydride has metallic cations of calcium and non-metallic hydride anions.	To form a neutral formula, each calcium cation needs two hydride anions so the formula of calcium hydride is (Ca^{2+} + 2 H^-) or CaH_2
Calcium hydride is an ionic compound with a neutral formula.	Ca^{2+} + 2 H^- → CaH_2 calcium hydride

Chemistry Scaffold 3-Lesson 4

Reaction of an acid and a base

What happens when the two aqueous solutions HCl (aq), NaOH (aq) are mixed together? How do you justify the expected changes experimentally?

This scaffold is a chance to teach the differences between acids and bases, and how they react to produce salt and water as an activity that elaborates on previous lessons dealing with aqueous solutions of a compound of hydrogen and a non-metal, and the lesson dealing with aqueous solutions of a metallic hydroxide.

After learning the lesson about naming rules of acids and bases the teacher models and explains the argument while asking students to connect evidence to claims, using this evidence sheet.

Evidence sheet

Evidence	claims or ideas
NaOH(aq) is Sodium hydroxide solution	It forms Na^{+} Cations, and OH^{-}anion The presence of OH^{-} anions indicates a basic solution. Test for the base using litmus paper, it turns blue in base
HCl(aq) is hydrochloric acid solution	The aqueous solution contains the cations H^{+} H^{+} cation indicates an acidic solution Test for the acid using litmus paper, it turns pink
Bases and acids react to produce salt and water, and this reaction is called a neutralization reaction because the resulting	Base + Acid → Salt + water
Base + Acid → Salt + water	NaOH(aq) + HCl(aq) → NaCl + H_2O
Alternative evidence.	Rebuttal and alternative solution
The solution is neither acidic nor basic since it does not contain either H^{+} or OH^{-}, but only sodium chloride dissolved in water, under	If there is excess acid that does not react, then after the reaction there will be an acidic solution, and if there is excess sodium

conditions where equal quantities of ions of reactants exist.	hydroxide that does not react, then there will be a basic solution after the reaction

Scaffolding Writing in Biology

Biology Scaffold 1: Inheriting Freckles

Having freckles is reported to be related to a single gene and it is caused by a dominant trait.

Problem: a homozygous man with freckles married a homozygous woman with no freckles. Predict the future results if one of the children later married a woman with freckles. Write arguments to explain what percent results are expected from this marriage, and to explain why unexpectedly none of the children had freckles.

Evidence sheet

Evidence	Claims or ideas
• "Having freckles" is a dominant trait.	• Having the dominant freckles phenotype and being homozygous would be represented by genotype FF.
• "Having no freckles" is a recessive trait.	• Having no freckles recessive phenotype is homozygous and would be represented by ff
• Homozygous man with freckles marries a homozygous woman with no freckles	• FF man X ff woman

♀ / ♂	F	f
F	Ff	Ff
F	Ff	Ff

- Factorial analysis indicates that all 4 children are heterozygous with Ff genotype, so they have freckles

- A child from the earlier generation is heterozygous Ff and has freckles, marries a homozygous woman with ff genotype with no freckles.

♀ / ♂	f	f
F	Ff	Ff
F	ff	ff

- All expected genotypes are Ff, therefore if a child later marries a woman without freckles, then we expect a heterozygous and a homozygous cross Ff X ff
- There is a fraction of 2/4 or 50% chance of having children with freckles who are heterozygous of genotype Ff.

- There is a fraction of 2/4 or 50% chance of having children without freckles, who are homozygous and with the genotype ff
- However, with only three children, they might all have freckles and a genotype Ff
- So we only can get 50% with freckles and 50% without freckles if we are talking about all similar families together in a big population.

Biology Scaffold 2: Inheriting hairline shape

Hairline shape is reported to be related to a single gene and widow's peak trait is caused by a dominant gene, while a straight hairline trait is recessive.

Problem: a homozygous man with widow's peak hairline married a homozygous woman with a straight hairline trait. Predict the future results if one of the children later married a woman with a widow's peak trait. Write an argument to explain what the genotype of that woman may be if one of the children has a straight hairline trait.

<u>Evidence sheet</u>

Evidence	Claims or ideas
• Having widow's peak is dominant	• Having the dominant widow's peak hairline phenotype and being homozygous would be represented by genotype WW
• "Having straight hairline" is a recessive trait.	• Having straight hairline phenotype is homozygous and would be represented by ww
• Homozygous man with widow's peak marries a homozygous woman with straight hairline.	• WW man X ww woman
	• Factorial analysis indicates that all 4 children are heterozygous with Ww genotype, so they have widow's peak

First case: The woman is homozygous

♀ / ♂	W	W
W	WW	WW
w	Ww	Ww

- A child from the earlier generation is heterozygous Ww and has widow's peak marries a woman with widow's peak..

- This woman could be either homozygous WW, or heterozygous Ww because widow's peak is a dominant trait expressed when one gene exists.
- In the case when she is homozygous WW, there is no chance of any child having straight hairline since factorial analysis shows either a genotype WW, or Ww,with the dominant allele expressed in the phenotype of the children. So all children will have widow's peak.

Second case: The woman is heterozygous		
♀ / ♂	W	w
W	WW	Ww
w	Ww	ww

- There is a possibility or 25% chance of having a child with straight hairline in this case, since the recessive trait appears only when it is homozygous ww.
- Hence the woman is heterozygous of genotype Ww

♀ / ♂	w	w
W	Ww	Ww
W	Ww	Ww

Biology Scaffold 3: Inheriting Dimples

Dimples are reported to be related to a single gene and they are dominant traits. They may exist as a dimple on one side of the face.

Problem: a homozygous man with dimples married a homozygous woman with no dimples. Predict the future results if one of the children later married a woman with no dimples. Write arguments to explain what results are expected if this marriage produces 3 children, with only one child having dimples.

<u>Evidence sheet</u>

Evidence	Claims or ideas
• "Having Dimples" is a dominant trait.	• Having the dominant dimples phenotype and being homozygous would be represented by genotype DD.
• "Having no dimples" is a recessive trait.	• Having no dimples recessive phenotype is homozygous and would be represented by dd
• Homozygous man with dimples marries a homozygous woman with no dimples	• DD man X dd woman
• Punnet square	• Factorial analysis indicates that all 4 children are heterozygous with Dd genotype, so they have dimples. • All expected genotypes are Dd, therefore if a child later marries a woman with no dimples, then we expect a heterozygous and a homozygous cross Dd X dd

♀ / ♂	d	d
D	Dd	Dd
D	Dd	Dd

- A child from the earlier generation is heterozygous Dd and has dimples, marries a homozygous woman with dd genotype

  - Punnet square

♂ \ ♀	d	d
D	Dd	Dd
d	dd	dd

- There is a fraction of 2/4 or 50% chance of having children with dimples who are heterozygous genotype Dd.
- There is a fraction of 2/4 or 50% chance of having children without dimples, who are homozygous and with the genotype dd.

Alternative evidence

In many similar cases, if the marriage produces three children,they might be:

- All 3 Dd with dimples
- All 3 dd, with no dimples
- 2dd without dimples and one Dd with dimples
- 2 Dd with dimples and one dd without dimples

- To show 50% Dd and 50% dd the family must be very large, or it could be a chance in all similar situations.
- 50% reflects a chance in the population or in a large number of people, but the alternative evidence is for a small family where the chance for a certain combination might appear different from the large population.

Appendix VI

Chemistry Test of Conceptual Understanding

Answer the questions using the section of the periodic table below.

Group	I	II											III	IV	V	VI	VII	VIII
Period 1	H																	He
2	Li	Be											B	C	N	O	F	Ne
3	Na	Mg											Al	Si	P	S	Cl	Ar
4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr

1. A Phosphorus (P) atom has 15 protons and 16 neutrons in the nucleus. Another atom with the same number of protons , and one more neutron would be:
   a. An atom of a different element
   b. An atom of Sulfur S
   c. An atom of Silicon Si
   d. Another phosphorus atom

2. The number of electrons in a neutral atom of sodium $^{23}_{11}Na$ would be:
   a. 23
   b. 11
   c. 12
   d. 33

3. An element that has similar chemical properties to magnesium (Mg) is:
   a. B
   b. Ca
   c. Al
   d. Na

4. An atom of calcium with 20 protons and 23neutrons has a nuclide

a. $^{43}_{20}Ca$ b. $^{20}_{43}Ca$ c. $^{23}_{20}Ca$ d. $^{20}_{23}Ca$

5. An oxygen atom has eight protons. This means that a neutral oxygen atom also has:
    a. Eight electrons in the electronic cloud
    b. Sixteen neutrons in the nucleus of the atom
    c. More protons in the nucleus than neutrons
    d. An atomic number equal to that of neutrons

6. One molecule of carbon monoxide would be:
    a. Co
    b. Co_2
    c. CO
    d. CO_2

7. When magnesium ribbon is burned in oxygen gas, magnesium oxide MgO is produced. The properties of this product are different from both elements Magnesium and Oxygen , since the product is a(n)
    a. Element
    b. Compound
    c. Solution
    d. Mixture

8. Silver reacts with oxygen to form Silver oxide, Ag_2O. The properties of Ag_2O are
    a. different from properties of both elements
    b. similar to properties of both elements
    c. similar only to those of the element silver
    d. Similar only to those of the element oxygen

9. Electrons are in regions around the nucleus called *energy levels*. The first energy level

    a. Is furthest from the nucleus of the atom
    b. Is closest to the nucleus of the atom
    c. Holds the greatest number of electrons.
    d. Needs more than two electrons to fill it up.

10. Why is cobalt (Co) placed before nickel (Ni) on the periodic table of the elements even though it has a higher atomic mass than nickel?
    a. Nickel has one more proton.
    b. Cobalt was discovered first.
    c. Nickel has fewer electrons.
    d. Cobalt has a lower density

11. The atomic number of an atom is
    a. The mass of the atom in atomic mass units
    b. The sum of numbers of protons and neutrons
    c. The number of protons in the nucleus of the atom
    d. Negatively charged number of electrons in the atom

12. A pure substance that cannot be broken down by heat or by physical change, but only through a chemical change is
    a. Atomic element
    b. Molecular element
    c. A compound
    d. A solution

13. An electron is an elementary particle that
    a. is larger than a proton and has no charge and no mass
    b. has a negative charge and a smaller mass than a proton
    c. is smaller than a proton and has a neutral charge
    d. has a positive charge, and a greater mass than a proton

14. Neutrons are in the nucleus of the atom. A neutron has
    a. a positive charge
    b. neutral charge
    c. a negative charge
    d. a +1 elementary charge

15. A teaspoon of table salt crystals is added to a cup of hot water. The salt dissolves, and this process forms a salt water solution. Table salt is:
    a. Solute
    b. Solvent
    c. Reactant
    d. Product

16. A carbon atom has six protons. This means that a carbon atom also has:
    a. Six electrons in the electronic cloud
    b. Six neutrons in the nucleus of the atom
    c. More protons in the nucleus than neutrons

d. An atomic number equal to that of neutrons

17. Neon (Ne) is:
    a. A reactive gas
    b. An inert gas
    c. A soft solid
    d. A dense liquid

18. A pure substance can be identified by its:
    a. Observable physical properties
    b. Measurable physical constants
    c. Measured mass or volume
    d. Ability to conduct heat

19. A physical change like boiling can separate a solution like NaCl salt dissolved in water H_2O into:
    a. NaCl and H_2O
    b. The elements H, O, Na & Cl
    c. Sodium dissolved in water
    d. Chlorine dissolved in water

20. A substance can be broken down by electrolysis. The conclusion is:
    a. Electrolysis breaks down the substance so it is not a pure substance.
    b. Electrolysis is a physical change, and the substance is a compound.
    c. Electrolysis is a chemical change, and the substance is a compound.
    d. Electrolysis is a physical change, and the substance is an element.

Appendix VII

Biology Test of Conceptual Understanding

Choose the correct answer and circle the corresponding letter.

1. The reproduction in which two gametes unite to produce the first cell of the offspring is called:
   a. Regeneration
   b. Growth and development
   c. Asexual reproduction
   d. Sexual reproduction

2. The offspring that results from the reproduction of unicellular organisms is:
   a. Identical to the parents.
   b. Different from the parents.
   c. Similar to the parents but not identical to them
   d. Not capable of asexual reproduction

3. ~~In Mendel's experiments on pea plants, the recessive alleles~~
   ~~a. appear in the phenotypes of the first generation of cross pollination~~
   ~~b. appear in the phenotypes of the second generation of self-pollination~~
   ~~c. appear in the phenotype of both the first and second generations~~
   ~~d. appear when they are combined with the alternative allele~~

4. In genetics, the description of the actual characteristics that are observable in the organism is called
   a. Generation
   b. Genotype
   c. Phenotype
   d. Gene map

5. A gene is a unit of
   a. Reproduction
   b. Heredity
   c. Color
   d. Dominance

6. An alternative form of the gene is called Allele. Which statement is true about the alternative gene?
   a. An allele has the same position on the homologous pairs of chromosomes
   b. An allele has a different position on the homologous pairs of chromosomes
   c. An allele does not appear on any chromosome because it is recessive.
   d. An allele appears only when it is dominant.

7. Sex cells or gametes in humans have 23 chromosomes each. During fertilization the two gametes unite to produce the zygote or first cell of the individual. Therefore, a human body cell has
   a. 46 chromosomes
   b. 23 chromosomes
   c. 69 chromosomes
   d. An infinite number of chromosomes

8. The placenta and umbilical cord provide nutrients for the embryo in the case of
   a. birds
   b. amphibians
   c. mammals
   d. reptiles

9. An animal cell has a nucleus that contains a nucleic acid responsible for:
   a. Providing the cell with energy
   b. Providing the cell with sugar
   c. Carrying the genetic material
   d. Respiration of cells

10. During cell division it is possible to observe that the genetic material in the nucleus changes into compact bodies that look like wrapped thread. These compact bodies are called
    a. Chromosomes
    b. Mitochondria
    c. chloroplasts
    d. DNA

11. If a true breeding pigeon with normal feathers (FF) is crossed with a true breeding pigeon with frizzy feathers (ff), how many different feather phenotypes are possible in the first generation offspring?

    a. 1
    b. 2
    c. 3
    d. 4

12. When true breeding pea plants with yellow colored pods are cross pollinated with true breeding pea plants with green colored pods in step 1, the results for the F1 generation show 100% of the offspring have green pods. This result shows that true breeding pea plants with green pods are Dominant.

In step 2, when the offspring of the F1 generation are self-pollinated, they produce the F2 generation. The genotypes of the F2 generation according to the Punnett square below indicate:

a. 25% Yellow pods
b. 25% Green pods
c. 50% yellow pods
d. 50% green pods

	G	y
G		
y		

13. The offspring of sexual reproduction shows variation. This variation in wild animals and plants allows them to adapt to new environments. If a species has no variation, then it cannot survive. This process is called natural selection.

Which of these statements best illustrates natural selection?

a. An organism with favorable genetic variations will tend to survive and breed successfully
b. A population dominates all of the resources in its habitat, forcing other species to migrate.
c. A community whose members work together uses up all existing resources and habitats
d. The largest organism in the species receive the only breeding opportunities and resources

14. The diagram below represents a cross between two pea plants

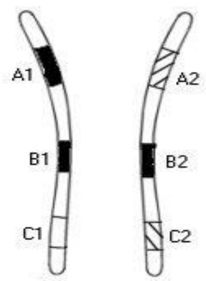
In pea plants, the allele for smooth seeds is dominant, while the allele for wrinkled seeds is recessive. In the cross below what is the percentage of the offspring that has smooth seeds?

a. 100%
b. 75%
c. 50%
d. 25%

	S	S
w		
w		

15. A pair of homologous chromosomes is represented by the figure below. Which statement is true about the represented genes?

   a. A1, B1, and B2 are alternative forms of the same gene
   b. A2, and C2 are alternative forms of the same gene
   c. A1 and B1 are alternative forms of the same gene
   d. A1 and A2 are alternative forms of the same gene



Appendix VIII

Students' Views of Nature of Science questionnaire (SVNOS)

Grade 8, Section ---------

Student Name ---

This questionnaire contains statements about ideas related to what you know about science. You will be required to show your agreement on each statement. Your opinion is what is needed. There are no right or wrong answers. Think of how each statement agrees with your views about science. Circle 1 if you strongly disagree, 2 if you disagree, 3 if you have no opinion, 4 if you agree and 5 if you strongly agree.

1. The value of scientific knowledge is different for people from different cultures and societies.

Strong disagree	Disagree	No opinion	Agree	Strong agree
1	2	3	4	5

2. People from different cultures have the same method of interpreting natural phenomena.

Strong disagree	Disagree	No opinion	Agree	Strong agree
1	2	3	4	5

3. Science is affected by culture.

Strong disagree	Disagree	No opinion	Agree	Strong agree
1	2	3	4	5

4. Scientific knowledge is the same in various cultures.

Strong disagree	Disagree	No opinion	Agree	Strong agree
1	2	3	4	5

5. Scientists' research activities will be affected by the theories they know.

Strong disagree	Disagree	No opinion	Agree	Strong agree
1	2	3	4	5

6. Scientists select effective methods to study nature based on the theories they accept and know.

Strong disagree	Disagree	No opinion	Agree	Strong agree
1	2	3	4	5

7. Scientists with different theoretical backgrounds may make totally different observations even for the same observable fact.

Strong disagree	Disagree	No opinion	Agree	Strong agree
1	2	3	4	5

8. Recent scientific knowledge contradicts previous knowledge.

Strong disagree	Disagree	No opinion	Agree	Strong agree
1	2	3	4	5

9. Scientists can make totally objective observations which are not influenced by other factors.

Strong disagree	Disagree	No opinion	Agree	Strong agree
1	2	3	4	5

10. The theories scientists hold do not have effects on the process of their exploration.

Strong disagree	Disagree	No opinion	Agree	Strong agree
1	2	3	4	5

11. Some accepted scientific knowledge came from human imagination, hunches, and guessing.

Strong disagree	Disagree	No opinion	Agree	Strong agree
1	2	3	4	5

12. The development of scientific theories requires scientists' imagination and creativity.

Strong disagree	Disagree	No opinion	Agree	Strong agree
1	2	3	4	5

13. Scientists sometimes get ideas from several apparently unrelated theories.

Strong disagree	Disagree	No opinion	Agree	Strong agree
1	2	3	4	5

14. Creativity is important for the growth of scientific knowledge.

Strong disagree	Disagree	No opinion	Agree	Strong agree
1	2	3	4	5

15. All questions in science have one right answer (-)

Strong disagree	Disagree	No opinion	Agree	Strong agree
1	2	3	4	5

16. The most important part of doing science is coming up with the right answer. (-)

Strong disagree	Disagree	No opinion	Agree	Strong agree
1	2	3	4	5

17. Scientists pretty much know everything about science; there is not much more to know. (-)

Strong disagree	Disagree	No opinion	Agree	Strong agree
1	2	3	4	5

18. Once scientists have a result from an experiment that is the only answer. (-)

Strong disagree	Disagree	No opinion	Agree	Strong agree
1	2	3	4	5

19. Scientists always agree about what is true in science. (-)

Strong disagree	Disagree	No opinion	Agree	Strong agree
1	2	3	4	5

20. The ideas in science books sometimes change.

Strong disagree	Disagree	No opinion	Agree	Strong agree
1	2	3	4	5

21. Ideas in science sometimes change.

Strong disagree	Disagree	No opinion	Agree	Strong agree
1	2	3	4	5

22. Sometimes scientists change their minds about what is true in science.

Strong disagree	Disagree	No opinion	Agree	Strong agree
1	2	3	4	5

23. New scientific knowledge becomes widely accepted through the acceptance of many scientists in the field.

Strong disagree	Disagree	No opinion	Agree	Strong agree
1	2	3	4	5

24. The discussion, debates, and sharing of results in the science community is one major reason causing the development of scientific knowledge.

Strong disagree	Disagree	No opinion	Agree	Strong agree
1	2	3	4	5

25. Well-founded or valid scientific knowledge requires the acceptance of scientists in related fields of science.

Strong disagree	Disagree	No opinion	Agree	Strong agree
1	2	3	4	5

26. Scientists have agreed upon an acceptable set of standards with which to evaluate scientific findings.

Strong disagree	Disagree	No opinion	Agree	Strong agree
1	2	3	4	5

27. Through the discussion and debates among scientists, the scientific theories become better.

Strong disagree	Disagree	No opinion	Agree	Strong agree
1	2	3	4	5

28. Ideas about science experiments come from being curious and thinking about how things work.

Strong disagree	Disagree	No opinion	Agree	Strong agree
1	2	3	4	5

29. One important part of science is doing experiments to come up with new ideas about how things work.

Strong disagree	Disagree	No opinion	Agree	Strong agree
1	2	3	4	5

30. Good ideas in science can come from anybody, not just from scientists.

Strong disagree	Disagree	No opinion	Agree	Strong agree
1	2	3	4	5

31. A good way to know if something is true is to do an experiment.

Strong disagree	Disagree	No opinion	Agree	Strong agree
1	2	3	4	5

32. Good answers are based on evidence from many different experiments.

Strong disagree	Disagree	No opinion	Agree	Strong agree
1	2	3	4	5

33. Ideas in science can come from your own questions and experiments.

Strong disagree	Disagree	No opinion	Agree	Strong agree
1	2	3	4	5

Appendix IX

Student Motivation towards Science Learning Questionnaire (SMTSL)

This questionnaire contains statements about ideas related to what you know about science. You will be required to show your agreement on each statement. Your opinion is what is needed. There are no right or wrong answers. Think of how each statement agrees with your views about science. Circle 1 if you strongly disagree, 2 if you disagree, 3, if you have no opinion, 4 if you agree and 5 if you strongly agree.

1. Whether the science content is difficult or easy, I am sure that I can understand it.

Strong disagree	Disagree	No opinion	Agree	Strong agree
1	2	3	4	5

2. I am not confident about understanding difficult science concepts.

Strong disagree	Disagree	No opinion	Agree	Strong agree
1	2	3	4	5

3. I am sure that I can do well on science tests.

Strong disagree	Disagree	No opinion	Agree	Strong agree
1	2	3	4	5

4. No matter how much effort I put in, I cannot learn science.

Strong disagree	Disagree	No opinion	Agree	Strong agree
1	2	3	4	5

5. When science activities are too difficult, I give up or only do the easy parts.

Strong disagree	Disagree	No opinion	Agree	Strong agree
1	2	3	4	5

6. During science activities, I prefer to ask other people for the answer rather than think for myself.

Strong disagree	Disagree	No opinion	Agree	Strong agree
1	2	3	4	5

7. When I find the science content difficult, I do not try to learn it

Strong disagree	Disagree	No opinion	Agree	Strong agree
1	2	3	4	5

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