**ABSTRACT**

SBHATU, DESTA BERHE. **Investigating the Effects of Metacognitive Instruction in Learning Primary School Science in Some Schools in Ethiopia.** (Under the Direction of Professor John E. Penick.)

*Metacognition is increasingly recognized as an important component in successful learning. In science, metacognitive instructional interventions have been successfully incorporated to promote conceptual change learning, facilitate negotiating and constructing of meanings, and foster reading and problem solving abilities of learners. The present study investigated the contribution of three metacognitive instructional methods, namely graphic organizers, metacognitive reflection, and metacognitive reading in learning science among primary school students (age 10-14 years) in Mekelle, Ethiopia. The metacognitive instructional methods were believed to be efficient to introduce and transform learner-centeredness in science instruction under Ethiopia's primary school settings by allowing students to think productively and regulate their own learning. Qualitative study indicated that the metacognitive instructional methods fostered student conceptual understanding of science topics and enhanced active student participation. Quantitative study of post-scores of Immediate test-groups revealed that graphic organizers had some contribution in helping students perform better in 'application' type tests. Metacognitive reflection activities enabled students to perform better in 'application' and 'transfer' type tests as well as enhancing mean post-test scores. Metacognitive reading activities did not yield any apparent effects on post-intervention tests. The effects of the metacognitive methods were diminished among Delayed post-test groups.*

# INVESTIGATING THE EFFECTS OF METACOGNITIVE INSTRUCTION IN LEARNING PRIMARY SCHOOL SCIENCE IN SOME SCHOOLS IN ETHIOPIA

**BY**
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## DEDICATION

This dissertation is dedicated to the victims of Aider Elementary School massacre of June 5, 1998.

**IN MEMORIAM**

**TO**

**TSEGAI BERHE SBHATU**

## BIOGRAPHY

Desta Berhe Sbhatu was born on September 9, 1967 in a village southeast of Adigrat, Ethiopia. He is the first of 10 children born to Berhe Sbhatu Araya and Mihret W. Gabriel G. Mariam. Desta attended grades 1 and 2 at Agazi Elementary School, grades 3 through 6 at Agoro Elementary School, and grades 7 through 12 at Agazi Secondary School, Adigrat. He completed his secondary education in 1985. Desta received the Bachelor of Science Degree in Biology from Asmara University (Eritrea) in July 1989. After working as secondary school biology teacher for five years, Desta enrolled in graduate school at Addis Ababa University (Ethiopia) and earned a Master of Science Degree in Biology in July 1997. Then, he was hired at Abbiyi Addi College of Education and worked as lecturer of biological sciences, department head, and academic vice dean during his five years employment. Desta started graduate study in January 2002 at North Carolina State University (Raleigh, USA) and earned his PhD in Science Education in May 2006.

Desta is married to Tseganesh Alem, and has two children–Jordanos and Andebeth.

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## INTRODUCTION

Metacognition, first introduced in the works of Flavell in the mid 1970s, is regarded as one of the salient characteristics of human cognition (Lories, Dardenne, & Yzerbyt, 1998). Even though it is usually defined simply as ‘cognition about cognition’ or other equivalents like ‘knowledge about knowledge,’ ‘knowledge about cognition,’ ‘thought about thoughts’ and the like, studies about metacognition show that it is indeed a very complex construct. The most commonly used definition of metacognition is *the knowledge (i.e. awareness) of one’s cognitive processes* and *the efficient use of this self-awareness to self-regulate these cognitive processes* (e.g. Brown, 1987; Gordon & Braun, 1985; Loper & Murphy, 1985; Miller, 1985; Niemi, 2002; Schraw & Dennison, 1994; Shimamura, 2000).

Based on this definition, metacognition is viewed as a way of knowing about our cognitive processes and a way of exercising deliberate and conscious control over such processes (Gordon & Braun, 1985), usually referred to as ‘knowledge of cognition’ and ‘regulation of cognition,’ respectively (Allen & Armour-Thomas, 1991; Jacobs & Paris, 1987; Schraw, 2001; Schraw & Dennison, 1994; Sternberg, 1985). According to the current understanding of the construct, however, three components, ‘metacognitive knowledge’ (i.e. knowledge of cognition), ‘metacognitive regulation’ (usually called self-regulation) and ‘metacognitive experiences’ are apparent (Borkowski, 1992; Niemi, 2002; Pintrich 2000).

After metacognition was introduced by Flavell, a multitude of studies have been conducted about it as an object of research in its own right, as a factor in memory performance and as a tool for teaching and learning. Developmental researchers address metacognition as an object of study, investigating metacognition in relation to variables such as age (Flavell, 1987; Koriat & Shitzer-Reichert, 2002; Paris, 2002), novice versus expert (Paris, 2002), gifted versus non-gifted (Alexander, Carr, & Schwanenflugel, 1995), and high academic versus low academic achievers (e.g. Hwang & Vrongistinos, 2002; Short, 1992). Cognitive psychology research about metacognition examines the bases and accuracy of metacognition in memory. Such research deals with the role of metacognitive experiences (i.e. judgments and feelings) in monitoring cognitive states and subsequent control of cognitive processes (Koriat & Shitzer-Reichert, 2002; Paris, 2002). These studies are narrowly confined to monitoring and control of memory processes.

More broadly, educational psychologists investigate the role of metacognition in self-regulated learning and teaching. They study the effect of metacognitive knowledge, methods, and skills in helping learners understand contents and processes in various subject matter. Studies in this area examine the effects of metacognitive knowledge, methods, and skills on academic achievement/performance (e.g. Everson & Tobias, 1998; Masui & DeCorte, 1999), transfer of learned concepts and processes (e.g. Aleven & Koedinger, 2002; Georghiades, 2000; 2004), retention of learned information (e.g. Adey & Shayer, 1993; Georghiades, 2000; 2004), problem-solving (e.g. Howard & McGee, 2000), independent, self-regulated or autonomous learning (e.g. Boekaerts, 1999; Webster, 2002), and intelligence (e.g. Alexander & Schwanenflugel, 1996; Veenman, Prins, & Elshout, 2002). Moreover, educational psychologists investigate how metacognition is enhanced through instruction (e.g. Hartman, 2001a, 2001b; Schraw, 2001). Science education research usually follows the educational psychology research paradigm with studies conducted on the role of metacognition in science instruction (e.g. Adey & Shayer, 1993; Beeth, 1998; Koch, 2001; Georghiades, 2000; 2004; Neto & Valente, 1999; White & Frederiksen; 1998).

Despite the multitude of studies about the role of metacognition in learning and teaching, several limitations are apparent. First, while studies on the effects of metacognitive instructional methods in reading and mathematics are relatively extensive, not much work has been done in science. Second, most of the investigations and interventions about the effects of metacognition in learning and teaching science have concentrated on secondary schools, colleges, and universities. Even though there are some studies in middle schools, studies in elementary schools are rare. Third, no research has been done about the contribution of metacognitive instructional intervention in the schools of developing countries, characterized by populous classes and limited resources.

A lack of comparable studies in elementary schools or in developing countries prompted this study of metacognitive instructional methods in learning of primary school science (addressing the first two limitations) under marginally supported, larger class-size schools (addressing the third limitation). Following the educational psychology research paradigm, the present study investigated the contribution of metacognitive instructional intervention in learning of science in primary schools in Ethiopia. The next section will establish the context of the study.

## Metacognition from the Perspective of Global Science Instruction

Since metacognition is increasingly recognized as an important component in successful learning, many emphasize the importance of metacognition in educational practice. Jacobson (1998) writes:

> Metacognition or knowing the process by which one learns is then vital to the renovation of the current educational system. If we do not recognize what the students know, what they believe that they know, or more important yet, what they do not know, efforts to improve education will be futile (p. 583).

As noted by Pintrich (2002), ‘metacognitive knowledge of methods and tasks, as well as self-knowledge, is linked to how students will learn and perform in the classroom’ (p. 222). The active involvement of students in their own learning is a fundamental prerequisite for academic success and the instructional environment must be designed to help learners actively engage in their own learning. Quality of learning depends (among other things) ‘on learners’ abilities to steer their learning orientation, to develop inquiry skills and to learn to reflect on and control their own learning’ (Niemi, 2002, p. 764). Metacognition can enable learners to better manage their cognitive skills while determining and correct weaknesses (Sternberg, 1998). As Webster (2002) noted ‘The need for students to become more actively involved in the management of their own learning implies an associated need for each student to be more metacognitively aware of his or her personal resources’ (p. 1).

Metacognitive expertise also helps learners play an active role when learning, enabling students to function as independent learners (e.g. Corkill, 1996; Gavelek & Raphael, 1985). Metacognitive knowledge and regulation are clearly important determinants of successful learning, efficient reading, and effective studying (Brown, 1980).

In science, metacognitive instructional interventions have been successfully incorporated to promote conceptual change learning, facilitate negotiating and constructing of meanings, and foster reading and problems solving abilities of learners (e.g. Adey & Shayer, 1993; Beeth, 1998; Guterman, 2002; Hogan, 1999; Howard &

McGee, 2001; Magnusson, Templin, & Boyle, 1997; Mittlefehldt & Grotzer, 2003; White & Frederiksen, 1998).

From the theoretical and practical perspectives of science education, a number of points support the need for research on the role of metacognition in primary science learning.

(a) Metacognitive instruction has yielded encouraging results in primary schools in reading (e.g. Loper & Murphy 1985; Perry & VandeKamp, 2000) and mathematics (e.g. Desoete, Roeyers, & Buysse, 2001). Moreover, some studies have reported promising results in science among primary school students (Adey & Shayer, 1993; Georghiades, 2000; 2004).

(b) The basic tenet of inquiry science instruction is the active involvement of learners, both physically and mentally, in their own learning (NRC, 1996). Furthermore, teaching or learning for conceptual development demands interactive instructional practices (Duit, 1999).

(c) All of the interventions for investigating the effect of metacognitive instruction on learning gains of students focus on creating interactive instructional environments. When such interventions are tested in individual learning settings, they require the students to monitor, self-reflect, and control their own learning and progress (e.g. Blank, 2000; Prain & Hand, 1999; White & Frederiksen, 1998).

Based on these premises and the conditions found in Ethiopia, it is reasonable to predict that appropriate metacognitive instructional interventions that foster more minds-on activities and complement a lack of hands-on activities would yield learning gains in any school setting.

## Metacognition from the Perspective of Ethiopia's Science Instruction

Until the early 1900s, Ethiopia's education was confined to a system of religious instruction organized and presented under the support of the Ethiopian Orthodox Church. In 1906, four public schools began offering training on foreign languages, elementary mathematics, rudimentary science, and physical education and sports, taught in French and English to a limited number of students. These four schools also taught Amharic language and religious subjects (Berry, et al., nd; Teshome, 1979). However, up until the 1940s Ethiopian education was very limited in scope and quality. The real rehabilitation and development of Ethiopia's public education system began in 1942 after the Italian war of aggression was averted.

Various reforms and policies were made to address contemporary education problems since the early 1940s. The most prominent reforms include the beginning of the Education Development Plan in 1957 (Fassil, 1990), the 1971 Education Sector Review (ESR, 1972), the 1984/85 Evaluative Research of the General Education System in Ethiopia (ERGESE) (Fassil, 1990; Temechegn, 2002) and the 1994 Education and Training Policy (ETP) (Ethiopian Ministry of Education (MoE), 1994a, 1994b). Inquiry teaching, an important science education reform, was part of the two pre-1991 governments' efforts (e.g. Samuel & Welford, 1999). Similarly, the 1994 ETP addressed issues of science education, including its purposes and contexts, science teacher education, and conditions that foster practical school science (MoE, 1994a, 1994b). Despite these policies, reforms, and commitments, science education remained a target of criticisms for its lack of relevance, its traditional and teacher-centered mode of teaching, and its characteristic bulky content (Samuel & Welford, 2000, Temechegn, 2003).

Ethiopia’s education system was often described as being in crisis because of inappropriate instructional methods that failed to incorporate relevant practical experiences (Tekeste, 1990).

Ethiopia’s science education problems extend across all levels. Science teacher education is characterized by too much factual information, lower order cognitive skills, few inquiry activities, and a mismatch between theoretical research and practical knowledge (Temechegn, 2003). Samuel and Welford (1999) assert that science teachers and instructors in Ethiopia are not themselves educated in such a way that they can help their students to develop science skills and processes. They further contend that an apparent gap exists between what has been planned in the policies and what is being practiced in schools and colleges. Teachers and teacher educators continue to use teacher-centered teaching methods that do not promote achieving the national goals and policies (Samuel & Welford, 1999).

Recognizing this gap, the current Education and Training Policy of Ethiopia strives to shift science instruction from the traditional teacher-centered approach to a more learner-centered one (MoE, 1994a, 1994b, 2002). Accordingly, the Federal Ministry of Education and the education bureaus of the regional states are initiating various efforts to promote learner-centered instruction. Learner-centered instruction creates learning environments that allow learners to act and think productively with appropriate resources, including support and guidance from the teacher.

Unfortunately, Ethiopia’s classroom facilities and supplies for hands-on activities are limited or nonexistent. At the same time, the well-established traditional teaching methods critically limit children from learning science on their own. This disconnect between goals and realities demands a search for alternatives that promote instructional practices and environments that allow science students to be actively engaged in physical and mental activities as they learn.

Metacognitive instruction is predicted to be an efficient approach to introduce and transform learner-centeredness in science instruction under Ethiopia's primary school settings as it creates suitable instructional environments that allow students to think productively and to evaluate and regulate their own learning (Schraw, 2001). Metacognitive instruction has also been shown to foster conceptual development and ensure transfer and durability of science concepts (Georghiades, 2000, 2004),

## The Purposes of the Study

The present study investigated the effects of three metacognitive instructional methods in learning primary science (grades 5 and 6) in large class-size and resources-limited Ethiopian schools. The three metacognitive instructional methods were: (1) Graphic organizers: metacognitive tools in learning primary school science, (2) Metacognitive reflection for conceptual change learning model, and (3) Metacognitive science reading checklist. The effects of the methods were assessed in relation to two learning settings, individual and pair cooperative learning settings. Hence, the study addressed the following questions.

(1) As compared to more traditional instruction, did the intervention yield better overall learning gains among students of Ethiopia's large class-size primary schools (grade 5 and 6)?

(2) Did the treatment classes perform better on higher order thinking tests than did the comparison classes?

(3) Did the intervention help students in the treatment classes to better retain learned content than those in comparison classes?

(4) Was the instructional method more effective in a pair learning setting as compared to individual learning setting?

(5) Did the intervention produce similar positive outcomes in both grades?

## Limitations of the Study

The participating teachers could not master the metacognitive instructional methods as rapidly as anticipated. Moreover, their proficiency in employing the methods did not develop into perfection, limiting the quality of the intervention. Thus, the treatment classes were not as effective as was hoped for.

The researcher personally collected the observation data. Although the researcher tried to record exact actions and verbal statements of the teachers and the students, his biases, skills, and limitations in capturing all the actions and verbal statements have to be taken into account. In addition, the end-of-intervention tests were developed by the researcher and were used for the first time. Their characteristics were not studied.

The studies were carried out in non-randomly selected urban schools in one regional state. Moreover, the participated students were from non-randomly selected intact classrooms. Thus, generalizations to other states and contexts should be done with caution.

## REVIEW OF LITERATURE

Metacognition attracted the interest of researchers for its potential contribution in improving learning outcomes as well as its role in supporting cognitive theories of learning (Georghiades, 2004). A multitude of studies have reported on the role of metacognition in learning since the construct was first introduced in the mid 1970s. Three fairly separate lines of inquiry about metacognition have emerged, as developmental, educational, and cognitive researchers base their studies distinctly on one of the three major components of metacognition. This review focuses on how metacognition is incorporated in science education research and its relationship to conceptual change, curriculum, and instruction.

Metacognition, conceptual change, and constructivism are regarded as the three major theoretical bases for research in science teaching and learning (Baird, Fensham, Gunstone, & White, 1991). Conceptual change learning models underline the importance of altering learners' incomplete or unscientific prior conceptions to become more congruent with scientific ones. Likewise, constructivism emphasizes the active involvement of learners during negotiation of meanings and construction of knowledge. Hence, learners' awareness about and expertise with metacognitive strategies and skills for monitoring and controlling their own learning are of central importance in conceptual change learning and constructivism (Tsai, 2001).

Customarily, studies of metacognition by science educators follow the educational psychology research paradigm where metacognition is a tool for learning and teaching of science. Science education research on metacognition is usually grounded in constructivist, conceptual change learning, and/or inquiry models of instruction. The major areas of research are indicated in the following sections.

## Metacognition in Conceptual Change Science Learning

Studies on the role of metacognitive instructional strategies in learning focus on the contribution of such strategies to conceptual change learning, constructing meanings, and inquiry learning. Metacognition empowers learners to recognize, evaluate and revise personal views (Baird, Fensham, Gunstone, & White, 1991). These premises lead to instructional practices where metacognitive strategies are implicitly or explicitly made available to subjects, and their effects are assessed through comparative or correlation methods.

The basic principle of contemporary science instructional practice strives to create an active learning environment where students develop the ability to construct understandings and evaluate ideas, rather than passively accepting scientific information (Hogan, 1999). Proponents strongly argue that active involvement of students in their own learning for conceptual change would be achieved by including a metacognitive dimension (Lehtelä, 2001). Metacognition is incorporated in conceptual change learning research and practice by: (a) developing new instructional models, (b) modifying existing instructional models, and (c) supporting traditional teaching practices.

### *Developing new instructional models*

By promoting one's own expertise to regulate thinking and make reflection on one's own thinking processes, metacognition has gained attention in conceptual change research. The development and use of science curriculum models for inquiry and conceptual change, such as the Science Curriculum Improvement Study (SCIS) Learning

Cycle, Inquiry Cycle, Conceptual Change Model (CCM), Cognitive Acceleration through Science Education (CASE), and Knowledge Integration Environment (KIE), have been the focus of research and practice. By the same tradition, curriculum models that incorporate metacognitive activities or components have been developed and tested. Some of the prominent interventions are indicated below.

Hogan (1999) developed a model called ‘Thinking Aloud Together,’ to help students construct knowledge cooperatively. Tests with 8$^{th}$ graders indicated that students in the intervention groups were better in their collaborative reasoning abilities than those in comparison groups. Similarly, Mittlefehldt and Grotzer (2003) developed a learning guide, referred to as ‘Good Science Thinking Moves,’ to help students pose questions (to themselves and colleagues) and reflect about the intelligibility, applicability, and plausibility of science ideas. Then, the authors examined if active regulation of one’s cognitive processes helps students transfer learning. They found encouraging results related to the learning guide in transferring concepts of density to concepts of pressure among 8$^{th}$ graders.

The importance of metacognition in conceptual change was also indicated in a study investigating conceptual change learning (Magnusson, Templin, & Boyle, 1997). These authors developed dynamic science assessments (DSA) to help them: (a) determine students’ potential to change their understanding, and (b) inform them of the processes of conceptual change toward scientific knowledge. In the DSA tasks, students engaged in metacognitive activities while learning a topic on current and electricity. The activities included predicting, providing reasons for predicting, describing observations, comparing the congruence between what is predicted and observed, and explaining results and observations. Metacognitive instructional models for teaching college level chemistry and physics developed and described by Rickey and Stacy (2000) include ConcepTests (aimed at bringing students' misconceptions to scrutiny), Predict-Observe-Explain (POE) Tasks (requiring students to make predictions about an event and explain the reasons for their prediction so that their initial ideas are highlighted), and the Model-Observe-Reflect-Explain (MORE) Thinking Frame (to promote metacognition in guided-discovery environments while students are engaged in authentic inquiry). These models were found to be effective in furthering meaningful learning.

Graphic representations, important tools for conceptual change learning, also have been highly studied. As a means of creating interactive teaching-learning settings, concept maps, concept cartoons, and other graphic organizers are recognized to be useful metacognitive tools. Hence, the development of instructional models could also involve the use of such visual representations. For example, van Boxtel, van der Linden, Roelofs, and Erkens (2002) studied the potential of collaborative learning tasks in learning science concepts using a model called Collaborative Concept Mapping. These authors used the model to teach concepts about electricity to secondary level physics students requiring them to articulate their thoughts, elaborate their conceptual knowledge, and co-construct meanings. While elaborating their conceptual knowledge, students were involved in metacognitive activities such as active use of prior knowledge, recognition and acknowledgement of problems, and finding out meaningful relationships. The model was shown to be helpful in ensuring productive student interaction.

Similarly, Ward and Wandersee (2002a) designed and studied the effects of a metacognition-based visual learning model, Roundhouse Diagramming, for teaching science to low achieving middle school students. The diagram contains a central part representing a conceptual turntable with the central theme, and seven outer sectors containing concepts associated with the central theme and graphic icons that remind the learner about the concepts. After students were taught how to use the Roundhouse Diagram, they used it to represent abstract or complex information from their science curricula. In the course of constructing a Roundhouse Diagram, students were expected to be involved in metacognitive endeavors such as recognizing a problem, analyzing the problem, making suggestions and inferences, and making decisions to select materials needed to solve the problem.

When students' expertise on the use of Roundhouse Diagram improved, so did their science achievement. The authors (Ward & Wandersee, 2002b) examined the effects of the model in science learning among grade 6 students over a 10-week intervention. Like the previous intervention, students were required to recognize the main ideas within the science lesson, breaking down the information into interrelated segments and linking each portion to an iconic image. The intervention led to better conceptual understanding of the science topic addressed.

The use of computer-based concept mapping in promoting conceptual learning is also gaining popularity (e.g. Chang, Sung, & Chen, 2001; DeSimone, Schmid, & McEwen, 2001). Chang, Sung, and Chen (2001) compared the effectiveness of three concept mapping strategies—computer assisted construction, scaffolded computer assisted construction, and non-assisted paper-pencil construction—among high school biology students. The use of computer guided concept mapping, where learners were allowed to complete partially constructed maps, yielded encouraging results. Concept cartoons are also getting attention as tools for conceptual change learning. Keogh and coworkers investigated the role of concept cartoons in teaching science (Keogh, Naylor, & Wilson, 1998; Keogh & Naylor, 1999) and found them to be essential in helping students assess their own level of understanding of science content and making connections between school concepts and everyday life phenomena.

### *Modifying existing instructional models*

Another approach of inquiry for examining the role of metacognitive activities is by incorporating such activities within existing prominent instructional models of science education research and practice. For example, Adey and Shayer (1993) studied the effects of including metacognitive activities in their Cognitive Acceleration through Science Education (CASE) model for teaching 11 to 12 year old students in Britain. Treatment groups gained more in science (as well as mathematics and English language) achievement measured two and three years after intervention. Likewise, Beeth (1998) argued that the Conceptual Change Model (CCM) be supported by metacognition. CCM contains two components, status and conceptual ecology. Status refers to learner's attributes to a conception such as intelligibility, plausibility and fruitfulness. While conceptual ecology refers to a context within which a conception survives and has meaning or that provides context in which the conceptual change occurs and has meaning, such as: anomalies, expected or unexpected behaviors of natural phenomena, ecological commitments that lead to generalization, metaphysical beliefs and concepts, analogies, metaphors, exemplars and images (Beeth, 1998; Magnusson, Templin, & Boyle, 1997). Thus, Beeth (1998) proposed that science instruction must be planned in such a way that it allows students to make metacognitive comments to determine the status of conceptions and conceptual ecology.

White and Frederiksen (1998) developed a computer-enhanced middle school science curriculum, the ThinkerTools Inquiry Curriculum, which makes scientific inquiry accessible to a wide range of students. The curriculum includes a metacognitive teaching/learning model, the Reflective Assessment to the Inquiry Cycle. The metacognitive components of the curriculum promote students' metacognitive knowledge and skills through scaffolded inquiry, reflection, and generalization. Instructional trials of the curriculum were successful and student performance on physics and inquiry assessment was significantly improved.

Blank (2000) modified the SCIS Learning Cycle model by incorporating metacognitive components to allow students to reflect on their own ideas. The effect of the modified model, called Metacognitive Learning Cycle, was compared against the effect of the SCIS Learning Cycle among grade 7 students in learning during a three-month ecology unit. The intervention helped students to restructure their ecology understanding, though no difference was apparent in content knowledge.

Another model including metacognitive components is the famous Knowledge Integration Environment (KIE) developed by Linn (2000). KIE curricula are developed in software for middle school science teaching. Extensive work has been done on KIE and *Volume 22*(8) of the *International Journal of Science Education* has published articles about KIE. A study by Davis (2003) dealt with incorporating reflective prompts (sense-making or metacognitive) to KIE activities. Students provided with generic prompts, where they are told *to stop and think*, developed more coherent understanding as they worked on complex science projects.

### *Supporting traditional teaching practices*

A third line of science education research on metacognition deals with the effect of adding metacognitive activities to the usual (traditional) practices of teaching and learning. For instance, Osman and Hannafin (1994) studied the contribution of incorporating conceptual-orienting questions in grade 10 introductory genetics lessons. Such metacognitive endeavors helped the intervention group outperform a comparison one in post-test performances of comprehension and problem-solving tasks. When students were required to write explanations about the rationale of such conceptual-orienting questions, their post-test performance scores were even better. Orienting questions that emphasize concept-relevant knowledge helped students identify, activate, and evaluate their own learning processes and integrate knowledge more completely.

The effects of implanting metacognitive activities, called metacognitive instances, such as brief discussions, comments, thinking/writing/drawing tasks, and pair activities, in teaching science to Year 5 primary students in Cyprus was a focus of investigation by Georghiades (2000). This study reported positive results in student performance, transfer ability, and retention capacity of learned concepts. In his later reports Georghiades (2004) provided supporting evidence that brief metacognitive instances are essential in conceptual learning. Students engaged in these metacognitive activities demonstrated a more permanent restructuring of their understanding about current and electricity. A study by Thomas and McRobbie (1999) found promising results while investigating the effect of incorporating a metaphor referred to as '*learning is constructing*' to help high school students become more metacognitive so that they will be more constructivist in their chemistry learning.

## Metacognition in Science Reading

It has long been known that metacognitive reading strategies lead to impressive results. For example, a study by Loper and Murphy (1985) show that when children are given simple instructions to use self-regulatory skills, their performances on reading tasks improved rapidly. Hall and coworkers state that, in accordance with constructivist learning theory, learners should be guided both to learn how to read and to be aware of how they learn to read (Hall, Bowman, & Myers, 1999). Based on this basic metacognitive assumption, studies on reading strive to provide models or checklists of metacognitive reading strategies that guide learners to be actively engaged in learning from texts.

Most metacognitive reading studies have looked at strategies in language instruction; few are in science. Usually, studies on metacognition as tools of instruction focus on assessing the effects of a certain set of strategies on learning. By the same token, studies on the role of metacognition in reading concentrate on investigating the effects of a list of metacognitive reading strategies in text comprehension and understanding. Based on such empirical studies, many researchers provide various lists of metacognitive reading skills, though not always distinctly different from one another.

Brown (1980), a pioneer researcher in this area, described several reading strategies; (a) clarifying the purpose of reading (i.e. understanding both explicit and implicit task demands), (b) identifying the important aspects of a message, (c) focusing attention on the major content than rather trivia (major focus), (d) monitoring ongoing activities to determine whether comprehension is occurring, (e) engaging in self-questioning to determine whether goals are being achieved, and (f) taking corrective actions when failures in comprehension are detected. Later, Brown and Palincsar modified these strategies to enhance monitoring and fostering of reading comprehension (Brown & Palincsar, 1989; Palincsar & Brown, 1984). Their modifications included: (a) clarifying purpose of reading and determining appropriate reading strategies, (b) activating relevant prior knowledge and linking it to the text, (c) allocating attention to important ideas, (d) evaluating content for internal consistency and compatibility with prior knowledge, (e) self-monitoring (e.g. by self-questioning) to verify comprehension, and (f) drawing and testing inferences.

Similarly, Hartman's (2001a) metacognitive reading skills include skimming, activating relevant prior knowledge, constructing mental images, predicting, self-questioning, and comprehension monitoring, as well as summarizing and connecting new material with prior knowledge. It is essential to note that consideration of prior knowledge is a fundamental tenet in constructivism, and, thus, conceptual change learning.

Studies on reading consistently show that metacognitive reading strategies lead to positive results. Improvements in these skills can lead to dramatic progress in academic achievement (Brown & Palincsar, 1989; Palincsar & Brown, 1984). Students who are aware of and in control of their metacognitive reading behaviors are at a distinct advantage because many of these behaviors involve monitoring comprehension, taking steps to clarify difficulties, and restoring comprehension processes when comprehension has broken down (Hartman, 2001a).

Gourgey (1999) indicated that metacognitive reading strategies similar to these were more evident in more competent readers than less competent ones. Moreover, Gourgey

(2001) reported improved reading comprehension by students who were guided by self-regulatory strategies. When students were guided through the process of generating questions, making predictions, and monitoring and checking comprehension in reading, they improved the accuracy of their comprehension and their use of a variety of strategies.

Science education research and interventions focused on the role of hands-on and problem-solving activities until the 1980s (Koch, 2001), marginalizing the role of science texts and science reading despite both being frequently used across levels (Yore, Craig, & Maguire, 1998). During the early 1990s the importance of reading skills in learning science was attracting some attention. Hence, studies that examined the role of strategic reading skills in learning science began to be available in the literature (e.g. Holliday, Yore, & Alvermann, 1994, Alexander & Kulikowich, 1994; Glynn & Muth, 1994). Nowadays, there exists a consensus among science educators that effective science reading is an essential prerequisite for better learning in the field. Since the bulk of content is provided in science textbooks across all levels, it is argued that students need to have effective reading strategies to learn successfully (Yore, Craig, & Maguire, 1998).

As in other disciplines, science reading involves accessing prior knowledge through information retrieval strategies, interpreting messages from the text and sensory information from the environment, and interactively constructing meaning from these data (Yore, Craig, & Maguire, 1998).

Science educators should not, however, be tempted to follow the language reading research paradigm. Unlike narrative readings, Yore and coworkers argue that reading science texts requires knowledge about the scientific enterprise, the concepts under consideration, the scientific language, the patterns of argumentation, the canons of evidence, warrants and claims, and the processes and strategies of reading science. In line with this argument, a study by these authors among elementary and middle school students indicated that majority of them have surface knowledge about science reading, science text, and science reading strategies. Thus, they recommended the use of explicit science reading instruction.

Metacognitive reading strategies support the interactive-constructive models of instruction. Thus, once science reading research reports began to appear in the literature, science educators did not waste much time inquiring into the role of metacognition in science reading. Yore, Craig, and Maguire (1998) argue that metacognitive knowledge provides insights into the awareness and control of science reading and texts, and should be part of science education research agenda. Yore and others also note that metacognitive comprehension strategies such as planning, monitoring, and regulation of global meaning making should be addressed in reading research in science education (Yore, Bisanz, & Hand, 2003).

Some studies that incorporated a metacognitive component in science reading research have been done. Koch (2001) studied the development, application, and evaluation of a metacognitive reading technique for improving comprehension of physics texts by freshman college students. The metacognitive technique required students to self-assess their reading comprehension and rank their abilities and disabilities hierarchically. The study revealed that the metacognitive group had significantly higher post-test scores than did the control. Moreover, the metacognitive group had statistically significant gains in their post-test scores. Hence, the author recommended the development and application of metacognitive techniques for reading and comprehension of physics texts. Similarly, Keys, Hand, Prain, and Collins (1999) employed a teacher template consisting of a series of activities to involve secondary school students in meaningful thinking, writing, reading, and discussion about laboratory concepts. These activities produced better learning gains in students. In another study, the use of well-established reading strategies helped two high school students to comprehend biological research articles (Brill, Falk, & Yarden, 2004). A study with Israeli 4$^{th}$ graders indicated that students who used metacognitive reading guidance outperformed their counterparts in control and placebo groups (Guterman, 2002). A reading strategy called Concept-Oriented Reading Instruction (CORI), which requires students to be engaged in metacognitive thinking, was also found to be beneficial in promoting intrinsic motivation, literacy strategy use, and conceptual understandings in science (Swafford & Bryan, 2000).

Graphic organizers, such as concept maps, can also be essential metacognitive tools for facilitating reading comprehension of science texts. Studies that incorporate concept-mapping activities for reading comprehension of science texts have yielded encouraging results (e.g. Guastello, Beasley, & Sinatra, 2000; Sungur, Tekkaya, & Geban, 2001).

## Metacognition in Problem Solving

Knowledge of metacognitive processes and strategies is important in guiding learners during problem solving activities (Davidson, Deuser, & Sternberg, 1994). A repertoire of metacognitive knowledge and strategies improves learner problem solving ability (e.g. Rickey & Stacy, 2000) and it is well known that proficient learners use a variety of metacognitive processes to successfully execute complex problem solving tasks (Allen &

Armour-Thomas, 1991). Thus, it is not surprising that sophisticated learners know a number of strategies or processing rules as compared to novices (Pressley, Borkowski, & O'Sullivan, 1985).

Many studies show the importance of metacognitive knowledge in helping students develop and employ mathematical problem solving strategies (e.g. Carr & Jessup, 1996; Pugalee, 2001; Schurter, 2002; Stillman & Galbraith, 1998; Zan, 2000). A study by Pugalee (2001) showed that grade 9 algebra students demonstrated various metacognitive behaviors during orientation, organization, execution, and verification phases of mathematical problem solving. Similarly, a study on mathematical problem solving capacity of secondary school girls showed that those who were involved in organization, regulation of execution, and evaluation activities were more successful (Stillman & Galbraith, 1998). Furthermore, Schurter (2002) reported that students who were trained to use comprehension-monitoring strategies performed better in mathematical problem solving than those who were not trained. Also, college biology students who were trained to self-evaluate their mathematics knowledge performed better in their exams (Zan, 2000).

The role of metacognition in scientific problem solving is also gaining attention in science education research. Metacognition in science is, in principle, the same as metacognition in reading and mathematics. Once students have acquired the basics (like computation in mathematics and decoding in reading), their abilities to think in the domain involve clarifying goals, understanding important concepts, monitoring understanding and clarifying confusion, predicting appropriate direction, and choosing appropriate actions. These are the strategies used by effective problem solvers (Gourgey, 2001). Therefore, such metacognitive components are incorporated into instructional practices as tools of problem solving and their effects are examined. For example, Howard and McGee (2001) studied the effect of metacognitive self-regulation (described as knowledge of cognition, objectivity, and problem representation) on problem solving in science through inferential methods. Their study showed that metacognitive self-regulation methods were better predictors of success in problem solving than many standardized measures used in classrooms across the US. Previous study by these authors indicated that metacognitive monitoring and regulatory skills were significant predicators of content understanding and problem solving (Howard and McGee, 2000). Based on these findings, they recommended that science instruction be tailored to include metacognitive self-regulation for successful problem solving (Howard and McGee, 2001). Also, Neto and Valente (1999) gave strategy training to grade 9 physics students and found out that such training led to better performance on problem solving tasks. These authors suggested metacognitive oriented problem solving approaches as an alternative to a conceptual change paradigm.

## Incorporating Metacognition into Science Instruction

The goal of science education research and practice has long been to develop instructional methods that would improve conceptual change learning and problem solving abilities of students (Rickey & Stacy, 2000). It is argued that even though cognitive skills are essential for learning, they are not sufficient to support conceptual learning and problem solving transfer. Cognitive strategies must be supported through metacognitive knowledge and strategies as well as motivational aspects to guarantee successful learning (Mayer, 2001). The fundamental problem of failing to apply school learned content to novel situations (i.e. transfer) and retain it for longer time (i.e. durability) can be minimized through the use of metacognitive knowledge and strategies. Metacognition is thought to ensure deeper, more durable, and transferable learning (Georghiades, 2000; Richey & Stacy, 2000).

This may be explained because, while cognitive strategies enable one to *make* progress (to build knowledge), metacognitive strategies enable one to *monitor and improve* one's progress (to evaluate understanding and apply) (Gourgey, 2001). Metacognitive regulation improves performance in a number of ways, such as better use of attention resources, better use of existing strategies, and greater awareness of comprehension breakdown. Gourgey eloquently presented the importance of metacognition in learning:

> Through metacognition one can define the nature of the task or the problem; select a useful mental and physical representation; select the most useful strategy for executing the task; allocate resources such as time; activate prior knowledge; pay attention to feedback on how the task is proceeding; and translate feedback into improved performance, either during execution or in plan for the future. Metacognition enables one to use knowledge strategically to perform most effectively (2001, p. 18).

Enough evidence exists to make a compelling case for science education practitioners to consider the use of metacognitive components in their teaching.

Nearly all the studies described in the preceding paragraphs require students to explicitly employ metacognitive strategies. From those studies we see that when attempts to include metacognitive models or strategies in the teaching-learning process are made, those models or strategies are designed to create interactive-constructive learning environments. Likewise, the models or activities promote learner reflection and deep thinking. According to Lin (2001), strategy training and creating supportive social environments should enable teachers to teach the contents of a given domain, and attributes students should know about themselves as learners. Admittedly, Lin noted that approaches that incorporate content knowledge and knowledge about self-as-learner are rare. In the following paragraphs, research and findings about considerations and mechanisms of incorporating metacognitive models are provided.

### *Creating interactive learning environments*

Metacognitive models that create interactive learning environment are known to lead to better learning. For example, high school students engaged in collaborative metacognitive activity when learning mathematics demonstrated skills of ‘self-disclosure’ (statements and responses to clarify, elaborate, evaluate or justify one’s own thinking), ‘feedback request’ (self-oriented questions that invite a partner to critique one’s own thinking), and ‘other-monitoring’ (statements, questions and responses one poses in an attempt to understand a partner’s thinking) (Goos, Galbraith, & Renshaw, 2002). Yet, creating socially interactive learning environments requires teachers and instructors to change the classroom culture and social dynamics whereby student metacognitive activities become spontaneous and habitual (Lin, 2001).

Supportive classroom climates for conceptual learning in science, as Duit (1999) states, could be achieved by including metacognitive learning strategies. For example, Blank (2000) developed a model called Metacognitive Learning Cycle by modifying the famous SCIS Learning Cycle to provide opportunities for the teacher and students to talk about their science ideas. Another intervention study that engaged secondary science students in a variety of writing tasks (brochures, letters and newspaper articles, construction of posters, development of concept maps, and preparation of power-point presentations) under various task factors yielded positive outcomes (Prain & Hand, 1999). These activities demanded deep thinking and interactive group endeavors on the part of the students and led to qualitative learning gains. Prain and Hand asserted that this gain was attributable to the students' deep thinking as well as reflection on their own thinking, which were the requirements of the various writing tasks. Previously, White and Frederiksen (1998) developed computer-enhanced middle school science curriculum that required students to reflect upon their own ideas and the ideas of their classmates, leading to significant benefit, with low achieving students at better advantage.

### ***Fostering active learning***

While learning science students should be involved in text comprehension and mathematical problem solving in addition to construction and reconstruction of meanings and understandings. Hence, it would be legitimate to provide supporting research evidence from language, mathematics, and other school subjects. An important instructional consideration of metacognition is creating a situation whereby students verbalize and reflect on their learning and thinking processes (Masui & DeCorte, 1999). In fact, Palincsar and Brown's (1984) reciprocal teaching model was designed to help students generate and answer their own questions, differentiate important contents from trivial details, monitor comprehension, and find ways to clarify misunderstanding. All of these activate prior knowledge and create expectations about future contents. Similarly, the use of intelligent instructional software called *Cognitive Tutor*, for teaching geometry, requires students to scaffold and self-explain their solution steps (by interacting with the software) (Aleven & Koedinger, 2002). Veenman, Prins, and Elshout (2002) created a computer-simulated environment to teach optics contents to college psychology majors. The computer-simulated laboratory environment provides students the opportunity to think-aloud and use metacognitive skills to carry out the tasks. A model called 'Cognitive-metacognitive strategies for mathematical problem-solving,' developed by Montague (1992), requires learners to question and reflect on their own cognitive processes.

Metacognitive support *during* mathematical word problem-solving process, where grade 8 students were asked a series of questions that would help them identify the problem, represent the problem, plan solution strategies and evaluate outcomes, were reported to be more effective than *before* or *after* problem-solving process. Furthermore, students of kindergarten through grade 3 who completed reading and writing tasks supported by self-evaluation questions exhibited high levels of metacognition (Perry & VandeKamp, 2000). Students who were taught through *Cognitive Tutor* were successful on mathematics transfer problems as compared to groups who were not allowed to self-explain (Aleven & Koedinger, 2002). Students who were required to explain their solution steps also performed better than control groups and were better at explaining their problem-solving steps. These same students needed to solve fewer problems to fulfill the mastery level criteria of the software. Nursing students who were instructed to use a clinical reflective log, which required them to reflect upon clients' problems, improved their metacognitive knowledge, perhaps because they were actively engaged in their own learning and manage their own thinking (Fonteyn & Cahill, 1998).

Likewise, promising outcomes are apparent when including metacognitive components that promote self-reflection and self-evaluation in teaching science. Year 11 (Australian) students, who employed metaphors to describe themselves as learners in chemistry classrooms, were congruent with their views of learning and the learning processes. Use of metaphors to make student views about themselves as learners congruent with their own learning processes was reported to have enhanced student learning processes and metacognition (Thomas & McRobbie, 1999). Also, a metacognitive reading strategy training that involved self-critical reflection of the students' own reading comprehension abilities and active monitoring enhanced physics text comprehension (Koch, 2001).

### ***Promoting strategy knowledge***

In order to carry out cognitive tasks effectively, students apparently need to have a repertoire of metacognitive strategies. However, students cannot be expected to be competent with many of the metacognitive skills and strategies because such skills and strategies are rarely taught and not everyone develops them independently (Hartman, 2001a; Pintrich, 2002). The development or selection of models or strategies that are known to be effective in creating interactive instructional settings and, thus, better learning, may not be sufficient by themselves. Hence, instructions that focus on helping students develop metacognitive strategies for thinking and independent learning are increasingly acknowledged (Gourgey, 1999). After students are informed about the existence and importance of metacognitive strategies for academic success, they need to be taught about them explicitly (Hartman, 2001a; Pintrich, 2002; Schraw, 2001; Spence, 1995). Metacognitive strategies and skills must continually be addressed, practiced, polished, and internalized (Hartman, 2001a; Pintrich, 2002).

Various researchers provide many recommendations about the strategies and contents of metacognitive strategy training. They recommend that metacognitive strategy training place sufficient emphasis on the active involvement of learners (Borkowski, 1992) and creation of supportive social environments. Schraw (2001) promotes an interactive training approach that blends direct instruction, teacher and expert student modeling, reflection on the part of the students, and group activities that allow students to share their knowledge about cognition. ‘Students may learn valuable strategies, but these cannot be applied unless they are supported by broad learning goals and cultural norms in a community’ (Lin, 2001; p. 33). Thus, Pintrich (2002) suggests that teachers need to include goals for teaching metacognitive knowledge, which should be explicitly labeled, tried under different contents, modeled, and explained to students, without denying the importance of contextualzing it. A more or less similar recommendation by Bonds, Bonds, and Peach (1992) includes planning the strategy to be learned, modeling of the strategy by the teacher, guided practice while the teacher monitors the students, and feedback to the students from the teacher and classmates.

Metacognitive strategies that are the focus of training include ‘…error detecting, effort and attention allocating, self-questioning, self-explanation, constructing visual representations, activating prior knowledge, rereading difficult text sections, and going back to revise’ (Lin, 2001; p. 25). All deal with self-awareness, self-regulation and self-reflection before, during and after cognitive endeavors (Hartman, 2001a; Loper & Murphy, 1985; Pintrich, 2002). Moreover, students must be taught about declarative, procedural, and conditional knowledge of various strategies (Pressley, Borkowski, & O’Sullivan, 1985).

Perhaps equally important is training students to create graphic organizers (internal, visual representations) for summarizing main points from textbooks and lessons (Hartman, 2001a). While advocating the use of graphic representations as essential metacognitive strategies, Jones, Pierce, and Hunter (1988/89) outlined procedures for teaching about their use. The procedures are: presenting at least one good example of a completed graphic organizer that matches the type of outline one will teach; modeling how to construct either the same graphic outline or one to be introduced; providing procedural knowledge; coaching the students; and, giving the students opportunities to practice—outlining individually and independently and giving them feedback. When students are trained about various strategies used in a given area of study, metacognition is believed to arise spontaneously upon the use of such strategies (Pressley, Borkowski, & O'Sullivan, 1985).

Nonetheless, some researchers do not favor explicit training for metacognitive skills and strategies. They believe that classroom social interaction should itself lead to induction of metacognition (e.g. Day, French, & Hall, 1985; Georghiades, 2004). Day, French, and Hall (1985) argue that metacognitive activities are not always explicitly modeled to learners, but the social interactions that take place in the learning environment often serve as a context for the induction of metacognitive skills. They further argue that teachers could model problem solving and metacognitive strategies by creating interactive instructional environments. Likewise, Georghiades (2004) stated, "Metacognitive skills are thinking skills requiring appropriate stimuli for their 'awakening' and gradual development. Metacognition is not something to be taught to the learner in an 'outside-in' process, but rather it is a skill that can be helped to develop in an 'inside-out' manner" (p. 369). When such a stance is taken, however, any attempt to examine the effects of metacognitive instructional interventions through comparing pre-test—post-test or treatment—control scores, a usual practice in education research in the field, will not be easy, if not inappropriate.

Strategy training to promote metacognitive knowledge and regulation yields notable results in many subject areas, across levels, and with various learner characteristics. Interestingly, when students are explicitly trained about metacognition knowledge and strategies or skills, they use them productively. For example Cullen (1985) provided evidence that even 10 year olds could be trained to use metacognitive strategies in learning mathematics. Also, 7th graders who received metacognitive strategy training that enabled them to make connections and apply those strategies to carry out mathematics problems outperformed their counterparts who were involved in strategy training only (Mevarech, 1999). In the metacognitive strategy-training group, students were trained to make a series of comprehension, comparison, and procedural questions while executing a given task. Likewise, pre-test—post-test scores on metacognitive surveys and comprehension tasks show significant correlations among 7th graders who were trained how to read science texts (Spence, 1995). “Explicit instruction of metacognition in terms of getting the students to ‘think about thinking’ showed very promising results” (p. 31), helping students perform better on subject matter tasks and to acquire metacognitive knowledge. Furthermore, middle school students with learning disabilities benefited from cognitive-metacognitive strategy instruction for solving mathematical word problems (Montague, 1992). Moreover, Kramarski and Ritkof (2002) taught junior high students about the importance of self-addressed metacognitive questions of comprehension, connection, strategies, and reflection, and modeled the strategies before students were required to use them. The students who used the metacognitive questions were better in mathematical problem solving and mathematical reasoning. The level of interaction of the students who used metacognitive questioning was better than that of a comparison group. Students from an undergraduate reading class who received intensive instruction on metacognitive reading strategies were in a position to understand and apply these strategies in their personal readings. Moreover, they were more aware of the metacognitive processes that make them strategic readers (Thomas & Barksdale-Ladd, 2000).

Nevertheless, metacognitive intervention may not always lead to positive outcomes. All learners may not benefit by metacognitive intervention. In fact, Paris (2002) has indicated circumstances in which metacognition becomes debilitating. For example, metacognitive intervention was more useful to low achieving students only, while its contribution for high achievers was minimal (Kapa, 2001). Moreover, it is argued that under conditions of maximum external support, students' metacognitive skills develop minimally. Thus, students with minimum metacognitive skills will not experience their advantage in learning (Boekaerts, 1999).

The many studies thus far discussed that show promise for metacognitive strategies led the researcher to investigate the effectiveness of metacognitive instructional models in yet unstudied settings. For this purpose, the researcher designed three instructional models, predicted to advance meaningful science learning. The models employ metacognitive regulatory strategies (self-questioning, self-monitoring, self-evaluation and self-reflection) during classroom discourse, guided activities, and science reading, which create interactive learning environment and promote active learning. The models were predicted to be fairly workable with students of lower grades and teachers of limited expertise, without upsetting even the most traditional teaching practices.

## METHODOLOGY OF THE STUDY

This study investigated the effects of three metacognitive instructional methods on learning science among primary school students (grades 5 and 6, age 10-14 years) in Ethiopia. Three instructional methods, Graphic Organizers, Metacognitive Reflection for Conceptual Learning Model, and Metacognitive Science Reading Checklist, were developed to reflect current global science education research and the goals of primary school science instruction in Ethiopia. Details of the models and strategies of incorporating them into the instructional processes are indicated in the articles reporting the effects of methods.

### Study Schools

The study was conducted in four complete public primary schools in Mekelle town (Tigrai State, Ethiopia). Of 43 schools under the supervision of the Department of Education of Mekelle town, 27 are public (i.e. governmental) schools, while the rest are private or run by non-governmental organizations (NGOs). The private and NGO schools were not considered for the study, because they enroll students from economically privileged families and are with smaller class size. Eight of the 27 public schools, located in rural and semi-urban communities around the town were not also included for the demographic characteristics of the students are different from those in urban schools. Out of the remaining 19 public schools, only 10 had grades 5 and 6. Since the study required at least three classes at a grade level, each to be designated as Individual learning, Pair learning or Comparison classes, four of the 10 schools were dropped because they had less than three classes of grade 5 and/or grade 6. Finally, one of the remaining six schools was dropped because the science teachers did not volunteer to participate in the study, while in a second school no science teacher was assigned until the beginning of the intervention. Thus, the four schools for this study were selected by default. All four schools had large classes (as many as 70+ students per class) and lacked facilities to teach practical or hands-on lessons.

### Participating Teachers

The plan of the study was to test the effectiveness of each of the three metacognitive instructional methods among $5^{th}$ and $6^{th}$ graders. As indicated above, three classes were needed in each grade and six teachers (three $5^{th}$ grade and three $6^{th}$ grade) from the four schools were needed. After the teachers were briefed about the purpose of the study, the methods of the intervention, the sources and procedures of data collection, and their responsibilities during the intervention, they volunteered to participate.

Each of the six teachers had over 20 years of teaching service. While two had college diplomas, the other four held certificates for teaching in lower grades (grades 1 to 6). Some details about each of the participating teachers are indicated in the articles reporting the contribution of each metacognitive instructional method.

### Pre-intervention Training of Teachers

The six teachers from the four primary schools; i.e. school-1 (a $5^{th}$ grade teacher and a $6^{th}$ grade one), school-2 (a $6^{th}$ grade teacher), school-3 (a $5^{th}$ grade teacher) and school-4 (a $5^{th}$ grade teacher and a $6^{th}$ grade one), attended a pre-intervention training, conducted from 15 to 19 September 2004. The researcher trained the participating teachers. The training began by providing brief background information on metacognition, constructivism, conceptual change, and inquiry learning. Then, all the teachers were trained in the use of the three metacognitive instructional methods, namely: Graphic Organizers (GOs), Metacognitive Reflection for Conceptual Learning Model, and Metacognitive Science Reading Checklist. The training was supported by discussions and activities.

The teachers were each assigned to teach using one of the three metacognitive instructional methods based on their interest and abilities as noted in the training. The two teachers from school-1 were assigned to teach using GOs. The 5$^{th}$ grade teacher from school-3 and the 6$^{th}$ grade teacher from school-2 were assigned to teach using the Metacognitive Science Reading Checklist. The two teachers from school-4 were assigned to teach using the Metacognitive Reflection for Conceptual Learning Model (Table 1).

Table 1. Study schools

| School | Grades | Metacognitive Methods | Treatment Classes | | |
|---|---|---|---|---|---|
| | | | 1 | 2 | 3 |
| 1 | 5 | Graphic Organizers | Individual | Pair | Comparison |
| | 6 | Graphic Organizers | Individual | Pair | Comparison |
| 2 | 5* | Graphic Organizers | Individual | Pair | Comparison |
| | 6 | Metacognitive Reading | Individual | Pair | Comparison |
| 3 | 5 | Metacognitive Reading | Individual | Pair | Comparison |
| | 6 | Not Included | -- | -- | -- |
| 4 | 5 | Metacognitive Reflection | Individual | Pair | Comparison |
| | 6 | Metacognitive Reflection | Individual | Pair | Comparison |

* Included at request of the teacher of the classes

After these assignments were made, the researcher trained the teachers in each group in the procedures of incorporating their respective metacognitive method in their instructional practices and about how to prepare reflective journals. At the completion of the pre-intervention training, the teachers were provided with training packets that contained all the notes of the training. They were also instructed to train their students assigned to the treatment classes.

The 6th grade teacher from school-1 withdrew after attending the pre-intervention training, thus a substituted teacher was assigned. A lately hired 5th grader teacher from school-2 also participated in the study at her request. These two teachers were given a three-hour training about GOs and, strategies using GOs in their teaching.

### Participating Students

The majority of the students belonged to middle to low income families of inner and outer town neighborhoods. According to Ethiopia's education policy, 5th and 6th graders are expected to be $11^{1/12}$ and $12^{1/12}$ years old, respectively. But there were 5th graders as old as 14 years and 6th graders as old as 15 years. Overall, the study began with 815 5th graders (48.5% males and 51.5% females) and 596 6th graders (52.3% males and 47.7% females).

The three classes in each grade of the study schools were arbitrarily assigned to one of two treatment classes (Individual learning and Pair learning) or a Comparison class (Table 1). The metacognitive instructional interventions were tested among the treatment classes. Thus, the students in the treatment classes were trained by their teachers about the strategies of carrying out the respective metacognitive activities at the beginning of the intervention. The training for the GO group lasted for two 40-minute sessions, while the training for the metacognitive reflection and metacognitive reading groups completed within a 40-minute session. Then, students in the Individual learning classes were instructed to carry out the metacognitive activities individually while those in Pair learning classes were carrying out similar activities in pairs. Students in Comparison classes were not involved in metacognitive activities.

## Lesson and Course Planning

The course plans and daily lesson plans of the units of both grades covered in the study were prepared during the pre-intervention training. Each of the three 5th grade teachers who attended the pre-intervention training had already prepared their own annual plans for the grade at the end the previous academic year. These teachers and the researcher revised the three annual plans and prepared a single one to be uniformly used by all three teachers. Based on the new annual course plan, we decided to include the first three units of the five-unit curriculum. The three units were distributed into 14 weekly plans. Since four of the 30 weekly sessions (40 minutes each) are assigned to Science, the 14 weekly plans were further divided into 56 daily lesson plans.

Likewise, the 6th grade participating teachers and the researcher prepared a new plan during the pre-intervention training. According to the new annual plan, the first four units of the seven-unit curriculum were selected to be covered in the study. Then, the units were distributed into 15 weekly plans, yielding a total of 60 daily lesson plans.

## Contents Covered during the Intervention

**Grade 5:** The three units covered during the study were Breathing and Respiration, Human Nervous and Endocrine Systems, and Animal Reproduction. The contents of each unit are indicated as follows.

*Unit 1 Breathing System and Respiration:* This unit included breathing and organs of breathing (nose, nostril, trachea, bronchi, bronchioles, alveoli); inhalation and exhalation;

gaseous exchange and composition of inhaled and exhaled air; respiration; artificial respiration (the need and procedure); smoking and respiratory health; and, respiratory diseases (common cold, influenza and tuberculosis). The unit was provided with three activities and five exercises.

*Unit 2 Human Nervous and Endocrine Systems:* The unit provided a brief background of human nervous and endocrine systems, including the nerve cell (structure, types and functions); the central nervous system (the brain–gross anatomy and functions of cerebrum, cerebellum and hypothalamus, and the spinal cord–gross anatomy and functions); reflex action; and, the effects of excessive alcohol consumption on the functioning the three parts of the brain. Likewise, the endocrine system includes topics on pituitary, thyroid, parathyroid, adrenal, pancreatic and reproductive glands. The location, gross anatomy and secretion of each of glands were briefly addressed. The functions of the major hormones secreted by each gland and the problems associated with over- and/or under-secretion of the glands were also briefly included. The unit included one activity and three exercises.

*Unit 3 Reproduction in Animals:* The unit covered the modes of reproduction in insects, fishes, amphibians, reptiles, and birds. The topic on insect reproduction dealt with complete and incomplete metamorphosis. The modes of metamorphosis and life cycles of housefly, locust, mosquito, armyworm and honeybee were given. The harmful effects of the housefly, locust, armyworm, and mosquito, and the economic importance of honeybees and methods of apiculture (beekeeping) were also included. Reproduction of vertebrates briefly considered the modes of fertilization (external or internal), birth (oviparous or viviparous) and development. Basic techniques and methods of fish and poultry production were also included. The unit included two activities and five exercises.

**Grade 6:** The four units covered in the study in grade 6 were Our Environment, Human Diseases, Physical Properties of Matter, and Refraction. The contents of each unit are described below.

*Unit 1 Our Environment:* This unit addressed current problems of the environment such as overpopulation, air pollution and water pollution, and the mechanisms of control of these problems. The problems were locally and nationally contextualized and included topics on personal and community hygiene, roles of science and technology in solving environmental problems, relationships among water, soil and vegetation and problems associated with them, and, some recommendations for environmental rehabilitation. The unit had end of unit exercises.

*Unit 2 Human Diseases:* This unit dealt with diseases that are prevalent in Ethiopia. It began by providing the definition of disease, describing communicable and non-communicable diseases, listing causative agents of communicable diseases (viruses, rickettesia, bacteria, protozoa, worms and fungi), and explaining symptoms of diseases. The diseases addressed were: (a) airborne diseases (pneumonia, influenza and measles); (b) waterborne diseases (cholera, amoebic dysentery, ascariasis, and bilharziasis); (c) food-borne diseases (giardiasis, shigellosis, and tapeworm), and, (d) diseases transmitted by vectors and other agents (malaria, rabies, typhus, trachoma and fungal diseases). Causative agents, modes of transmission, symptoms, effects, and methods of prevention and treatment of each disease were given. The life cycles of some of the causative agents were also included. Moreover, food hygiene and potable water treatment methods were addressed. The unit included three end-of-topic exercises.

*Unit 3 Physical Properties of Matter:* The unit is divided into six topics, namely: (a) the state of matter–gases, liquids and solids as well as their salient characteristics; (b) volume–definition, unit of measuring volume and methods of calculating volumes of geometrical and non-geometrical objects; (c) mass–definition and the units of measuring mass; (d) density–definition, formula for calculating density, units of measuring density and relative density (definition and formula); (e) floating and sinking (why objects float or sink); and, (f) pressure–definition, formula for calculating pressure, unit of measuring pressure and pressure in solids, liquids and gases. The unit was supported by examples, four exercises, and eight activities.

*Unit 4 Refraction:* This unit had three topics, refraction, lenses, and magnifying instruments. Refraction explained how light rays behave when passing from one transparent medium to another and provided a brief introduction to mirages. The second topic, lenses, dealt with the nature of concave and convex lenses and the types of images formed by those lenses (real or inverted). It also briefly described the anatomy and functioning of the eye and the role of lenses in correcting sight problems. The last topic discussed instruments that are made of lenses such as cameras, hand lenses, microscopes, and telescopes. The unit had two activities and two exercises

## Incorporating of the Metacognitive Instructional Methods

The metacognitive activities were integrated into the lesson plan sequence used by the schools as recommended by the Bureau of Education. A typical lesson plan employed by the participating teachers contained four stages or activities. These were: Introduction, Presentation, Stabilization and Evaluation. Hence, the metacognitive activities were incorporated so as to support one or more of the classroom activities of a typical lesson plan. Graphic organizers were incorporated during Stabilization stages of the lessons. Sometimes such activities were provided to the students as homework assignments. In general, after a teacher did introduce a lesson (Introduction) and taught it using any appropriate method of her/his choice (Presentation), the students in the treatment classes were required to summarize the lesson using one or more of the GOs (Stabilization). Finally, the teacher would finish the lesson by providing evaluation questions (Evaluation).

In the case of the metacognitive reflection model, metacognitive activities were included during the Introduction and Stabilization stages of a typical lesson. During the Introduction part of a given lesson, the students were invited to reflect on their ideas, understandings and beliefs about the lesson topic. Then, after teaching the lesson using any appropriate method (Presentation), the students were asked to compare their pre-instructional understandings and beliefs with post-instructional ideas and concepts covered during the Presentation stage and provide their reflections by stating the scientific conceptions (Stabilization). Then, the lesson would be completed by providing evaluation questions (Evaluation).

The metacognitive science reading strategy was incorporated as students completed reading assignments for forthcoming lessons and took summary notes to be able to participate during instruction. Then, after the lessons were introduced (Introduction), the students were invited to be involved in the Presentation of the lesson. During this stage, the teachers were guiding their students to reflect on their pre-reading beliefs and thoughts about the reading topic, explain the main ideas and concepts of the topic they read, and compare their pre-reading beliefs and post-reading understandings. Finally, the teachers were required to complete the lessons by providing summary points (Stabilization) and evaluation questions (Evaluation).

### Data Sources

#### *Qualitative data*

The intervention lasted for 14 weeks in grade 5 and 16 weeks in grade 6, lagging by one week from the planned time. Qualitative data sources of the study include researcher non-participant observation data, teacher notes on student reflections, student products and teacher reflections. The purposes of non-participant observations were to: (a) check whether or not the teachers were teaching according to the design of the study by incorporating the metacognitive activities, (b) observe the abilities of the students in carrying out the metacognitive activities, and (c) record students' products (such as GOs) and reflections. The participating teachers were also recording samples of the pre-instruction/pre-reading and post-instruction/post-reading reflections provided by students. A limited amount of teachers' reflections about the use of GOs were also included. Then, the qualitative data was examined to evaluate whether the interventions were carried out as planned and triangulated with the quantitative data.

#### *Quantitative data*

Students' prior school performance (considered as pre-test) and post-intervention tests scores were the sources of quantitative data. Students' prior school performances (PSP) scores were computed using their average scores from the core subjects of the previous academic year. The records of the students were obtained from the record offices of the schools and the average scores of the core subjects were recalculated after the scores of non-core subjects (i.e. Aesthetics, Civics and Physical Education) were dropped. The core subjects for grade 5 are Amharic (Ethiopia's federal working language), Tigrinya (instructional and mother tongue language of the students), English, Mathematics and Environmental Science. These subjects constitute about 87% of the weekly schedule. Likewise, the core subjects for grade 6 are Amharic, Tigrinya, English, Mathematics, General Science, and Social Studies, covering about 73% of the weekly schedule.

Post-intervention test scores constituted the major source of quantitative data. The post-intervention tests were developed for investigating knowledge and comprehension, application and transfer abilities of the students. Moreover, students' retention abilities were investigated by comparing the scores of the Immediate and Delayed test-groups in each class. Thus, the post-tests for each grade included 10 true or false, 10 fill in the blank, 30 multiple choice and 10 short answer items; distributed into Knowledge/ Comprehension, Application, and Transfer tests (20 items each), each administered as separate tests. (The tests are indicated in Appendix A and B).

While questions in the Knowledge and Comprehension tests required students to recall or know facts, the Application tests required applying what one learned in a slightly different situation (i.e. context transfer) or to a new situation that was not identical to the learning situation (i.e. near transfer). Questions in the Transfer tests required applying one's learning to situations not similar to the original situation (i.e. far transfer) (Haskell, 2001). The questions were developed according to the elementary science question development guide indicated in Victor and Kellough (2000). Two primary school science curriculum experts approved the content validity of each test. The experts have a good deal of expertise in the Ethiopia's elementary school science curriculum. They worked as writers and evaluators of science textbooks for both grades.

The questions for 5th graders were pilot tested with a sample of 30 students from two non-study classes of school-1, and those for 6th graders were pilot tested with a sample of 30 students from two non-study classes of school-4. Questions that were answered by 20% of the students or fewer were revisited, and some modifications were made to make them clearer. The amount of time required to complete each test was also decided. Thirty minutes was allotted for Knowledge/Comprehension tests of both grades. While 35 minutes each was given to the Application and Transfer tests of 5th graders, 45 minutes each was allotted for those of 6th graders.

The intervention began with 815 5th graders and 596 6th graders. Some of these students were older than the legal ages of the Ethiopian education policy (about 14%) and were excluded from the quantitative study. Hence, only 5th graders from 10 to 13 years old and 6th graders from 11 to 14 years old were included. Overall, 696 5th graders (49% males, 51% females) and 519 6th graders (53% males, 47% females) were selected for the quantitative study. Then, the students in each class were divided into Immediate and Delayed test-groups. After the students in each class were ranked based on PSP scores, those with odd ranks were assigned to Immediate test-groups while those with even ranks were assigned to Delayed test-groups. The mean PSP scores of the Immediate and Delayed test-groups in each class were nearly comparable.

By the end of the intervention, students were given seven days to study for the tests. At the end of Day Seven, the students in the Immediate test-groups were told to come for the tests next day and took the three tests one by one with about 30 minutes recess between each. The researcher and participating teachers supervised the tests. Students in the Delayed test-groups waited to take the same tests 24 weeks after the completion of the intervention without being required nor informed to make additional preparations.

The numbers of students who completed the post-intervention tests were 996 (49% males and 51% females), constituting 82 % of the population selected for quantitative study. The author and one participating teacher scored the tests. The interrater reliabilities of the scores of the various groups were 0.94 to 0.99. Scores of PSP and post-interventions tests were analyzed using one-way ANOVA and Post-hoc comparisons using Least Significant Difference (LSD), at significance level of $p \leq 0.10$.

The findings of the study are presented in three Articles. Article 1 presents the findings of the study on the effects of GOs on learning primary school science. Article 2 provides the results of the study on the effect of Metacognitive Reflection for Conceptual Learning Model, while Article 3 reports the contribution of the Metacognitive Science Reading Checklist on learning primary school science.

# ARTICLE 1

## GRAPHIC ORGANIZERS:

## METACOGNITIVE TOOLS IN LEARNING PRIMARY SCHOOL SCIENCE

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**ABSTRACT**

SBHATU, DESTA BERHE **Graphic Organizers: Metacognitive Tools in Learning Primary School Science.** (Under the Direction of Professor John E. Penick.)

*This study investigated the effectiveness of graphic organizers (GOs) as metacognitive instructional tools in learning science among primary school students (age 10-14 years) in Mekelle, Ethiopia. Six classes of grade 5 and three classes of grade 6 were involved. Students in each grade were assigned into two treatment classes (Individual and Pair learning), or Comparison class. Teaching of treatment classes involved metacognitive activities requiring students to summarize lessons using GOs while the Comparison classes were taught through traditional methods. Students in Individual learning classes were carrying out the activities individually, and those in Pair learning were doing the same in pairs. Non-participant observation, teacher's reflections and student work were the sources of qualitative data. Prior school performance and post-test scores of Immediate and Delayed test-groups constituted quantitative data. Quantitative data analyses of scores of the Immediate test-groups showed that the intervention helped students in Individual treatment classes perform better in 'application' type tests than those in comparison classes. The contribution of the intervention did wane among the Delayed test-groups. Study of qualitative data showed that the metacognitive activities fostered students' conceptual understanding and active participation.*

## Introduction

There is no tendency among researchers to use similar terminologies for denoting similar graphic displays of information. Researchers and teachers usually opt to develop and describe their own text or information displaying visuals, while there exists a consensus to call all kinds of spatial arrangements or graphic displays of information or concepts ‘graphic organizers’ (GOs) (Cyrs, 1997). The unifying element of GOs as visual illustrations of verbal statements is the arrangement of information containing words or statements that are connected graphically to yield a meaningful diagram (Horton, Lovitt, & Bergerud, 1990).

Graphic organizers present concepts in ways that are easily communicated (Katayama & Crooks, 2003). Concept maps and Vee diagrams constitute the most common GOs used and studied in science education (Wandersee, 1990). Jones, Pierce, and Hunter (1988/89) identified a number of other GOs; namely spider maps, fishbone maps, network trees, compare/contrast matrices, problem–solution outlines, human interaction outlines, and cycles, that could be used in science instruction and other subject areas. Sinatra (2000) and Gil-Garcia and Villegas (2003) provide more or less similar listings and descriptions of GOs.

## Graphic organizers in teaching and learning

Graphic organizers have emerged as a basis of successful learning strategies that help learners organize, abstract, and reflect upon expository information (Trowbridge & Wandersee, 1998). They are becoming important in promoting the teaching and learning processes across levels, subject-areas, and learners’ characteristics. Graphic representations such as concept mapping can be used successfully: by individuals or in teams; with concepts, events, and social relationships; with young children and adults; in schools with teachers, students and researchers; in corporations with workers and managers; and in everyday life (Hartman (2001a). They facilitate the teaching and learning of textual materials (Hartman, 2001b; Kim, Vaughn, Wanzek, & Wei, 2004) and problem solving (Hartman, 2001b). GOs help learners see the relationships of key concepts more readily and economically (Cyrs, 1997), and help them to communicate information more clearly (Eden & Potter, 2003). The graphic representation of networks of related ideas (schemata) of a reading facilitates understanding and interpretation of what is read (Hartman, 2001b).

The role of GOs in eliciting higher-level thinking and facilitating retrieval of information from memory is well documented, because they peculiarly provide both verbal and visual information that complements class discussion and text (Fisher, Frey, & Williams, 2002). GOs are also described as inexpensive teaching and learning tools as they link prior knowledge, foster active learner participation, and promote understanding of conceptual relationships to facilitate comprehension (Kirylo & Millet, 2000). And, they are instructional organization tools available for teachers and proven to be effective in inclusive classrooms (Baxendell, 2003) across all levels and subject areas. GOs (such as concept maps) can serve as important sources of information for teachers about the organization and the contents of student knowledge, by which they can identify and correct student misconceptions (Boxtel, Linden, Roelofs, & Erkens, 2002; Kinchin, 2000a; McClure, Sonak, & Suen, 1999).

Many argue that students should be introduced to strong metacognitive learning strategies, such as concept maps, which enable them to create structural representations of the knowledge they acquire and facilitate their transition from passive to engaged and thoughtful learning (Zele, Lenaerts, & Wieme, 2004). GOs allow thinkers, readers, and writers to translate ideas and concepts into visual graphic displays that are manageable to understand (Sinatra, 2000). By way of their importance as a means of creating interactive teaching–learning setting as well as fostering engaged and thoughtful learning, GOs are recognized to be powerful metacognitive tools used to enhance understanding (Novak, 2002; Sirias, 2002; Wandersee, 1990). Graphic representations help people learn and learn how to learn (Wandersee, 1990). Concept mapping, the GO that has been extensively studied and used in science education, is described as a metalearning strategy based on The Ausubel–Novak–Gowin theory of meaningful learning, a major psychological theory in science education, which focuses on helping students ***learn how to learn*** science (Wandersee, 1990).

**Considerations for incorporating GOs as instructional tools**

Studies that incorporated GOs as instructional methods resulted in positive outcomes across levels, subject areas, and learner characteristics (e.g. Baxendell, 2003; Braselton & Decker, 1994; Chang, Sung, & Chen, 2002; Crawford & Carnine, 2000; Griffin, Malone, & Kameenui, 1995; Hoffman, 2003; Katayama & Crook, 2003; Odom & Kelly, 2001; Tekkaya, 2003; Willerman & MacHarg; 1991).

Incorporating GOs in an instructional process is an important issue that deserves critical attention. The following five considerations are indicated in the literature. First, GOs are effective instructional tools only when employed consistently, coherently, and creatively (Baxendell, 2003). This author explained that the use GOs has to be consistent within and across subjects, where the relationships of the concepts or ideas are clearly and coherently indicated. The creativity of teachers to include GOs in various learning stages and settings is also described as important. Baxendell further stated that students are more likely to retain contents presented through GOs when those tools are inviting.

Second, the use of GOs should not be restricted. They can be used for various purposes such as brainstorming to begin a new lesson, as a method of presentation of a lesson, or as a means of summarizing one (e.g. Ward & Wandersee, 2002b). While the usual practice of including GOs is for brainstorming, some researchers argue that GOs must be given some time after a text has been read rather than before (Robinson, Katayama, Dubois, & Devaney, 1998). A brief review on secondary reading research by Hoffman (2003) indicated that students' comprehension abilities are promoted when they are required to summarize graphically what they have taught. GOs can also be provided to students as study guides. Moreover, students can be required to design, complete or correct GOs in class work or homework assignments, exams or other students' activities (Baxendell, 2003; Chang, Sung, & Chen, 2002; Katayama & Crook, 2003; Marchand-Martella, Miller, & MacQueen, 1998).

Third, when GOs are used as a post-reading activity, teachers need to let their students think about the kind of GO that can be produced out of a given lesson, a key metacognitive component (Hoffman, 2003). This requires teachers to make sure that students can employ GOs while learning. Hence, it is recommended that teacher modelling and guided practices precede student independent activities using GOs (Braselton & Decker, 1994; Marchand-Martella, Miller, & MacQueen, 1998).

Fourth, science education research usually focuses on the use of one or two of the various types of GOs. In practice, nonetheless, the use of one or two of the GOs is not sufficient. Baxendell (2003) studied the effects of four GOs; namely, cause–and–effect diagrams, sequence charts, main–idea–and–detail charts, and compare/contrast diagrams, and reported encouraging results. Teachers and instructors may need to use various GOs in their instruction.

Lastly, whether teachers and instructors have a repertoire of GOs or are going to try to use some, the presence of explicit guidelines is helpful. Egan (1999) provided extensive guidelines for using GOs in teaching, stating that: (a) teachers should be authentically prepared about the preparation and use of GOs before presenting them to a class, (b) GOs must promote classroom social interaction through cooperative learning, (c) the selection of GOs must be based on the nature and objective of the lesson, the interest of the students, and the ability of the teacher to use them, and (d) the use of GOs must be extended to organize non-print information. Egan gave a Six-Step Topical Guide for developing GOs, each accompanied by a metacognitive self-question to help students and teachers include all relevant concepts of a topic.

### GOs in the present study

Four of the GOs listed and described in Jones, Pierce, and Hunter (1988/89), Gil-Garcia and Villegas (2003) and Sinatra (2000), namely: (a) concept maps, (b) compare/contrast matrices, (c) series of events/processes chains, and (d) cyclical representation, were employed in this study. These GOs were employed as tools of lesson summary or stabilization. Thus, throughout the course of the intervention the participating teachers required their students to develop GOs as part of classroom activities and/or homework assignments.

For this purpose, each of the GOs was modelled and exemplified for the students by the participating teachers at the beginning of the intervention. Explicit and direct instruction to students about the use of GOs is known to be very essential (Rock, 2004). Moreover, the students were provided with a guideline (as indicated in Table 2) for selecting, developing and evaluation of GOs for any topic. Since the purpose of this study was to employ GOs as metacognitive tools of instruction and to see their effects on learning, the guidelines entail that teachers and students be engaged in metacognitive questions when planning, developing, and evaluating the GOs.

Table 2. Regulatory Checklist for developing GOs while learning science

| **Phase** | **Guiding Questions** |
|---|---|
| 1. Planning | • Did I understand the main idea/concepts of the lesson?<br>• Can I figure out the supportive ideas/concepts of the lesson?<br>• Which type of GO should I use to summarize the lesson?<br>• Why should I use this GO?<br>• Can I use another GO? Why or why not? |
| 2. Executing | Does the GO:<br>• Begin with the main idea/concept?<br>• Include all the supportive ideas/concepts?<br>• Make sense?<br>• Summarize the lesson? |
| 3. Evaluation | • Did the GO summarize the ideas/concepts of the topic?<br>• Did the GO include all the ideas/concepts of the topic?<br>• Is the GO clear to me? Can I explain it to my friend? My teacher?<br>• Would I need to modify my GO? Why? |

## Purposes of the study

The study investigated the effects of GOs as metacognitive instructional tools in learning primary science (grades 5 and 6) under large class-size in poorly equipped Ethiopian classrooms. Moreover, it looked at the effectiveness of GOs under two learning settings; namely, individual and pair cooperative learning. Thus, the study addressed the following questions.

(1) As compared to more traditional instruction, did the intervention yield better overall learning gains among students of Ethiopia's large class-size primary schools (grade 5 and 6)?

(2) Did the treatment classes perform better on higher order thinking tests than did the comparison classes?

(3) Did the intervention help students in the treatment classes to better retain learned content than those in comparison classes?

(4) Was the instructional method more effective in pair learning setting as compared to individual learning setting?

(5) Did the intervention produce similar positive outcomes in both grades?

## Methodology

This study was conducted in two primary schools (school-1 and school-2) in Mekelle (Ethiopia). During the time of study, school-1 enrolled over 4,800 students while school-2 had over 3,000 students. The study began with two science teachers and 203 students from three classes of grade 5 and 200 students from three classes of grade 6 in school-1, and one science teacher and 197 students from three classes of grade 5 in school-2.

### *Pre-intervention training on metacognitive instructional methods*

The purpose of the pre-intervention training was to enable the participating teachers to employ metacognitive instructional methods. While the 5th grade teacher from school-1 did attend the pre-intervention training, the 6th grade teacher from the same school and the teacher from school-2 received the training a week later. (Details about the training are indicated in the methodology section.) After the teachers completed the training, they were provided with guidelines for incorporating GOs in their teaching. They were also instructed to write reflective journals about the intervention.

### *Participating teachers*

As indicated above, two science teachers from school-1 were assigned to participate in the study. However, the $6^{th}$ grade teacher withdrew from participating and a substitute from the same school was included.

The $5^{th}$ grade teacher from school-1 was a 45-year old female with a teaching service of 26 years. Though she was certified to teach any subjects in grades 1 through 6, the current Ethiopian Education and Training Policy (ETP) requires her to teach in grades 1 up to 4. Nonetheless, due to shortage of qualified teachers, she has been teaching General Science in grade 5 for the last three years. She had a total load of 24 periods (40 minutes each) per week throughout the intervention period, teaching General Science for five classes of grade 5 and one class of grade 6.

The $6^{th}$ grade teacher was a 50-year old male with a teaching service of 28 years. He was certified to teach any subjects in grades 1 to 6, but the current ETP requires him to teach in grades 1 through 4. Due to shortage of teachers, he was teaching grade 6 General Science for the first time. During the course of the intervention the teacher had a total load of 20 periods per week, teaching five classes of grade 6. Since this teacher began the intervention a week later, he was given a three-hour training on the use of GOs as metacognitive instructional methods, and the strategies of incorporating these methods in his daily lesson plans and methods of reflective journaling.

A 5th grade female teacher from school-2 began to work with the GOs a week later as per her request. She was 37 years old, earned her primary teacher education certificate in 1984 to teach any subjects in grades 1 to 6. She obtained a college diploma in Biology in July 2004. Though she had taught science in grades 1 to 4 for some years before, this was her first time to teach General Science in grade 5. During the intervention, she had a total teaching load of 24 periods. She was given a three-hour training on the use of GOs as metacognitive instructional methods and the strategies of incorporating these methods in her daily lesson plans to commence.

#### *Participating students*

The majority of students of school-1 and school-2 were from low-income families. While the students from school-1 belonged to inner-town, those from school-2 were from outer-town neighborhoods. There were 10 classes of grade 5 in school-1, half assigned to the 5th grade participating teacher; and 10 classes of grade 6, half assigned to the 6th grade teacher. There were 6 classes of grade 5 in school-2, all assigned to the participating teacher. Three classes were randomly selected from each group for the study. Then, the three classes were arbitrarily assigned to: (a) Individual Learning class, (b) Pair Learning class, or (c) Comparison class.

The students of the treatment classes (i.e. Individual and Pair learning) were given a 2-session training (each session lasting 40 minutes) on the use GOs (i.e. concept maps, compare/contrast matrices, series of events/process chain and cyclical representations) as metacognitive tools for learning science prior to the beginning of the intervention. The training began by describing each of the GOs, followed by guidelines for constructing GOs. Each of the GOs was modeled for the students. The students were then provided with the guidelines indicated in Table 1 to construct GOs when required throughout the course of the study. Studies that dealt with the effects of GOs on learning begin with more or less similar methods of pre-intervention training (e.g. McClure, Sonak, & Suen, 1999; Willerman & MacHarg, 1991).

### *Contents covered during the intervention*

Details about the preparation of the annual course plans and daily lesson plans, as well as the descriptions of the contents covered during the study are indicated in the methodology section. The three units covered in grade 5 were Human Breathing System, Human Nervous and Endocrine Systems, and Animal Reproduction. The four units covered in grade 6 were Our Environment, Human Diseases, Physical Properties of Matter, and Refraction.

### *Incorporating the GOs as metacognitive instructional methods*

Major activities in a typical daily lesson are: (a) Introduction, (b) Presentation, (c) Stabilization, and (d) Evaluation, with metacognitive activities incorporated to support one or more of these instructional activities. In this study, the metacognitive component was incorporated for stabilizing the lessons. Sometimes, such activities were provided to the students as homework assignments. Thus, after a teacher introduced a lesson (Introduction) and taught it using any appropriate method of her/his choice (Presentation), the students in the treatment classes were required to summarize the lesson using one or more of the GOs (Stabilization). Kinchin (2000b) contends that incorporating GOs at this level, to support other classroom activities, is excellent as it considers large amount of information.  Students in Individual learning classes were required to carry out the metacognitive activities individually, while those in the Pair

Learning classes were required to do the same in pairs. Allowing students to construct concept maps to demonstrate their depth of understandings is usually recommended (e.g. Kinchin, 2000c). Students of the Comparison classes were not involved in doing metacognitive activities. Instead, the teacher would give summary points on the important ideas and concepts of the lesson. Lastly, the teacher would finish the lesson by providing evaluation questions (Evaluation).

#### *Data sources*

Non-participant observation data collected by the researcher was the major source of qualitative data. Samples of student work and brief reflections of the teachers are also included. Prior school performance and post-test scores constitute the quantitative data.

### Qualitative data collection, analyses and findings

#### *Non-participant observation*

Observations were carried out by the researcher to: (a) check whether or not the teachers were teaching according to the design developed for this research, (b) observe the abilities of the students in carrying out metacognitive activities, and (c) record some GOs developed by students. Overall, a total of 35 observations, each lasting about 40 minutes, were carried out in the intervention classes and the data were examined in relation to the above objectives.

*Did metacognitive activities incorporated according to the guideline?*

A total of 15 and 12 non-participant observations were carried out in the intervention classes of grades 5 and 6, respectively, of school-1. Eight observations were conducted in school-2. Observation data were recorded in field notes and later expanded and written in computer files. Then, the data were sorted and grouped according to teaching behaviors of the teachers. Sorting and grouping the teachers' activities yielded four routines: (i) Recap of Previous Lesson or Pre-instructional Questioning, (ii) Lesson Presentation, (iii) Metacognitive Activity, (iv) Lesson Evaluation. These routines represent the four phases of classroom instruction, as per the plan of this study.

Thirteen of the 15 observations in grade 5 of school-1 were summarized. Analyses showed that metacognitive activities were incorporated during Stabilization phases in all 13 lessons. Moreover, metacognitive activities were part of Recaps in eight of the 13 lessons. Likewise, the metacognitive component was part of the teaching activities in all of the lessons observed in grade 6. Furthermore, in all of the lessons observed in school-2 students were required to summarize what they had learned using GOs. These show that the metacognitive method was incorporated as planned.

*Were teachers capable of guiding their students?*

Analysis of the non-participant observation revealed that the 5$^{th}$ grade teacher from primary school-1 properly guided her students in 12 of the 13 observations sessions, while the 6$^{th}$ grade teacher from the same school guided his students in nine of the 12 lessons observed. The second 5$^{th}$ grade teacher from school-2 provided clear guidance in four of the eight lessons. The abilities of the teachers in guiding their students and providing models of GOs did develop during the study period. Thus, along the course of the intervention the guiding abilities of the teachers were getting more clear, automatic, and precise. These suggest that the teachers were capable of teaching using GOs as metacognitive tools and learning from their use.

*Were students capable of learning through GOs?*

Few students in either grade demonstrated ability at summarizing contents using GOs at the beginning of observation. Thus, the GOs developed at that time could only indicate important concepts without showing appropriate hierarchical relationships. In 12 of the 13 observation sessions among 5$^{th}$ grade classes of school-1, many students were seen as capable of developing GOs out of the lessons they learned. Similarly, in nine of the 12 sessions observed in grade 6 of the same school, the involvement of the students was encouraging. In the case of 5$^{th}$ graders of primary school-2, student participation was evident in four of the eight observations. Along the course of the intervention, non-participant observation showed that: student participation was boosted, GOs were getting more complete, and abilities to identify the appropriate GO were becoming automatic. Overall, observation data could fairly show that the students were involved in their own learning through GOs. Examples of GOs developed by students are included in the discussion section of the report.

***Reflective journal***

The participant teachers were required to write reflective journals about their experiences, impressions, challenges, and feelings when using GOs as metacognitive instructional methods. They were also asked to record observations on how their students were engaged in metacognitive activities. However, they were unable to carry out these tasks on a daily basis. Hence, the teachers from primary school-1 provided a very brief reflective journal. Excerpts of these journals are included in the discussion section.

### *Student work*

Graphic organizers constructed by students in class activities were collected during non-participant observation sessions. Additional GOs developed by students as homework assignments were also collected. Samples of GOs are included in the discussion section.

## Quantitative data collection, analyses, and findings

Between 65 and 68 students per class participated in the study. However, only those students around the legal ages as per Ethiopia's education policy (i.e. $11^{1/12}$ and $12^{1/12}$ years for $5^{th}$ and $6^{th}$ graders, respectively) were selected for the quantitative study. Thus, $5^{th}$ graders from 10 to 13 years old and $6^{th}$ graders from 11 and 14 years old were included in the quantitative study. Students were divided into Immediate and Delayed test-groups based on prior academic performance scores (Details are given in Article 2).

Students' mean scores of the core subjects of the previous academic year (i.e. prior school performance (PSP) scores) were used as pre-test scores. The method of collection and the rationales of including prior academic performance scores are explained elsewhere (Article 2). Scores of end-of-intervention tests (i.e. post-test scores of the Immediate and Delayed test-groups) were the major sources of quantitative data. Post-intervention testing compared the comprehension, application, transfer, and retention abilities of students. Thus, three tests each containing 20 questions were prepared. The first test was a knowledge/comprehension type, while the second and third ones comprised application and transfer questions, respectively. Details about the preparation of the questions, the piloting of the tests and the methods of administering the tests are given in Article 2.

The intervention lasted for 14 weeks in grade 5. Students in the Immediate test-groups sat for the tests at the end of the $15^{th}$ week. In grade 6, on the other hand, the intervention was completed by the end of the $16^{th}$ week. Thus, the students in the Immediate test-groups took the tests at the end of the $17^{th}$ week. Students in the Delayed test-groups of both grades sat for the same tests 24 weeks after the end of the intervention. Because of high attrition, students of the Delayed test-groups of primary-school-2 did not complete the tests as planned. The author and one participating teacher scored all the tests. The interrater reliabilities of the scores of the various test-groups ranged from 0.94 to 0.99. Then, PSP and post-test scores were analyzed using one-way ANOVA followed by Post-hoc comparisons using LSD at an a priori significance level of $p \leq 0.10$. Findings of the quantitative analyses are presented below.

## ***Post-test performances the Immediate test-groups***

### *$5^{th}$ graders of school-1*

Analyses of mean PSP and post-test scores revealed some variability (Table 3). Post-ANOVA comparison showed that the mean PSP score of the test-group from the Comparison class (67.43; SD = 13.08) is significantly higher than the mean PSP score of the test-group from the Individual learning class (60.81; SD = 10.46) at $p \leq 0.05$. But, the mean post-test scores of the test-group from the Comparison class were not statistically different from the mean post-test scores of the test-groups from the treatment classes (Table 4).

Table 3. Mean (and SD) scores of 5th graders of Immediate test-groups of school-1 and ANOVA summaries

| Variables | Mean Score (SD) of Treatments | | | ANOVA | |
|---|---|---|---|---|---|
| | Individual | Pair | Comparison | $F_{(2, 74)}$ | p |
| PSP (100%) | 60.81 (10.46) | 64.13 (11.63) | 67.43 (13.08) | 1.997 | .143 |
| Know./Comp. Test (25 pts) | 6.75 (2.78) | 6.89 (2.63) | 6.57 (2.82) | .083 | .921 |
| Application Test (25 pts) | 5.80 (2.66) | 5.81 (2.35) | 6.18 (2.48) | .174 | .840 |
| Transfer Test (25 pts) | 4.54 (2.67) | 5.63 (2.54) | 5.64 (2.13) | 1.736 | .183 |
| Total Score (75 pts) | 17.08 (6.32) | 18.33 (5.88) | 18.39 (5.32) | .412 | .664 |

Table 4. Comparison matrices of mean scores of 5th graders of Immediate test-groups of school-1 using LSD

| | Variables | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PSP | | | Know./Comp. | | | Application | | | Transfer | | | Total | | |
| | IL | PL | CC | IL | PL | CC | IL | PL | CC | IL | PL | CC | IL | PL | CC |
| IL | 1 | | | 1 | | | 1 | | | 1 | | | 1 | | |
| PL | .294 | 1 | | .852 | 1 | | .987 | 1 | | .107 | 1 | | .437 | 1 | |
| CC | .050* | .328 | 1 | .817 | .685 | 1 | .597 | .611 | 1 | .124 | .992 | 1 | .443 | .975 | 1 |

NB: IL—Individual learning class; PL—Pair learning class; CC—Comparison class

* = Differences are significant at $p \leq 0.10$.

### *5th graders of school-2*

Similar one-way ANOVA analyses were carried out using the scores of participating students from primary school-2. The mean PSP scores of the test-groups of the three classes were statistically comparable ($F_{(2, 81)} = 0.439$; $p \leq 0.646$). Even though ANOVA of the post-test scores showed comparably pronounced F-values (1.322 to 2.195) (Table 5), Post-hoc comparisons revealed that only the Application mean score of the test-group from the Individual learning class (5.58; SD = 1.94) was statistically higher than the score of the test-group from the Comparison class (4.55; SD = 1.75) at $p \leq 0.053$ (Table 6).

Table 5. Mean (and SD) scores of 5th graders of Immediate test-groups of school-2 and ANOVA summaries

| Variables | Mean Score (SD) of Treatments | | | ANOVA | |
|---|---|---|---|---|---|
| | Individual | Pair | Comparison | $F_{(2, 81)}$ | *p* |
| PSP (100%) | 60.96 (8.07) | 61.12 (9.12) | 63.01 (9.76) | .439 | .646 |
| Know./Comp. Test (25 pts) | 6.13 (1.83) | 6.33 (2.21) | 5.50 (1.97) | 1.322 | .272 |
| Application Test (25 pts) | 5.58 (1.94) | 4.73 (2.02) | 4.55 (1.75) | 2.195 | .118 |
| Transfer Test (25 pts) | 4.29 (1.87) | 4.95 (1.84) | 4.27 (1.42) | 1.475 | .235 |
| Total Score (75 pts) | 16.00 (4.46) | 16.02 (4.57) | 14.32 (3.46) | 1.512 | .227 |

Table 6. Comparison matrices of mean scores of 5th graders of Immediate test-groups of school-2 using LSD

| | Variables | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PSP | | | Know./Comp. | | | Application | | | Transfer | | | Total | | |
| | IL | PL | CC | IL | PL | CC | IL | PL | CC | IL | PL | CC | IL | PL | CC |
| IL | 1 | | | 1 | | | 1 | | | 1 | | | 1 | | |
| PL | .948 | 1 | | .715 | 1 | | .103 | 1 | | .155 | 1 | | .988 | 1 | |
| CC | .409 | .431 | 1 | .252 | .121 | 1 | .053* | .721 | 1 | .965 | .135 | 1 | .146 | .128 | 1 |

NB: IL—Individual learning class; PL—Pair learning class; CC—Comparison class

* = Differences are significant at $p \leq 0.10$.

### *6th graders of school-1*

Analyses of PSP and post-test scores showed that the Immediate test-groups had comparable mean PSP scores ($F_{(2, 68)} = 0.145$; $p \leq 0.865$) while variations are evident in the post-test scores of Knowledge/Comprehension, Application and Transfer tests (Table 7). Statistically significant differences are observed between mean Knowledge/ Comprehension scores of the test-group from the Pair learning class and the one from the Comparison class at $p \leq 0.085$, mean Application scores of the test-group from the Individual learning class and the one from the Pair learning class at $p \leq 0.021$, mean Application scores of the test-group from the Individual learning class and the one from the Comparison class at $p \leq 0.083$, and mean Transfer scores of the test-group from the Individual learning class and the one from the Pair learning class at $p \leq 0.088$ (Table 8).

Table 7. Mean (and SD) scores of 6th graders of Immediate test-groups of school-1 and ANOVA summaries

| Variables | Mean Score (SD) of Treatments | | | ANOVA | |
|---|---|---|---|---|---|
| | Individual | Pair | Comparison | $F_{(2, 68)}$ | *p* |
| PS Performance (100%) | 61.05 (13.48) | 61.71 (11.34) | 62.54 (12.89) | .145 | .865 |
| Know./Comp. Test (25 pts) | 10.69 (4.16) | 11.83 (4.10) | 9.94 (2.88) | 1.537 | .222 |
| Application Test (25 pts) | 8.37 (3.14) | 6.50 (2.47) | 7.00 (2.43) | 2.983 | .057* |
| Transfer Test (25 pts) | 6.63 (2.75) | 5.36 (2.44) | 5.84 (2.29) | 1.528 | .224 |
| Total Score (75 pts) | 25.70 (8.59) | 23.69 (7.65) | 22.78 (5.56) | .983 | .380 |

***** **=** Differences are significant at $p \leq 0.10$.

Table 8. Comparison matrices of mean scores of 6th graders of Immediate test-groups of school-1 using LSD

| | Variables | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PS Performance | | | Know./Comp. | | | Application | | | Transfer | | | Total | | |
| | IL | PL | CC | IL | PL | CC | IL | PL | CC | IL | PL | CC | IL | PL | CC |
| IL | 1 | | | 1 | | | 1 | | | 1 | | | 1 | | |
| PL | .929 | 1 | | .309 | 1 | | .021* | 1 | | .088* | 1 | | .355 | 1 | |
| CC | .682 | .617 | 1 | .487 | .085* | 1 | .083* | .523 | 1 | .276 | .506 | 1 | .173 | .671 | 1 |

NB: IL—Individual learning class; PL—Pair learning class; CC—Comparison class

* = Differences are significant at $p \leq 0.10$.

### *Post-test performances of the Delayed test-groups*

#### *5th graders of school-1*

Prior school performances of the Delayed test-groups are somewhat variable. Nonetheless, one-way ANOVA indicated that the variations are not statistically significant ($F_{(2, 65)} = 1.182$; $p \leq 0.313$) (Table 9). Mean post-test scores of the test-groups from the Pair learning and Comparison classes are comparable. Mean Application and Transfer scores of the test-groups from the Individual learning class are comparably lower than the test-groups from the Pair learning and Comparison classes. Post-hoc comparisons disclosed that mean Application score of the test-group from the Individual learning class (5.19; SD = 1.46) is statistically significantly lower than that of the test-groups from the Pair learning (6.46; SD = 3.08) and Comparison (6.85; SD = 3.05) classes at $p \leq 0.097$ and $p \leq 0.039$, respectively. Similarly, the mean Transfer score of the test-group from the Individual learning class (4.65; SD = 2.01) is significantly lower than the score of the test-group from the Pair learning class (5.97; SD = 2.45) at $p \leq 0.067$ (Table 10).

Table 9. Mean (and SD) scores of 5th graders of Delayed test-groups of school-1 and ANOVA summaries

| Variables | Mean Score (SD) of Treatments | | | ANOVA | |
|---|---|---|---|---|---|
| | Individual | Pair | Comparison | $F_{(2, 65)}$ | *p* |
| PS Performance (100%) | 62.48 (11.66) | 64.77 (11.98) | 68.03 (12.22) | 1.182 | .313 |
| Know./Comp. Test (25 pts) | 6.33 (2.89) | 5.73 (3.09) | 6.30 (2.77) | .314 | .732 |
| Application Test (25 pts) | 5.19 (1.46) | 6.46 (3.08) | 6.85 (3.05) | 2.512 | .089* |
| Transfer Test (25 pts) | 4.65 (2.01) | 5.97 (2.45) | 5.51 (2.92) | 1.784 | .176 |
| Total Score (75 pts) | 16.17 (4.59) | 18.16 (7.06) | 18.66 (6.74) | 1.033 | .362 |

* = Differences are significant at $p \leq 0.10$.

Table 10. Comparison matrices of mean scores of 5th graders of Delayed test-groups of school-1 using LSD

| | Variables | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PS Performance | | | Know./Comp. | | | Application | | | Transfer | | | Total | | |
| | IL | PL | CC | IL | PL | CC | IL | PL | CC | IL | PL | CC | IL | PL | CC |
| IL | 1 | | | 1 | | | 1 | | | 1 | | | 1 | | |
| PL | .509 | 1 | | .478 | 1 | | .097* | 1 | | .067* | 1 | | .270 | 1 | |
| CC | .130 | .370 | 1 | .970 | .523 | 1 | .039* | .622 | 1 | .249 | .542 | 1 | .188 | .788 | 1 |

NB: IL—Individual learning class; PL—Pair learning class; CC—Comparison class
* = Differences are significant at $p \leq 0.10$.

*6th graders of school-1*

One-way ANOVA and Post-hoc comparisons of PSP and post-test scores of the treatment and comparison classes showed no significant variations (Tables 11 and 12).

Table 11. Mean (and SD) scores of 6th graders of Delayed test-groups of school-1 and ANOVA summaries

| Variables | Mean Score (SD) of Treatments | | | ANOVA | |
|---|---|---|---|---|---|
| | Individual | Pair | Comparison | $F_{(2, 54)}$ | *p* |
| PS Performance (100%) | 58.69(9.54) | 59.71 (10.21) | 63.26 (14.56) | .727 | .488 |
| Know./Comp. Test (25 pts) | 10.12 (2.78) | 8.57 (3.13) | 9.14 (3.43) | 1.368 | .263 |
| Application Test (25 pts) | 6.28 (1.86) | 7.08 (2.60) | 6.82 (2.05) | .718 | .493 |
| Transfer Test (25 pts) | 5.40 (2.47) | 5.57 (2.00) | 5.96 (2.13) | .290 | .749 |
| Total Score (75 pts) | 21.80 (5.31) | 20.97 (6.74) | 21.93 (5.49) | .095 | .910 |

Table 12. Comparison matrices of mean scores of 6th graders of Delayed test-groups of school-1 using LSD

| | Variables | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PS Performance | | | Know./Comp. | | | Application | | | Transfer | | | Total | | |
| | IL | PL | CC | IL | PL | CC | IL | PL | CC | IL | PL | CC | IL | PL | CC |
| IL | 1 | | | 1 | | | 1 | | | 1 | | | 1 | | |
| PL | .767 | 1 | | .105 | 1 | | .240 | 1 | | .857 | 1 | | .728 | 1 | |
| CC | .247 | .354 | 1 | .367 | .585 | 1 | .486 | .728 | 1 | .464 | .554 | 1 | .950 | .705 | 1 |

NB: IL—Individual learning class; PL—Pair learning class; CC—Comparison class

***Comparing performances of the Immediate and Delayed test-groups***

*5th graders of school-1*

Comparisons of mean scores of the Immediate and Delayed test-groups of each treatment class are given in Table 13. ANOVA and subsequent Post-hoc comparisons showed no statistically significant differences.

*6th graders of school-1*

Summary of ANOVA and Post-hoc comparisons of the PSP and post-test scores of the Immediate and Delayed test-groups of the treatment and comparison classes are given in Table 14. ANOVA of PSP scores of the Immediate and Delayed test-groups in each class revealed no significant statistical difference between the means. Nonetheless, comparisons of post-test scores of the two test-groups in the Individual learning class revealed significant differences in Application ($F_{(1, 42)} = 6.794$; $p \leq 0.013$ and in mean Total scores ($F_{(1, 42)} = 3.083$; $p \leq 0.087$). In the case of the test-groups from the Pair learning class, statistically significant difference was observed in mean Knowledge/ Comprehension scores ($F_{(1, 44)} = 9.174$; $p \leq 0.004$). But none of the mean post-test scores of the Immediate and Delayed test-groups of the Comparison class showed statistically significant differences.

Table 13. Comparisons of the mean (SD) scores of Immediate and Delayed test-groups of 5th graders of school-1

| Treatment Classes | §Test-group | PSP Mean (SD) | Know/Comp Mean (SD) | Application Mean (SD) | Transfer Mean (SD) | Total Mean (SD) |
|---|---|---|---|---|---|---|
| Individual Learning | 1 (n = 28) | 60.81 (10.46) | 6.75 (2.78) | 5.80 (2.66) | 4.54 (2.67) | 17.08 (6.32) |
| | 2 (n = 24) | 62.48 (11.66) | 6.33 (2.89) | 5.19 (1.46) | 4.65 (2.01) | 16.17 (4.59) |
| | $F_{(1, 50)}$ | 0.297 | 0.278 | 1.022 | 0.027 | 0.351 |
| | p-value | 0.588 | 0.600 | 0.317 | 0.869 | 0.556 |
| Pair Learning | 1 (n = 27) | 64.13 (11.63) | 6.89 (2.63) | 5.81 (2.35) | 5.63 (2.54) | 18.33 (5.88) |
| | 2 (n = 24) | 64.77 (11.98) | 5.73 (3.09) | 6.46 (3.08) | 5.97 (2.45) | 18.16 (7.06) |
| | $F_{(1, 49)}$ | 0.037 | 2.093 | 0.713 | 0.233 | 0.010 |
| | p-value | 0.848 | 0.154 | 0.403 | 0.631 | 0.923 |
| Comparison | 1 (n = 22) | 67.43 (13.08) | 6.57 (2.82) | 6.18 (2.48) | 5.64 (2.13) | 18.39 (5.32) |
| | 2 (n = 20) | 68.03 (12.22) | 6.30 (2.77) | 6.85 (3.05) | 5.51 (2.92) | 18.66 (6.74) |
| | $F_{(1, 40)}$ | 0.024 | 0.096 | 0.613 | 0.025 | 0.022 |
| | p-value | 0.879 | 0.758 | 0.438 | 0.875 | 0.883 |

§ = 1, Immediate; 2, Delayed

Table 14. Comparisons of the mean (SD) scores of Immediate and Delayed test-groups of 6th graders of school-1

| Treatment | [§]Test-group | PSP Mean (SD) | Know/Comp. Mean (SD) | Application Mean (SD) | Transfer Mean (SD) | Total Mean (SD) |
|---|---|---|---|---|---|---|
| Individual | 1 (n = 23) | 61.05 (13.48) | 10.69 (4.16) | 8.37 (3.14) | 6.63 (2.75) | 25.70 (8.59) |
| Learning | 2 (n = 20) | 58.69 (9.54) | 10.12 (2.78) | 6.28 (1.86) | 5.40 (2.47) | 21.80 (5.31) |
| | $F_{(1, 42)}$ | 0.425 | 0.271 | 6.794 | 2.355 | 3.083 |
| | p-value | 0.518 | 0.606 | 0.013* | 0.133 | 0.087* |
| Pair | 1 (n = 23) | 61.71 (11.34) | 11.83 (4.10) | 6.50 (2.47) | 5.36 (2.44) | 23.69 (7.65) |
| Learning | 2 (n = 23) | 59.71 (10.21) | 8.57 (3.13) | 7.08 (2.60) | 5.57 (2.00) | 20.97 (6.74) |
| | $F_{(1, 44)}$ | 0.099 | 9.174 | 0.615 | 0.080 | 1.427 |
| | p-value | 0.754 | 0.004* | 0.437 | 0.778 | 0.239 |
| Comparison | 1 (n = 25) | 62.54 (12.89) | 9.94 (2.88) | 7.00 (2.43) | 5.84 (2.29) | 22.78 (5.56) |
| | 2 (n = 14) | 63.26 (14.56) | 9.14 (3.43) | 6.82 (2.05) | 5.96 (2.13) | 21.93 (5.49) |
| | $F_{(1, 37)}$ | 0.025 | 0.595 | 0.054 | 0.028 | 0.212 |
| | p-value | 0.874 | 0.446 | 0.818 | 0.869 | 0.648 |

[§] = 1, Immediate; 2, Delayed

* = Differences are significant at $p \leq 0.10$.

## Discussion

The outcomes of qualitative and quantitative data analyses are discussed in relation to the questions of the study. Thus, each question constitutes a theme for discussion.

### *Did the intervention yield better overall learning gains?*

The first objective of the study was to investigate the contribution of metacognitive instructional intervention using Graphic Organizers (GOs) for learning gains in science among 5th and 6th grade students (10-14 years olds) in some populous, large class-size primary schools in Ethiopia. Previous studies on the contribution of GOs to learning pointed out positive outcomes. For instance, a study by Willerman and MacHarg (1991) with middle school students reported learning gains when concept mapping was used as an advance organizer in physical science with 8th graders. Students in the treatment group were taught a two-week introductory physical science unit through concept mapping. The same introductory unit was given to a comparison group through classroom discussion without employing concept mapping. The treatment group scored significantly higher on an end-of-unit test.

Similarly, Ward and Wandersee (2002a) studied the effects of a metacognition-based visual learning model called Roundhouse Diagramming for teaching science to low achieving middle school students. The diagram contains a central part representing a conceptual turntable where the central theme is put, seven outer sectors where concepts associated to the central theme, and graphic icons that remind the learners about the concepts. After students were taught how to use the Roundhouse diagrams, they used it to represent abstract or complex information from their science curricula. In the course of constructing Roundhouse diagrams, students were expected to be involved in metacognitive endeavors such as recognizing the problem, analyzing the problem, making suggestions and inferences, and making decisions to select materials needed to solve the problem. When student expertise on the use of Roundhouse diagrams improved, their science achievement did as well.

The authors (Ward & Wandersee, 2002b) examined the effects of the model in science learning among grade six students over a 10-week intervention. Like the previous intervention, students were required to recognize the main ideas within science lessons, breaking down the information into interrelated segments and linking each portion to an iconic image. The intervention led to better conceptual understanding of the science topic addressed. Similarly, Eden and Potter (2003) report that 4$^{th}$ and 5$^{th}$ graders who were allowed to draw generative pictorial representations about conservation of energy performed statistically better on conceptual understanding tests than their counterparts who were required to write a science log. Furthermore, an instructional intervention where GOs were employed to help grade 8 students organize their thoughts and ideas promoted critical thinking (Collier, Guenther, & Veerman, 2002).

Another study demonstrated that concept mapping by a group of inner-city, low achieving 7th graders improved their comprehension scores by about seven standard deviations when compared to a traditional learning group (Gaustello, Beasley, & Sinatra, 2000). A previous study in the Gaza Strip reported a similar finding, as students (median age 13) who constructed concept maps following the teacher's introduction performed better on post-tests than those who were taught via teacher lecture (Elhelou, 1997). Furthermore, an inquiry on the effect of concept mapping on biology achievement and anxiety reduction among 10th graders indicated that students taught through concept mapping significantly outperformed those taught via traditional/expository teaching strategies (Jegede, Alaiyemola, & Okebukola, 1990). In another study 10th graders who constructed concept maps following teacher explanation in a five-week topic on acids and bases outperformed their counterparts who were taught via traditional teacher-dominated method (Cakir, Uzuntiryaki, & Geban, 2002).

In the case of the present study, qualitative data showed that the metacognitive intervention had positive contributions to the learning of the students. Quantitative data partly support qualitative data. Considering the Immediate test-groups of 5th graders from school-1, the difference between the mean PSP scores of the test-group from the Comparison class (67.43, SD = 13.08) and the mean from the Individual learning class (60.81, SD = 10.46) was statistically significant ($p \leq 0.050$). However, the mean Total post-test scores of these groups were statistically comparable (Tables 3 and 4), implying the intervention enabled the Individual learning group to eliminate the difference due to prior academic performance. In line to this argument the 5th grade teacher from school-1 notes:

> In general, the performance of the students taught using the metacognitive instructional method has boosted. Those students who were not taught using the method did not perform as those taught using the method. It would have been better had all of the classes been taught using the metacognitive method (11 Dec 2004, Translation).

In the case of 5th graders from school-2 and 6th graders from school-1, differences in mean PSP and Total scores between the treatment and comparison classes lacked statistical significance. These data indicate that the intervention has no contribution in the overall performance. Analyses of scores of the Delayed test-groups of both grades of school-1 could not show that the treatment classes were benefited by the intervention.

Not all metacognitive interventions using GOs yield consistently anticipated outcomes for various reasons. For instance, Chang, Sung, and Chen (2002) studied the learning effects of three concept-mapping methods (i.e. map correction, scaffold fading and map generation) among 5th graders. The performance of the map generation group (which required generating concept maps like ours) did not differ from the performance of the comparison group. Furthermore, using concept mapping while learning electrochemistry among final year secondary school students from Belgium did not benefit students (Brandt, et al., 2001). Likewise a study by Markow and Lonning (1998) investigated whether concept-mapping activities can help first-year college chemistry students understand concepts included in the experiments they perform. The experimental group constructed pre- and post-lab concept maps, while the comparison group wrote essays on the concepts about the experiments. End of intervention achievement tests did not yield significance differences between the groups.

### ***Did treatment classes perform better in higher order thinking tests than comparison classes?***

Metacognitive instructional intervention could promote meaningful learning as better performances in higher order thinking tests are reported when GOs were employed to support instruction. For example, a study among high school biology students indicated that instructional interventions using concept maps yielded significantly higher performance on application-like items rather than on knowledge and comprehension types (Schmid & Telaro, 1990). Also, when 5$^{th}$ graders who were required to read and recall novel social studies content while receiving explicit instruction supported by GOs performed better on measures of transfer than those who received basal instruction without GOs (Griffin, Malone, & Kameenui, 1995).

The second question of this study was to see whether the intervention classes perform better in higher thinking tests. When we look at post-test performances of the Immediate test-groups of 5$^{th}$ graders from school-1, the mean post-test performance in Application and Transfer tests of the Comparison class are better than those of the Individual and Pair learning classes. Though we could see some contribution in overall post-test performance, there seems to be no apparent benefit of the intervention in helping the treatment classes to perform better than the Comparison one in higher order thinking tests. It seems that prior academic background outweighs the effect of the intervention.

In the case of the participants from school-2, the test-groups from the treatment classes performed better than the test-group from the Comparison class in Application and Transfer tests. In fact, the difference in mean Application scores of the test-groups from the Individual learning class (5.58, SD = 1.94) and the Comparison class (4.55, SD = 1.75) is significant at $p \leq 0.053$ (Tables 5 and 6). In this case, the intervention has some contribution in fostering students' ability to tackle higher level thinking problems.

Likewise, the performances of the Immediate test-groups of 6$^{th}$ graders of school-1 clearly indicate that the Individual learning class is benefited. The mean Application score of the test-group from the Individual learning class (8.35, SD = 3.14) is statistically significantly greater than that of the test-group from the Comparison class (7.00, SD = 2.43) at $p \leq 0.083$) (Tables 7 and 8). On the other hand, the intervention had no apparent effect on student performance in the Pair learning class. With regard to the Transfer tests, the treatment classes did not perform better than the Comparison class.

Now let us look at the performances of the Delayed test-groups of both grades from primary school-1. Since the mean Application and Transfer test scores of the test-groups of the treatment classes in grade 5 were either statistically comparable to or lower than the scores of the Comparison class, no contribution can be implied. The case with 6$^{th}$ graders shows that the mean Application and Transfer scores of the test-groups from the treatment and comparison classes were statistically comparable. In this case too, no apparent contribution is evident.

### *Did the intervention help the treatment classes to better retain learned content than comparison classes?*

An important objective of instruction is to enable students to retain what they have learned in the classroom. A study by Baxendell (2003) and his co-teacher revealed that 4$^{th}$ graders exposed to GOs demonstrated improvement in their content retention abilities.

One of the purposes of the present study was to investigate the contribution of metacognitive instructional intervention in promoting retention abilities of primary school students (10-14 years olds) when learning science. The effect of the intervention on retention was studied by comparing the difference in mean Total post-test scores of the Immediate and Delayed test-groups in each of the treatment classes in relation to the difference in mean Total post-test scores of the Immediate and Delayed test-groups of the Comparison class.

In grade 5 of school-1, it is evident that the Immediate test-group from Individual learning class benefited from the intervention. However, comparing the differences in mean Total post-test scores of the Immediate and Delayed test-groups of the three classes could not show that the treatment classes are benefited in terms of retention in any way. In grade 6, the difference in mean Total post-test scores of the Immediate (25.70, SD = 8.59) and Delayed (21.80, SD = 5.31) test-groups of Individual learning class, is statistically significant at $p \leq 0.087$ (Table 14). Data of the Immediate test-group showed that the Individual learning class was benefited by the intervention, which faded in the Delayed test-groups. Even though some studies showed that metacognitive instructional methods promote retention of learned concepts (e.g. Adey & Shayer, 1993; Georghiades, 2000, 2004), this study seems to have negative effect in relation to retention.

### *Was the instructional method more effective in pair learning setting?*

From the perspective of social constructivism a community of learners constructs meanings. Thus, instructional interventions or practices that promote group learning should result in better learning gains. Based on this premise, the study predicted that Pair learning classes will benefit more from the intervention than Individual learning classes.

Since long-term positive effect was not observed, comparisons on the effect of the learning setting (Individual or Pair) were made using post-test scores of the Immediate test-groups. In grade 5 of school-1, the method yielded some benefit among the Individual learning classes. In grade 6, the test-group from the Individual learning class performed better than the test group from the Pair learning class in Application and Transfer tests (Tables 7 and 8). Though no apparent difference in mean Total score was observed between the Individual and Pair learning classes of 5$^{th}$ graders of school-2, the first had significantly higher mean Application test score (5.58, SD = 1.94) than the Comparison group (4.55, SD = 1.75) at $p \leq 0.053$ (Tables 5 and 6). Thus, the pair cooperative learning setting did not produce results as predicted.

Non-participant observation revealed that the involvements of the students in the pair learning setting were not balanced. In the Individual learning class, all students usually made their own efforts to complete the metacognitive tasks and come up with some kind of product. In the case of the Pair learning classes, the proactive student of a given dyad completed the activities while the shy one usually remained passive. In support of this observation, the fifth grade teacher from school-1 wrote the following note in her reflection journal:

> In the Pair learning class, the students usually get off-task and do not carry out activities in dyads. The students in a dyad usually do their activities independently (Translation, 17/Dec/ 2004).

One could understand the problem of the teacher in charge to attend to each dyad and guide them to work cooperatively when there were 65 to 68 students in class. Arguably the unbalanced participation of the students in this learning setting might negatively affect their overall performances in post-tests.

In fact, all intervention studies on the effects of collaborative learning settings, using GOs or otherwise, do not yield consistent outcomes. One study which assessed the effectiveness of concept mapping and object manipulation as learning strategies among $6^{th}$ grade science students showed no significant differences between the scores of the individual and team concept mappers on immediate and delayed (32 days later) post-tests (Ritchie & Volkl, 2000). In another study where high school students were required to solve stoichiometric problems individually (comparison) and in groups (treatment) found no significant differences (Tingle & Good, 1990). Furthermore, an inquiry on the effects of group size (individuals, dyads and quads) on the learning of science process skills using microcomputers among $7^{th}$ and $8^{th}$ graders did not yield any statistically significant differences among their post-test scores (Berge, 1990).

On the other hand, a study on the effects of collaborative concept mapping strategies with Taiwanese primary school students ($5^{th}$ and $6^{th}$ graders) showed that better performance was evident among groups where the mapping task was restricted to one member (Chiu, 2004). Similarly, a study that assessed the contribution of a group mastery learning model as compared to an individual mastery model among $10^{th}$ graders when learning two biology topics (i.e. cells and plants) came up with two different findings. While the group mastery model group outperformed the individual mastery model group in end-of-intervention tests on cells, the reverse was true in a post-test on plants (Lazarowitz, Baird, Bowlden, & Hertz-Lazarowitz, 1996).

Another explanation for this pattern seems to be the prior school performance. When we consider the post-test performances of the treatment classes among $5^{th}$ graders in school-1 in relation to the prior academic performances, the class with lower mean PSP score benefited more from the intervention. An investigation on the effect of concept mapping on science achievement with middle school students reported better performance among lower ability students than higher ability ones (Snead & Snead, 2004). Likewise, research on the effect of using concept maps as study tools on achievement in chemistry among 10th graders showed that low achievers performed better (BouJaoude & Attiech, 2003). Previously, Schmid and Telaro (1990), in a study with high school students, came up with similar findings. Moreover, a review of studies conducted between 1990 and 2002 that dealt with the contribution of GOs showed that GOs benefit students with low verbal ability or low prior knowledge more than students with high verbal abilities or high prior knowledge (O'Donnell, Dansereau, & Hall, 2002). The fact that the students in the Individual learning class had lower prior academic performance, thus benefited more, could partly be a confounding factor when investigating the effects of learning setting.

### *Did the intervention produce similar positive outcomes in both grades?*

One important point to highlight here is that the metacognitive intervention could be employed with primary school students and produce encouraging outcomes. Non-participant observation, teachers' reflections, and student work indicated that the method is workable and productive under populous, poorly enriched primary schools' classrooms.

The outcomes of the intervention seem to be quite consistent in both grades, though not all as predicted. The contribution of the metacognitive intervention was more apparent among the Immediate test-groups of the Individual learning class. Better learning gains (in terms of overall performance scores) and better achievement in higher order thinking (in terms of Application and Transfer test scores) were observed among the Individual learning classes. On the other hand, the intervention did not yield any benefit in terms retention ability. Moreover, the pair learning setting could not yield the predicted outcome. There appeared to be some confounding factors that hinder the benefits of pair learning.

#### ***What did the qualitative data show?***

Study of qualitative data depicts that the intervention promoted better conceptual learning and fostered student involvement.

#### *Better student conceptual learning*

Various studies incorporating GOs resulted in positive outcomes across levels and subject areas. Besides increased post-intervention performance, GOs further student ability to summarize concepts and understand their interrelationships. In the present study, samples of GOs produced by students revealed students understanding of hierarchical relationships of concepts. Students became capable of organizing their understandings by including the important concepts. Studies among students around the age of 10-15 years reported findings that support our observations. Baxendell (2003) has reported that instructional intervention using concept mapping promoted fourth graders' organizational skills. In our case, the inclusiveness and clarity of GOs developed by the students increased along the course of the intervention. After repeated practice, students in both grades were able to identify appropriate GOs for a given topic almost automatically and summarize the topics with considerable ease. In support of this assertion the 5$^{th}$ grade teacher from school-1 stated that:

> The students are capable of summarizing topics using concept mapping, compare/ contrast matrix and chain-of-events techniques. On the other hand, since not much of the contents are suitable to be summarized using cyclic representations, not many students are using it (11 Dec 2004, Translation).

GOs that depict the progress of students' knowledge and creativity are provided. Examples of concept maps developed by 5th graders during the third and fourth weeks of the intervention are given in Figures 1 and 2. In Figure 1, we see the important concepts indicated, but each is not placed in its proper hierarchy. The linking phrases: 'compounds in it' and 'diseases caused by it' are included in boxes and the latter one is misplaced. In Figure 4, each of the concepts is placed in its proper hierarchy. However, the concept map lacks linking words or prepositions between the upper and subordinate concepts. While the left-handedness of the language of instruction (where the verb comes at the end of a sentence) could make the construction of concept maps somewhat difficult, those developed toward the middle and end of the intervention are more complete, where concepts are placed in more appropriate hierarchical positions linked by appropriate prepositions or words (e.g. Figures 3–4).

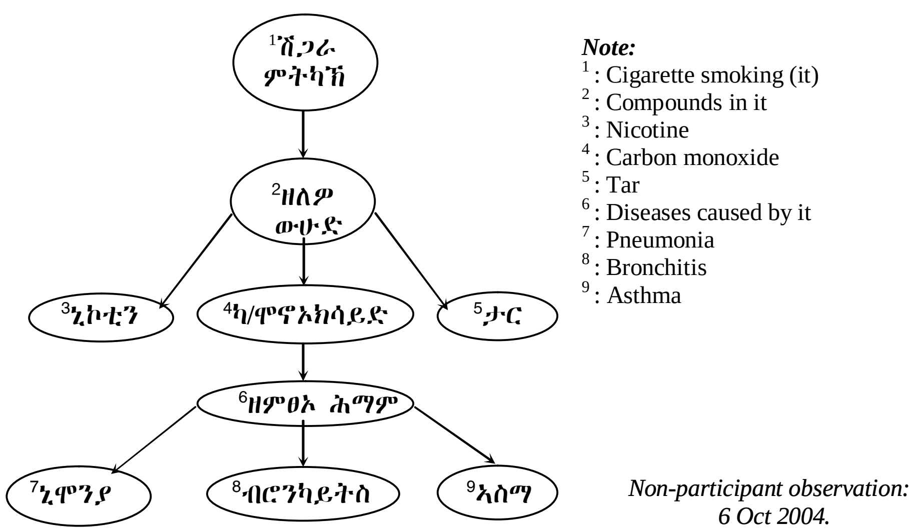
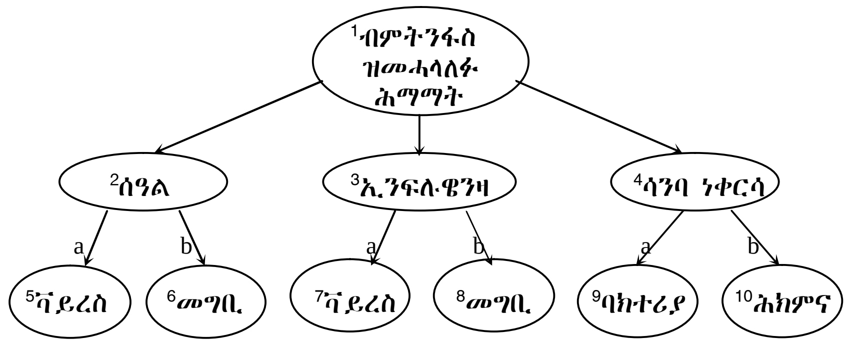
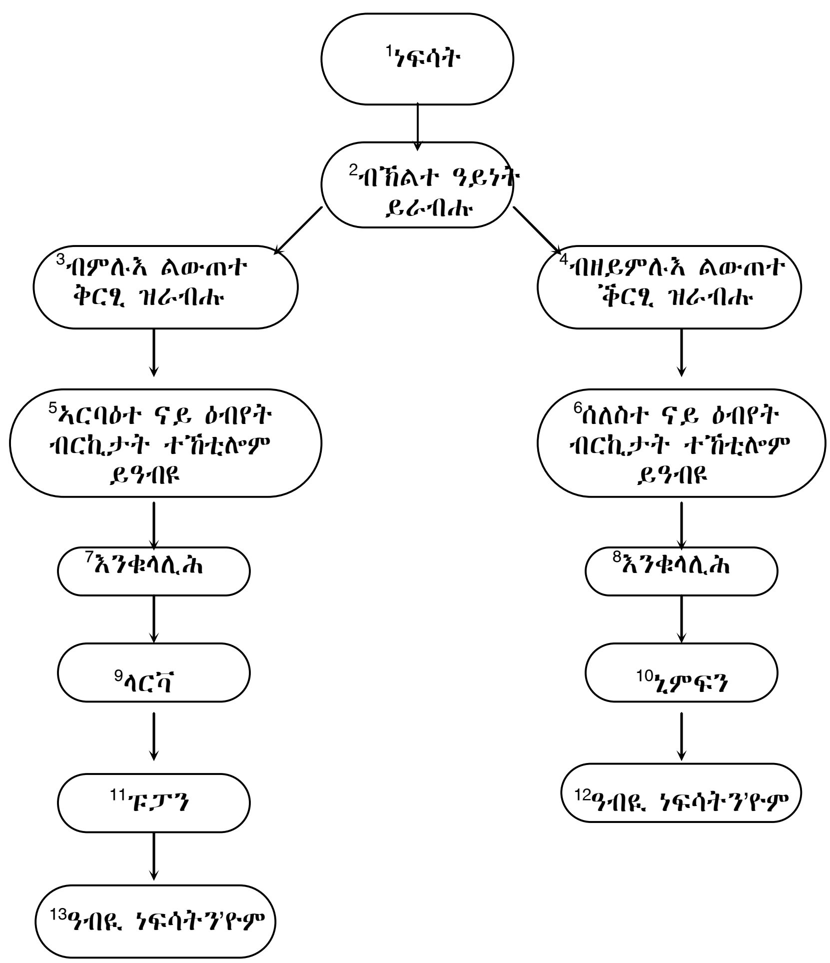



Figure 1. Concept map drawn by 11-year old boy from Individual learning class of school-1 during the 3rd week of the intervention




***Note:*** [1]: Airborne diseases; [2]: Common cold; [3]: Influenza; [4]: Tuberculosis; [5]: Virus; [6]: Proper diet; [7]: Virus; [8]: Proper diet; [9]: Bacteria; [10]: Treatment. Note that linking words or prepositions at 'a' and 'b' are missing. *Non-participant observation: 12 Oct 2004.*

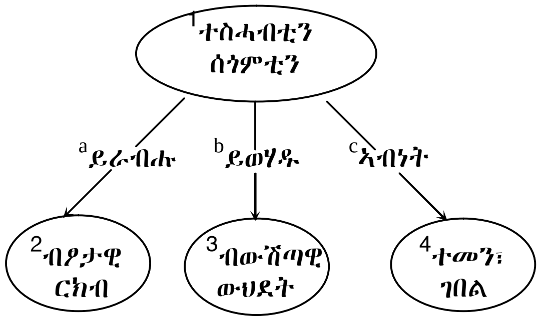
Figure 2. Concept map drawn by 11-year old boy from Individual learning class of school-1 during the 4th week of the intervention




***Note:***
[1] Insects
[2] Reproduce by two methods
[3] Those reproduce by complete metamorphosis
[4] Those reproduce by incomplete metamorphosis
[5] Develop following four stages
[6] Develop following three stages
[7] Egg
[8] Egg
[9] Larva
[10] and Nymph
[11] and Pupa
[12] Adults
[13] Adults

*From student assignment*

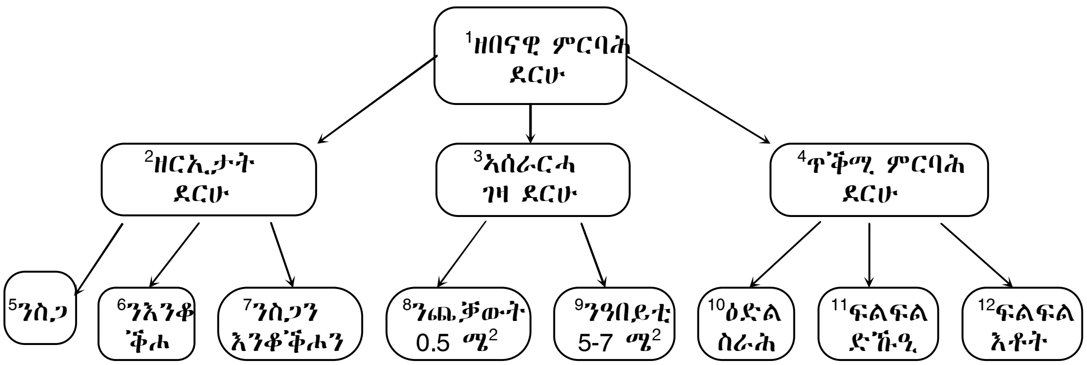
Figure 3. Concept map drawn by 11 and 13 year old girls from Pair learning class of school-1 during the 7th week of intervention




***Note:***
1: Reptiles
2: by Sexual means
3: by Internal means
4: Snake, python
a: reproduce
b: fertilize
c: examples

*Non-participant observation: 13 Dec 2004*

Figure 4. Concept map drawn by 12-year old girl from Pair learning class from school-1 during the 13th week of the intervention




***Note:*** 1: Poultry; 2: Traits of hens; 3: Poultry house; 4: Benefits; 5: for Meat; 6: for Eggs; 7: for Meat and egg; 8: for Young, 0.5 $m^2$; 9: for Adults, 5-7 $m^2$; 10: Job creation; 11: Source of manure; 12: Source of income; *Non-participant observation: 20 Dec 2004.*

Figure 5. Concept map drawn by 12-year old girl from Individual learning class of school-1 during the 14th week of the intervention

Moreover, examples of compare/contrast matrices and sequential representations are given. Compare/contrast matrices drawn by students to summarize the locations, hormonal secretions, functions and problems associated with under or over secretions of six human endocrine glands, as shown in Figure 6, were impressive. The figure shows compare/contrast templates drawn by three students for summarizing the main points of the endocrine glands. In all cases, the important comparing characteristics are included. But it is evident that the best sequence of the comparing characteristics is shown in Figure 6(c). Matrices to compare and contrast the parts of the brain and the members of a community of honeybees were also remarkable. Students were also able to include: the transmission of a nerve impulse, procedure of preparation of fish culture, and reproduction of frogs and reptiles in a series of events/process chains. The sequence of events by which frogs reproduce and develop is given in Figure 7, as drawn by two 12-year old boys.

| ረቛሒ<br>Comparing Variable | ተግባራት<br>Functions | ዝፍልፍሉዎም ሆርሞናት<br>Hormones they secrete | ዝርከቡሉ ቦታ<br>Locations | ዘስዕቡዎም ፀገማት<br>Problems |
|---|---|---|---|---|
| 1. ፒዩቲታሪ Pituitary | | | | |
| 2. | | | | |

(a) Template drawn by 11 year old girl

| ኢንዶክሪን ዕኪታት<br>Endocrine glands | ተግባራት<br>Functions | ዝርከቡሉ ቦታ<br>Locations | ዝፍልፍሉዎም ሆርሞናት<br>Hormones they secrete | ፀገማት<br>Problems |
|---|---|---|---|---|
| 1. ፒዩቲታሪ Pituitary | | | | |
| 2. | | | | |

(b) Template drawn by 11 year old boy

| ኢንዶክሪን ዕኪታት<br>Endocrine glands | ኣበይ ይርከቡ<br>Locations | ዝፍልፍሉዎም ሆርሞናት<br>Hormones they secrete | ተግባራት<br>Functions | ፀገማት<br>Problems |
|---|---|---|---|---|
| 1. ፒዩቲታሪ Pituitary | | | | |
| 2. | | | | |

(c) Template drawn by 11 year old boy

*Non-participant observation: 27 Oct 2004*

Figure 6. Compare and contrast templates drawn by three students from Individual learning class of school-1

ቈንቍራዕ።
Frog.

እቲ ተባዕታይ ነታ ኣንስተይቲ ይፀቕጣ።
The male presses down the female.

እታ ኣንስተይቲ ኣብ ማይ እንቋቑሖ ተውድቕ።
The female releases eggs into water.

ካብኡ ተባዕታይ ዘርኢ ይሰድድ።
Then, the male discharges sperms into the eggs.

እታ እንቋቑሖ ናብ ንእሽቶይ ትንኩልብ ትቕየር።
Egg hatches into tadpole.

ናብ ንእሽቶይ ቈንቍራዕ ትቕየር።
[Tadpole] grows into small frog.

*Non-participant observation: 7 Dec 2004*

Figure 7. Sequential representation of frog reproduction as drawn by two 12-year old boys from Pair learning class in school-1

Examination of student work showed that the advance of skills of producing GOs among 6th graders was more or less similar to that of 5th graders. Since many of the topics of grade six toward the beginning of the intervention were suitable to be summarized using compare/contrast matrices, students were using this method commonly and successfully. For example, a template usually used by the students for comparing or contrasting two or more diseases is given in Figure 8. It provides students with the opportunity to summarize and compare the salient features of the various diseases indicated in their lessons. The students were also able to summarize the characteristics of the three states of matter as gases, liquids, and solids, using the compare/contrast matrix.

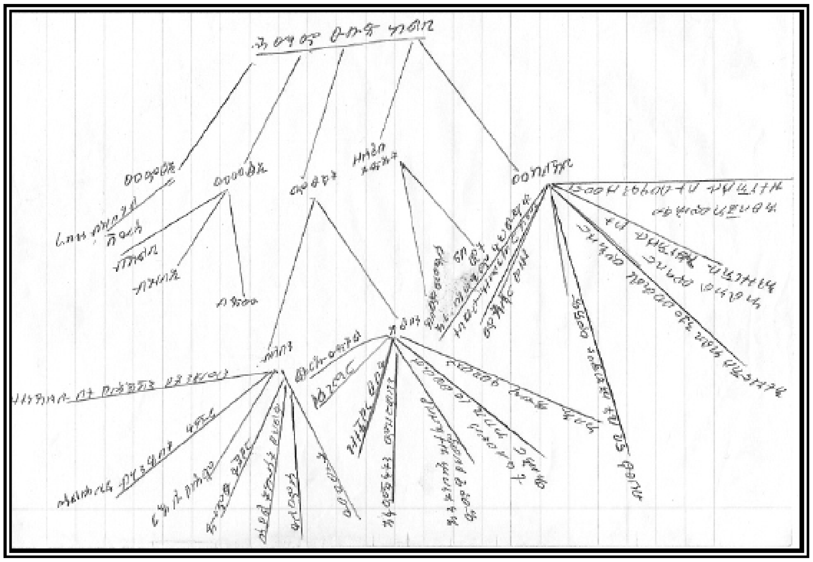
| ረቛሒ Comparing Features | ሕማም 1 Disease 1 | ሕማም 2 Disease 2 | ሕማም 3 Disease 3 | |
|---|---|---|---|---|
| መምፅኢ Causative agent | | | | |
| መመሓላለፊ Mode of transmission | | | | |
| ምልክት Symptoms | | | | |
| ሳዕቤን Effects | | | | |
| መከላኸሊ Prevention | | | | |

Figure 8. Compare/contrast template usually used by 6th graders from school-1 to compare different diseases

Along the course of the intervention, 6th graders were also able to produce notably impressive concept maps (refer to Figures 9 and 10). In line with this observation, the 6th grade teacher noted:

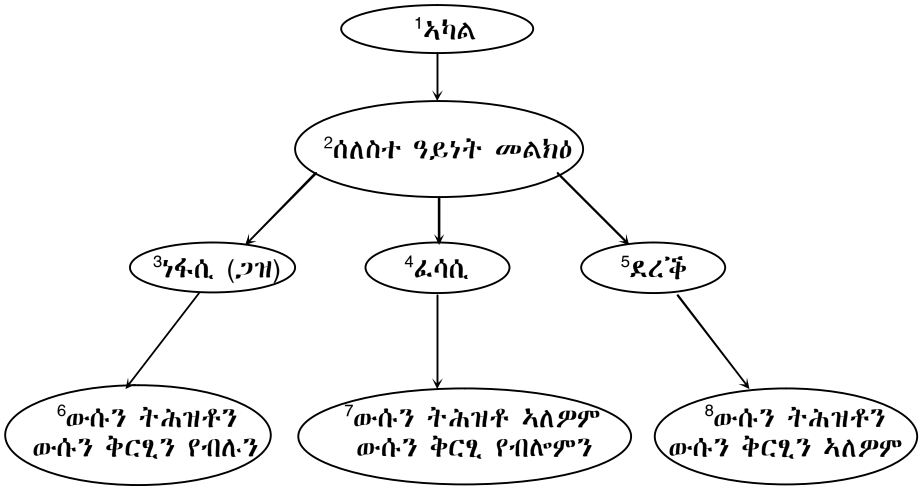
> Students read their texts well and summarize topics easily using GOs. They are doing especially well when they use compare/contrast matrix and concept maps. They are also doing relatively well using cyclic representation (17 Dec 2004, Translation).

Zele, Lenaerts and Wieme (2004) reached a similar conclusion by saying '… once students get acquainted with this [concept mapping] metacognitive learning tool, they can readily use it to structure any amount of information, enabling them to put large structures of knowledge into perspective' (p. 1061).



*Note:* The concept map in this Figure refers to rabies. It includes concepts: 'pathogen', 'vector', 'symptoms', 'effects' and 'prevention' of rabies. 'Pathogen' links to 'virus' and 'vector' links to 'dog', 'hyena' and 'cat'. The concept 'symptom' links to: 'in humans' and 'in dogs', where seven symptoms are listed under each carrier. 'Effect' links to 'death' and 'paralysis'; and 'prevention' links to six means of preventing and treating of rabies.

Figure 9. Concept map drawn by 14-year old girl from Individual learning class of school-1 during the 9th week of the intervention




*Note*: 1: Matter; 2: Has three states; 3: Gases; 4: Liquids; 5: Solids; 6: Has no definite volume and definite shape; 7: Have definite volume but not definite shape; 8: Have definite volume and definite shape.

Figure 10. Concept map drawn by two 12 year old girls from Individual learning class of school-1 during the 10th week of the intervention

On the other hand, there are also studies that report the inability of students to understand the interrelationships among concepts in interventions employing concept mapping. A study by Lin and Hu (2003) with 7th graders (13 year olds) revealed that a majority of the students had difficulties understanding the interrelationships among the various concepts in relation to energy flow and material cycling. In our case, some students had difficulties summarizing topics using GOs. The 6th grade teacher's reflection supports this assertion. He stated that:

> Few students still have difficulties to understand and master the use of GOs (17 Dec 2004, Translation).

A note by the 5th grade teacher indicates a more or less similar observation.

*Better student participation*

Another importance of the metacognitive intervention method is its role in encouraging student involvement during the instructional process. In typical Ethiopian upper primary classrooms, instructional activities are teacher-centered, leaving students to remain passive. The current education policy of Ethiopia promotes student-centeredness across all level of education (MoE, 1994a, 1994b). Therefore, instructional interventions that promote students' active involvement in their own learning are highly welcomed by all stakeholders. In this case, the participating teachers stated that:

> The instructional method is suitable because it is student-centered. … it helps students to grasp the ideas of a topic succinctly and understand them clearly and effortlessly (5th grade teacher, 11 Dec 2004, Translation).

> At the beginning, I [the teacher] had difficulties of teaching using the metacognitive method. Since the method supports the instructional process by promoting the involvements of the students, the ideas that come from the students were helpful to me. … the method is preferable because it is student-centered (6th grade teacher, 17 Dec 2004, Translation).

Where schools lack facilities to allow student hands-on activities, an instructional intervention like ours is important to complement hands-on activities by mind-on ones. Also, for teachers with limited and sometime no repertoire of instructional skills that foster student active participation, this method is an important asset.

### Implications for classroom practice and research

It is evident that the metacognitive instructional intervention could be employed under the Ethiopian primary school settings with populous classrooms, thus potentially yielding encouraging results. Moreover, it promotes student conceptual understanding and active participation as well as serving as an alternative teaching repertoire for the teachers. Thus, the instructional method can be introduced as a learner-centered alternative to the schools. Nonetheless, caution must be taken when employing it with cooperative learning. Teachers must ensure that students in cooperative learning settings are equally engaged and carry out the instructional activities as required.

It would be legitimate to recommend that further studies on the effectiveness of this method begin with groups of students who have comparative abilities or academic performances. The relatively higher prior school performances of comparison groups might confound the effect of the intervention. The prediction that the intervention will work better with pair learning settings could not be supported. A second prediction on the contribution of the intervention on retention ability of the students also could not be supported. This needs to be investigated further by addressing the limitations.

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# ARTICLE 2

## METACOGNITIVE REFLECTION

## IN LEARNING PRIMARY SCHOOL SCIENCE

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## ABSTRACT

SBHATU, DESTA BERHE. **Metacognitive Reflection in Learning Primary School Science.** (Under the Direction of Professor John E. Penick.)

*This study investigated the effectiveness of a metacognitive reflection model in learning science among primary school students (age 10-14 years) in Mekelle, Ethiopia. Three classes of grade 5 and three classes of grade 6 participated. Students in each grade were assigned into two treatment classes (Individual or Pair learning) or a Comparison class. Instruction in the treatment classes was supported by student metacognitive reflection while the Comparison classes were taught through traditional methods. Whereas the students in Individual learning classes were making metacognitive reflections individually, those in Pair learning were doing the same in dyads. Non-participant observation notes and student reflections constituted qualitative data. Prior school performance and post-test scores of Immediate and Delayed test-groups comprised quantitative data. Quantitative data analyses of scores of the Immediate test-groups showed that the intervention helped students in treatment classes perform better in higher order thinking and overall tests than those in comparison classes. The contribution of the intervention diminished among the Delayed test-groups. Qualitative data revealed that the metacognitive reflection activities advanced students' participation in stating and explaining their beliefs and understandings about science topics, thus fostering conceptual change learning. The report provides implications for classroom practice and research.*

### Conceptual change learning

Conceptual change is the basic tenet of constructivist learning theory in science education. Pioneer models of conceptual change learning include Piaget's 'assimilation–accommodation' and Posner and co-workers' 'dissatisfaction–intelligibility–plausibility–fruitfulness', both based on epistemologies of learners (Liu, 2004). According to the model of Posner and co-workers (Posner, Strike, Hewson, & Gertzog, 1982; Strike & Posner, 1985), conceptual change learning occurs when learners become dissatisfied with their pre-instructional alternative conceptions, while accommodating new ones that are intelligible, plausible and/or fruitful (Duit, 1999).

Later works, however, argue that conceptual change learning must involve multiple dimensions. For example, Qian and Alvermann (2000) explained that conceptual change learning in science involves cognitive processes as well as personal and social processes. Tyson, Venville, Harrison, and Treagust (1997) contend that conceptual change learning takes place in three-dimensional space and includes epistemological, ontological, and social/affective domains. In a later review, Harrison and Treagust (2001) indicated that conceptual change learning is explained from at least five theoretical perspectives, namely: epistemology, ontology, motivation/social, development, and explanatory coherence. For the purpose of showing how metacognition can be incorporated in an instructional approach that promotes conceptual change, it would be helpful to show how the first three theoretical perspectives affect conceptual change learning.

Conceptual change learning models based on learners' epistemologies require teachers to design instructional approaches that make learners' pre-instructional alternative conceptions explicit and introduce scientific conceptions that will explain the anomaly to promote dissatisfaction of the former and accommodation of the latter. Planning a lesson for conceptual change learning requires teachers to know students' pre-instructional alternative frameworks, the science conceptions to be taught, and the differences between them (Asoko, 2002; Duit & Treagust, 2003; Georghiades, 2000; Nussbaum & Novick, 1982). The role of the learners in deciding the status of their own pre-instructional alternative conceptions for making conceptual change is essential (Duit & Treagust, 2003). Hence, instructional approaches that require students to reflect on the status of their own alternative conceptions and the scientific ones (i.e. to be metacognitive) and make decisions for conceptual change are helpful (Beeth, 1998; Beeth & Hewson, 1999; Blank 2000; Lawson, 2001; Davis & Linn, 2000; Macbeth, 2000; Schwartz, Lederman, & Crawford, 2004; von Secker & Lissitz, 1999; Weaver, 1998; Yuruk, Ozdemir, & Beeth, 2003). Metacognitive teaching methods are important instructional approaches because they facilitate conceptual understanding and remediation of misconceptions (Novak, 2002).

The ontological dimension of conceptual change learning addresses the way learners perceive the nature of the thing being studied. It considers how learners view the outside world (Tyson, Venville, Harrison, & Treagust, 1997). The epistemological dimension shows us that students usually hold frameworks that do not match with scientific ones. Likewise, the ontological dimension shows us that students usually assign concepts to an ontological category to which they do not belong, such as assigning 'earth' to the ontological category of physical object rather than the astronomical one (Vosniadou, 1999), assigning 'heat' to the ontological category of matter rather than process (Chi, Slotta, & de Leeuw, 1994), and, classifying 'light, heat, and electric current' according to material ontology (Slotta, Chi, & Joram, 1995). The re-assignment of concepts to the correct ontological category is known to be difficult in some cases. According to Vosniadou (1999), 'initial conceptual structures are supported by a system of interrelated observations, beliefs, and presuppositions that form a relatively coherent and systematic explanatory system, which works relatively well in the everyday world and is rather difficult to change' (p. 8). Harrison and Treagust (2001) contended that this problem can be overcome in school science and provided evidence from a case study that supports their contention. Instructional approaches that focus on helping students ***be aware*** of the ontological category to which they assign their conceptions are recommended (Yuruk, Ozdemir, & Beeth, 2003), where metacognition plays a key role in promoting awareness.

Students' motivational beliefs about themselves as learners, the process of learning, and the social dynamics of the classroom can facilitate or hinder conceptual change learning (Pintrich, 1999; Tyson, Venville, Harrison & Treagust, 1997). Engaging students' interests, attitudes, and beliefs, and stimulating them to reflect on their own and colleagues' ideas and beliefs facilitate conceptual change learning (Mason & Boscolo, 2000). Pintrich (1999) provided five propositions on motivational factors of learning that affect conceptual change. The propositions are indicated as follows: (1) Adoption of a mastery goal orientation should facilitate conceptual change, (2) Adoption of more 'constructivist' epistemological beliefs should facilitate conceptual change, (3) Embracing higher levels of personal importance, value and interest should facilitate conceptual change, (4) Adoption of higher levels of self-efficacy for learning should facilitate conceptual change, and (5) Adoption of a belief in personal control of learning should facilitate conceptual change (pp. 35–44). The fifth proposition is clearly metacognitive. Social dimensions, such as collaborative learning and student-student interaction linked with motivational beliefs, are also important for conceptual change learning (Beeth & Hewson, 1999; Krasmarski & Mevarech, 2003; Lonning, 1993; Okebukola & Ogunniyi, 1994; Tyson, Venville, Harrison, & Treagust, 1997).

### Incorporating metacognitive reflection strategy

As indicated previously, teaching for effective conceptual learning requires teachers to: (a) make learners' alternative conceptions explicit, (b) show that such conceptions do not fit accepted science understandings (create dissatisfaction) and (c) present the scientific conceptions while explaining how they differ from the students' alternative conceptions (Asoko, 2002; Duit and Treagust, 2003; Georghiades, 2000; Nussbaum and Novick, 1982). Instructional models for conceptual change learning in science such as Sequence Based on the Generative Learning Model, Interactive Approach, and Science Lesson Sequence in Japanese Classrooms provide students the opportunity to: make their understandings explicit, reflect on these understandings (and test when necessary), and reach consensus (Tytler, 2002).

An instructional model proposed by Ridgeway and Dunston (2000) has four components, namely: elicitation of students' preconceptions, induction of conceptual dissonance, interaction to refine conceptions and resolve conflict, and reformulation, amendment, and extension of new concepts. These models not only consider students' prior conceptions but also ensure the awareness and active involvements of the learners.

Instructional strategies for conceptual change learning based on the 'dissatisfaction–intelligibility–plausibility–fruitfulness' model, usually make use of *cognitive conflict* and/or *learners' existing ideas* (Georghiades, 2000) in order to replace learners' pre-instructional alternative conceptions. Nonetheless, this approach does not completely extinguish students' pre-conceptions (Duit & Treagust, 2003) and findings about its effectiveness are argued to be inconclusive (Zohar & Aharon-Kravetsky, 2005). Moreover, it is doubtful whether every lesson can be supported by cognitive conflict and whether every pre-instructional conception needs to be replaced. This is because some of the pre-instructional conceptions may simply be enriched. Analogical reasoning (Lawson, 1993) has also been reported as a suitable instructional strategy promoting conceptual change learning. Nonetheless, it would be practically difficult, as Clement (1993) argues, to generate analogies for every science topic. Another strategy suggested for promoting conceptual change learning is the use of conceptual change texts, which are designed for remediation of misconception. In this case, students are asked to predict explicitly what would happen in a situation before being exposed to information (and explanations) inconsistent with their preconceptions (Sungar, Tekkaya, & Geban, 2001).

But, this method would arguably have limitations if employed across levels as it considers only the common misconceptions already identified but not all the misconceptions learners could have. Moreover, teachers or textbook writers usually identify the misconceptions, which is not an effective way to address all possible student preconceptions. After all, it would be difficult to prepare conceptual change textbooks for every student in every science curriculum.

An instructional strategy proposed by Tsai (2000), called conflict maps, employs discrepant events and resolves conflicts between students' alternative conceptions and scientific ones using critical events and relevant perceptions and conceptions. This approach is somewhat difficult for teachers with limited expertise as would be true in primary schools. These studies indicate that, as Asoko (2002) states, there are limitations in translating knowledge about learning into more effective instructional strategies.

Even though the assumptions of conceptual change learning call for metacognitive strategies and some researchers state that metacognition mediates conceptual change learning (e.g., Duit, 1999; Georghiades, 2000; Novak, 2002), much work is yet to be done. The present study focused on conceptual learning of primary school science from the perspective of students' epistemologies. Specifically, it dealt with the role of metacognitive instruction in facilitating conceptual learning. The metacognitive instructional approach was designed to help students reflect on their pre-instructional and scientific conceptions in such a way that they can assimilate and/or accommodate the scientific frameworks. This approach is intended to help students reflect on their pre-instructional conceptions and the concepts presented to them by the teacher or from their readings so that they will easily acquire the scientific ones. Students' pre-instructional conceptions would serve: (a) to create dissatisfaction for conceptual change or restructuring, or (b) as prerequisite knowledge for acquiring new scientific conception through assimilation and/or accommodation.

For this purpose, we developed an instructional model called Metacognitive Reflection for Conceptual Change Learning (Figure 11) based on Posner and co-workers' dissatisfaction–intelligibility–plausibility–fruitfulness' model (Posner, Strike, Hewson, & Gertzog, 1982; Strike & Posner, 1985) and Piaget's Cognitive Development model.

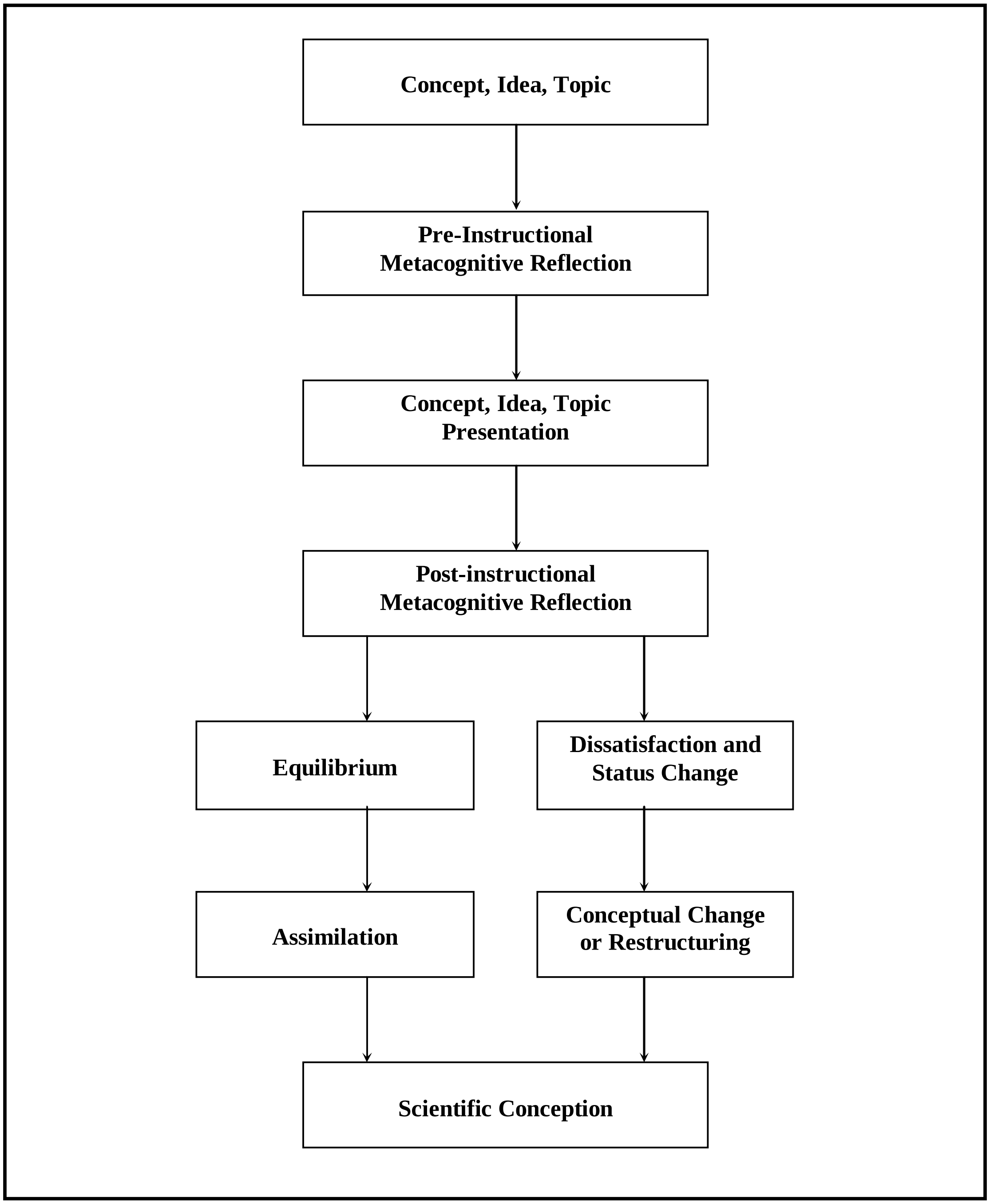


Figure 11. Metacognitive Reflection for Conceptual Change Learning Model

The strategy requires students to provide reflections about the status of pre-and post-instructional conceptions about science topics. When metacognitive reflection reveals that the pre-instructional conceptions are pre-requisite knowledge, it is apparent that those new conceptions will simply be added to or integrated with the old ones (assimilation). Such additions of new conceptions can result in or be avenues for conceptual [change] learning. On the other hand, when metacognitive reflection on pre-instructional conceptions leads to disequilibrium (or dissatisfaction), the pre-conceptions are changed in response to the new conceptions (accommodation or conceptual change/restructuring). These imply that when pre-instructional conceptions are different from the post-instructional conceptions, metacognitive reflections will help learners become conscious about the prevailing state of disequilibrium (e.g. Lawson, 2001). This awareness about the state of disequilibrium will enable students to easily modify or change their old understandings and create new scientific conceptions by accommodating some or all of the contents given during instruction. Restructuring of the prior conceptions without completely abandoning them is also a possibility.

### The need for the present study

Metacognitive instructional methods are increasingly recognized as important components to successful learning. Emphasizing the importance of metacognition in educational practice, Jacobson (1998) writes:

> Metacognition or knowing the process by which one learns is then vital to the renovation of the current educational system. If we do not recognize what the students know, what they believe that they know, or more important yet, what they do not know, efforts to improve education will be futile (p. 583).

Based on this strong argument, the present study attempted to: (a) provide supplements for global science education research and practice in metacognition and (b) complement the deficiencies in science instruction in Ethiopia's primary schools.

It is strongly argued that an active involvement of students in their own learning for conceptual change would be achieved by including a metacognitive dimension (Lehtelä, 2001), because it fosters an interactive instructional atmosphere (Duit, 1999). Various studies that incorporated metacognitive instructional approaches in science education supported this assertion (e.g. Adey & Shayer, 1993; Georghiades, 2004; Neto & Valente, 1999; Osman & Hannafin, 1994; White & Frederiksen, 1998). In fact, the active involvement (both physically and mentally) of learners in their own learning is congruent with the basic tenet of inquiry science instruction in the US (NRC, 1996). This shows that metacognitive instructional approaches are usually geared to support both inquiry and conceptual change learning. Hence, from theoretical and practical perspectives of science education, it is argued that appropriate metacognitive instructional intervention can yield learning gains in any school setting and complement the lack of hands-on activities by fostering more minds-on activities.

In addition to its contribution to global science education theory and practice, the study was expected to support the efforts of primary science instruction in Ethiopia. The fundamental issue in the current Education and Training Policy of Ethiopia is to shift the instructional practice from teacher-centered to learner-centered (MoE, 1994a, 1994b, 2002). Despite strong desire and various efforts to promote learner-centered instruction, the poorly enriched and populous Ethiopian primary school classrooms as combined with well-established teacher-centered instructional methods critically limit children's learning science by themselves. This requires us to seek alternatives that complement these deficiencies. In this case then, appropriate metacognitive instruction was predicted to be an efficient approach to ensure learner-centeredness in science teaching under Ethiopia's primary school settings.

## Purposes of the study

The present study investigated the effects of a Metacognitive Reflection for Conceptual Learning Model in learning primary science (grades 5 and 6, aged 10-14 years) under large class size and resources-limited Ethiopian school classrooms. Moreover, it looked at the effectiveness of the metacognitive method under individual and pair cooperative learning settings. Thus, the study addressed the following questions.

(1) As compared to more traditional instruction, did the intervention yield better overall learning gains among students of Ethiopia's large class-size primary schools (grade 5 and 6)?

(2) Did the treatment classes perform better on higher order thinking tests than did the comparison classes?

(3) Did the intervention help students in the treatment classes to better retain learned content than those in comparison classes?

(4) Was the instructional method more effective in pair learning setting as compared to individual learning setting?

(5) Did the intervention produce similar positive outcomes in both grades?

## Methodology

The study was conducted in a complete primary school (school-4), located in Mekelle (Ethiopia), which enrolled over 2600 students. The intervention began with two General

Science teachers (a 5$^{th}$ grade teacher and a 6$^{th}$ grade one) and 395 (211 boys and 184 girls) students from three classes of grade 5 and three classes of grade 6.

#### ***Participating teachers***

The fifth grade teacher was a 45-year old male with 21 years teaching experience in primary schools. He is certified to teach science subjects in grades 5 through 8. He had been teaching General Science and Biology at this level for the last 13 years. He had a total teaching load of 30 periods (40 minutes each) per week throughout the intervention period. He was teaching General Science to three classes of grade 5 and Biology to six classes of grade 7.

The sixth grade teacher was a 44-year old female with a total teaching service of 20 years. According to the current Education and Training Policy of Ethiopia, her qualification allows her to teach in grades 1 to 4. Nonetheless, she had been teaching primary school science, namely: General Science, Biology and Chemistry in grades 5 through 8 for the last 13 years. She had a total teaching load of 30 periods per week during the intervention period. She was teaching General Science and Aesthetics to five classes of 6$^{th}$ graders.

#### ***Pre-intervention training on metacognitive methods***

The principal objective of pre-intervention training was to enable the participating teachers to employ the metacognitive instructional methods. Both teachers participated in the pre-intervention training and preparations of annual course and daily lesson plans of the contents covered in the study. (Details about the pre-intervention training are indicated in the methodology section.) At the end of the pre-intervention training, these teachers were assigned to teach using the Metacognitive Reflection for Conceptual Change Model. Then, they were provided with guidelines for incorporating the Metacognitive Reflection method in their instructional practices. They were also briefed on how to record students' reflections when they employed the instructional method.

### *Participating students*

The majority of the students came from low to medium income, inner-town neighborhoods. There were six classes of grade 5 and five classes of grade 6 in the school. Three classes were selected from each grade for the study. Then, the classes were arbitrarily assigned to: (a) Individual learning class, (b) Pair learning class, or (c) Comparison class**.** The students in each of the treatment classes were given 40-minute training through lecture and guided practice on the use of Metacognitive Reflection as a method of learning science. Students were instructed to: (1) reflect on their ideas, understandings and beliefs about a lesson topic before they are taught about it, (2) reflect on their understandings about a lesson topic after they are taught about it, and (3) state their pre-instructional understandings and beliefs with post-instructional ideas and concepts, and maintain the acceptable ones. At the end of the training, the students were provided with a guideline for metacognitive reflection (indicated in Table 15). They were instructed to study the guideline so that they could use it automatically.

Table 15. Regulatory checklist for using metacognitive reflection for conceptual learning

| ***Lesson Topic:*** |
|---|
| **Prior Knowledge**<br>• What do I know about this topic/ idea/ concept?<br>• What understanding do I have about the topic/ idea/ concept?<br>• Can I tell my understanding to my friend? My teacher?<br>• Is my prior understanding intelligible? Plausible? Fruitful? |
| **Topic/ Ideas/ Concepts Presentation**<br>• Is there any difference between my prior understanding and what is presented now?<br>• What are the differences? Can I tell it to my friend? My teacher?<br>• Are the ideas / concepts presented intelligible? Plausible? Fruitful? |
| **Assimilation–Accommodation/ Conceptual Change/Restructuring**<br>• How can I reconcile my prior understanding and what I learned now?<br>• Which of my prior ideas/concepts should I maintain?<br>• Which ones should I correct? And which ones should I abandon? |
| **Output: Scientific Conception**<br>• What understandings do I have now? Can explain it to my friend? To my Teacher? |

### *Contents covered during the intervention*

Details about the preparation of the annual course plans and daily lesson plans, as well as the descriptions of the contents covered during the study, are indicated the methodology section. Three units, i.e. (a) Human Breathing System, (b) Human Nervous and Endocrine Systems, and (c) Animal Reproduction were covered in grade 5. Likewise, four units, namely: (a) Our Environment, (b) Human Diseases, (c) Physical Properties of Matter, and (d) Refraction were covered in grade 6.

### *Incorporating the metacognitive method*

The major activities in the lesson plans with respect to the actual instruction were: (a) Introduction, (b) Presentation, (c) Stabilization, and (d) Evaluation. The metacognitive reflection activities were integrated to support one or more of these instructional stages. Thus, they were incorporated in the Introduction and Stabilization part of the lessons. In the Introduction part of a given lesson, the students were invited to reflect on their ideas, understandings and beliefs about the lesson topic. After the teacher taught the lesson using any appropriate method of her/his choice (Presentation), the students in the treatment classes were asked to compare their pre-instructional understandings and beliefs with post-instructional ideas and concepts covered in the lesson and provide their reflections by stating the scientific conceptions (Stabilization).

Teachers play a vital role in guiding students to make them aware of the differences between their prior conceptions and the scientific ones (Hynd, Holschuh, & Nist, 2000; Maria, 2000). Students in Individual learning classes were required to make these reflections individually, while those in the Pair learning class were required to state their reflections in pairs. Students in the Comparison classes were not required to make such reflections. That is, no modification of the lesson plan was made for students in the Comparison classes. Lastly, the teacher finished the lesson by providing evaluation questions (Evaluation). The modified lesson activities are indicated in Table 16 below.

Table 16. Lesson activities incorporating metacognitive reflection

| **Activities** | **Treatment Classes** | **Comparison Class** |
|---|---|---|
| Introduction | Students reflect on their pre-instructional understandings, ideas, and beliefs. | Teacher introduces lesson |
| Presentation | Teacher teaches lesson | Teacher teaches lesson |
| Stabilization | Students reflect on their understandings of the contents taught, compare their pre-instructional understandings and beliefs with the ideas and concepts presented, and state the scientific ones. | Teacher gives lesson summary |
| Evaluation | Teacher ends lesson by providing evaluation questions | Teacher ends lesson by providing evaluation questions |

### *Data sources*

Non-participant observation data and student reflections recorded by the participating teachers are the major sources qualitative data. Prior school performance and post-intervention test scores are the sources of quantitative data.

## Qualitative data collection, analyses and findings

### *Non-participant observation*

The non-participant observation provided data to: (1) see whether or not the teachers were capable of carrying out the lessons according to the guideline developed for the study by which students were allowed to make pre- and post-instructional reflections, (2) observe the capabilities of the students to make such reflections, and (3) record student pre- and post-instructional reflections. A total of 13 observations were carried out in the intervention classes and the data were examined in relation to the objectives.

*Was the intervention carried out according to the guideline?*

Overall, six and seven non-participant observation sessions were carried out in the treatment classes of grade 5 and 6, respectively. During each observation session all the instructional activities were recorded in field notes. The notes were then expanded and written as computer files. Sorting and grouping of the instructional activities revealed that five instructional routines were apparent. These were: (i) Recap of Previous Lesson, (ii) Pre-instructional Reflection, (iii) Lesson Presentation, (iv) Post-instructional Reflection, and (v) Lesson Evaluation. These routines represent the four phases of classroom instruction, where (i) and (ii) denote Lesson Introduction and (iv) denotes Lesson Stabilization, as per the guideline introduced for the present study.

Analysis of the six observation sessions in the treatment classes of grade 5 showed that the teacher did invite his students for pre- and post-instructional reflections during the Introduction and Stabilization phases of the lessons, respectively. All of the instructional phases were demonstrated in four of the lessons observed, while lesson evaluation was not carried out in two lessons. Likewise analysis of the seven observation sessions in grade 6 indicated that the teacher did incorporate metacognitive reflections as per the plan. While recaps were not made in four of the lessons observed, lesson evaluation was missed in two lessons. On the whole, one can see that the lessons were taught in such a way that the metacognitive components were incorporated appropriately as required.

*Were the students capable of making metacognitive reflections?*

The pre-instructional metacognitive reflections were designed to help students state their beliefs, assumptions, thoughts, or understandings about a given topic. Post-instructional reflections were meant to help students to explicitly explain how their prior beliefs, assumptions, thoughts, or understandings are changed or modified after they learned new ideas, understandings, conceptions, and/or principles about the topic.

Observation data disclosed that students could give pre-instructional reflections of what they know, think, believe, assume, or understand about a topic in the form of words, phrases, or simple positive statements. On the other hand, the students usually gave post-instructional reflections in two or more statements in reference to their own prior beliefs, assumptions, thoughts, or understandings. Thus, in a given post-instructional reflection one would find the pre-instructional belief or conception as well as the post-instructional understandings indicated explicitly or implicitly.

Since students' pre-instructional beliefs, thoughts, knowledge, or conceptions as well as their post-instructional understandings could be found in the post-instructional reflections, examination of these reflections would suffice to ascertain whether or not the students were making thoughtful reflections. Close examination of post-instructional reflections recorded during non-participant observation sessions revealed that they included metacognitive and non-metacognitive ones.

Metacognitive post-instructional reflections are conscious reflections which indicate that the students: (a) had some beliefs, assumptions, or understandings that are contradictory to what was presented during instruction, (b) are *conscious* that they had such beliefs, assumptions, or understandings, and (c) are declaring that they are abandoning, modifying, or changing those and assimilating/accommodating the conceptions presented during instruction. Such reflections were given as follows.

> I thought that … 'this is true'. Now I understand that … 'this one is true'.
> I believed that … 'this is true'. Now learn that … 'this one is true'.
> I didn't know that … 'this is true'. I believed that … 'that was the case'.
> I didn't know that … 'this is true'. I thought that … 'that was the case'

Non-metacognitive reflections are reflections triggered by the new conceptions presented during lesson instruction, but didn't show that the students: (a) had prior beliefs, thoughts or understandings about those new conceptions, and (b) are ready to make anything about their prior beliefs, thoughts or understandings. Examples are given below.

> I didn't know about … 'that'. Now I learned … 'this' about 'that'.
> I didn't know … 'something'. Now I knew … 'something'.
> I didn't know … 'something'. Now I learned … 'something'.

The researcher recorded a total of 30 post-instructional reflection statements provided by students in the two treatment classes of grade 5 during the six observation sessions. The types of the reflections are summarized in Table 17. The summary depicted that about two-thirds of the reflections were metacognitive. Likewise the researcher recorded a total of 32 statements of post-instructional reflection in grade 6. Study of these reflections revealed that over four-fifths of them were metacognitive. From these accounts, we can see that the students were capable of stating metacognitive reflections. In fact, student participation was enhanced and their reflections became more thoughtful during the course of the intervention. Earlier study by Hennessey and Beeth (1993) that looked at the role of metacognition for conceptual change among primary school students (grade 1 to 6) revealed that students of these levels were capable of metacognitive reflection if they were given the classroom circumstances.

Table 17. Summary of post-instructional reflections given by 5th and 6th graders

| Post-Instructional Reflections | Treatment Classes | | | | | |
|---|---|---|---|---|---|---|
| | Grade 5 | | | Grade 6 | | |
| | Individual | Pair | Total | Individual | Pair | Total |
| Metacognitive | 13 (81%) | 7 (50%) | 20 (67%) | 10 (100%) | 17 (77%) | 27 (84%) |
| Non-metacognitive | 3 (19%) | 7 (50%) | 10 (33%) | 0 (0%) | 5 (23%) | 5 (16%) |
| Total | 16 (100%) | 14 (100%) | 30 (100%) | 10 (100%) | 22 (100%) | 32 (100%) |

### ***Students' reflections***

The participating teachers recorded samples of pre- and post-instructional reflections of their students during almost every lesson. Examples of translated pre- and post-instructional statements of the students are indicated in Tables 18 and 19. These reflections support the conclusions from non-participant observation data.

Table 18. Examples of translated pre and post-instructional reflections of 5th graders

| Wk | Topic | Pre-Instructional Reflections | Post-Instructional Reflections |
|---|---|---|---|
| 2 | Atmospheric Gases | • Benzene, oxygen and hydrogen (M11, IL).<br>• Oxygen, pure air, hydrogen, $CO_2$ (M10, PL). | • We usually hear that benzene and naphtha are called gasses. We used to assume that they are components of the atmospheric air. Now we learned that these are environmental pollutants (M11/11, IL). |
| 3 | Effects of Cigarette Smoking | • Smoking burns the heart, darkens the lips, burns the lungs, increases heartbeat and decreases breathing rate (F13, IL).<br>• Smoking damages the lungs, swells up the lungs, darken the lungs and increases heartbeat (M12, PL). | • I thought the smoke from cigarette gets into the heart and burns it. Now, I understand that it damages the lungs. I abandoned the idea that smoking damages the heart and hold the understanding that it really damages the lungs (M11, IL).<br>• We thought that smoking elevates heartbeat. Now, we abandoned the belief that 'cigarette smoking elevates heartbeat and darkens the blood', and hold the understanding that 'it damages the breathing system' (F11, PL). |
| 4 | Nerve | • Nerve is a muscle. It helps us to move (M12, IL).<br>• Nerve is a ligament. It is a tube for the flow of blood (F12, IL).<br>• Nerve is a device for weighing cotton (M10, PL). | • I thought that nerve means ligament. Now I understand that nerve refers to bundle neurons that transmit messages (M11, IL).<br>• We thought that nerve means an apparatus used to weigh cotton. Now, we understand that it is part of our body, which transmits messages from different parts of our body to the brain and spinal cord or from brain and spinal cord to other parts of the body and glands (M10, PL). |
| 5 | The brain | • Brain enables us to think (F13, IL).<br>• Brain is [an organ] that receives audio-visual messages (M11, IL).<br>• Brain is the capacity of thinking (M12, PL) | • I usually hear when the term brain is mentioned as one whole organ. But, now I learned that it has different parts (F11, IL).<br>• I thought that the organ that thinks is the heart but not the brain. Because, I usually hear people saying: 'a fool without a heart that can think' (M10, PL). |
| 6 | Alcoholism and Functioning of Nervous System | • It burns our intestine (M11, IL)<br>• It causes heart failure (M10, PL).<br>• It makes one out of breath (F12, PL). | • I used to believe that alcohol damages the intestine only. Now, I learned that it also damages the brain and other internal organs of our body (M12, IL).<br>• When I hear the term alcohol, I only associate it with disinfecting wounds in clinics. Now, I understand that it is also found in alcoholic beverages that may damage many parts of our body (M11, PL). |

Table 18. continued

| | | | |
|---|---|---|---|
| 7 | Animal Reproduction | • Animals reproduce through sexual intercourse. But hens lay eggs after they conceive them by wind (M12, IL).<br>• In oviparous animals, the eggs develop to young when they get coagulated (F11, PL). | • I used to believe that a cock releases gas to a hen so that it will produce eggs. I didn't know that it releases male sex cells (M11, IL).<br>• In oviparous animals, I thought that the eggs develop to offspring after they get coagulated. Now, I understand that those eggs that get coagulated (i.e., spoiled) are the ones, which are not fertilized (F11, PL). |
| 8 | Reproduction in Mosquito | • We suffer from malaria when the environment is not clean (M11, IL).<br>• We may be infected by malaria when we moisten a heap of dirt (F12, PL). | • I used to believe that malaria infects us when our environment is not clean. Now, I understand that malaria transmits by mosquito (F11, IL).<br>• I used to believe that malaria infects us when there are swamps and grasses around our homes. Now, I understand that malaria infects us when we stung by *Anopheles* mosquito (M11, PL). |
| 9 | Reproduction in Locust & Armyworm | • Locusts eat crops and cause drought (M11, IL).<br>• Locusts produce many offspring at once (F10, PL). | • I used to believe that locusts eat crops. Now, I learned that it consumes any vegetables and grasses (F12, IL).<br>• I used to believe that locusts give live births but not by laying eggs (F11, IL). |
| 10 | Reproduction in Honeybee | • Honeybees give birth to their likes (F11, IL)<br>• Honeybees and ants are hard-working insects (M10, PL). | • I used to believe that honeybees produce their likes live. Now, I learned that they reproduce by laying eggs (F11, IL).<br>• We used to believe that the bees in a hive are similar in kind and duty. Now, we understand that we find the queen, workers and drones in a single hive, each group with typical duty (M11/11, PL). |
| 10 | Reproduction in Honeybee | • Honeybees are harmful because they sting us. But, their excreta serve us as honey (M11, IL). | • I used to believe that honey is excreta of honeybees. Now, I understand that bees prepare honey by collecting nectar from flowers (F12, IL). |
| 12 | Reproduction in Fishes | • Fishes are created in lakes from the water (M11, PL). | • I used to believe that fishes are created from the water in which they live. I never realized that they get reproduced by sexual means (M11, PL). |

**Note:** F = Female, M = Male, IL = Individual learning, PL = Pair learning, M11 = 11 yr old male, M11/12 = 11 and 12 yr old males

Table 19. Examples of translated pre and post-instructional reflections of 6th graders

| Wk | Topic | Pre-Instructional Reflection | Post-Instructional Reflection |
|---|---|---|---|
| 2 | Environmental Pollution | • …<br>• … | • I used to believe that household wastes are the only sources of environmental pollution. Now, I understand that man-made wastes from factories and power plants as well as wastes from natural sources can pollute the environment (M12, IL).<br>• I thought that man and animals are the major agents of environmental pollution. Now, I learned that there are natural sources of environmental pollution (M12, IL). |
| | Air Pollution | • … | • I used to believe that dust is the only source of air pollution. Now, I realized that chlorine from volcano, sulfur dioxide from factories, salts from ocean spray and smokes from wild fire are some of the sources of air pollution (M12, PL). |
| 3 | Relationships among Soil, Water & Plants | • … | • I used to believe that plants germinate and grow simply. Now, I realized that plants would not grow without enough moisture and soil (F12, PL). |
| 4 | What is Disease? | • …<br>• …<br>• … | • I used to believe that communicable diseases transmit from person to person only. Now, I realized that they could transmit from plant to plant, from animals to animals, from plants to animals or from animals to humans (F12, PL).<br>• I thought that HIV/AIDS affects all animals. Now, I learned that the disease affects humans only (F12, IL).<br>• I used to believe that tuberculosis affects cigarette smokers only. Now, I realized that it could affect non-smokers and other animals (M13, IL). |
| | Bacteria | • Bacteria are harmful organisms (M12, IL).<br>• Bacteria live in water and soil only (M12, PL). | • All bacteria are not harmful. There are also beneficial bacteria (F12, IL).<br>• Bacteria live in water and soil as well as inside and outside the human body (M14, PL). |
| 5 | Cholera | • The bacteria that cause cholera are visible to naked eyes. | • I learned that cholera-causing bacteria are very tiny organisms, invisible to the naked eyes (M12, PL).<br>• I thought that drinking polluted water is the only cause of cholera infection. Now, I learned that washing our bodies, clothes and food utensils using water polluted with cholera causing microbes could cause cholera (F13, IL). |

Table 19. continued

| | | | |
|---|---|---|---|
| 6 | Amoebasis | • It is a kind of disease transmitted by breathing.<br><br>• It is a kind of disease that affects humans, which arise when we eat sugary foods. | • I learned that amoebasis is not transmitted by breathing. It is a kind of disease that could arise when we drink amoeba-polluted water or eat amoeba-polluted food (M13, IL).<br>• I learned that eating sugary foods does not cause amoebasis. I learned that eating amoeba-polluted food, drinking amoeba-polluted water, eating using amoeba-polluted utensils and washing with amoeba-polluted water causes amoebasis (M12, PL). |
| 7 | Waterborne Diseases | • Cleaning water tanks can help control the cleanliness of potable water (F23, IL).<br>• All water is clean (M12, IL). | • I thought that washing water tankers suffices to keep water clean and safe. But, I realized that boiling and chemical treatments of water are safer methods of maintaining the cleanliness of potable water (F23, IL).<br>• We thought that all water is clean. Now, we realized that water can be polluted via various means, thus should be boiled for consumption (M11/12, PL). |
| | Bilharziasis | • It is a disease that catches us when we drink raw milk (M13/14, PL).<br>• It is an animal that harms animals (F12, IL).<br>• It is a disease that catches us when we sleep, eat or drink with sick persons (F12/13, PL). | • We thought that bilharziasis catches us when we drink raw milk. Now, we realized that bilharziasis is water borne disease (M13/14, PL).<br>• I thought bilharziasis is an animal. Now, I learned that it is a human disease (M12, IL).<br>• I didn’t though that bilharziasis affects humans only. I thought that it affects all organisms (F13, PL). |
| 12 | Volume | • Volume implies the shape of an object like a house (M11, IL). | • I thought that volume means the shape of objects like house. But, I realized that volume is a space occupied by geometric or non-geometric objects (M11, IL). |
| 13 | Mass | • Mass implies the shape of a person (M12, PL). | • We thought that mass implies the shape or posture of a person. Now, we understood that mass is the measure of the amount of particles in an object (M12, PL). |
| 14 | Pressure | • Pressure is the act of press-ing some object (M12, IL).<br>• Pressure implies when an object sinks in water (F12, IL).<br>• Pressure is something that is forced inwards (F11, PL). | • I thought that pressure is something like pressing the roof of a house using blocks. After I learned about it, I understood that pressure is a force that is exerted on a given area (F11, IL).<br>• I thought that pressure is something that is forced inwards. Now, I understood that pressure is a force that is exerted on a given area (F11, PL). |

Table 19. continued

| | | | |
|---|---|---|---|
| 15 | Refraction | • Refraction is the reflection of light (F11, IL).<br>• Refraction is the travelling of light from the Sun towards the Earth (M12, IL).<br>• Refraction is an instrument used to measure the movement of light (M11/12, PL). | • I thought that refraction is the reflection of light. After I learned about it, I understood that refraction is not reflection but it implies a change in the direction and speed of light when it moves across different transparent objects (F11, IL).<br>• We thought that refraction is an instrument for measuring the movement of light. Now, we realized that refraction means that change in the direction and speed when light travels across transparent media (M11/12, PL). |
| 16 | Lenses | • Lens implies when light falls on rough surfaces (M13, IL).<br>• Lenses are sources of light (F12, PL). | • I thought that lens implies when light falls on rough surfaces. Now, I learned that lenses are devices made up of curved mirrors employed to aid seeing (M13, IL).<br>• I thought that lenses are sources of light. Now, I realized that lenses are not sources of light. They are devices used to develop various images (F12, PL). |

**Note:** F = Female, M = Male, IL = Individual learning, PL = Pair learning, M11 = 11 yr old male, M11/12 = 11 and 12 yr old males

## Quantitative data collection, analyses, and findings

### *Prior school performance (PSP)*

Students' prior school performances (PSP), computed using the mean scores of the core subjects of the previous academic year, were used as pre-test scores. The transcripts of the students were obtained from the record office of the school and the mean scores of the core subjects were calculated. The core subjects for grade 5 are: Amharic (Ethiopia's federal working language), Tigrinya (instructional and mother tongue language of the students), English, Mathematics and Environmental Science. These subjects cover about 87% of the weekly schedule. Similarly, the core subjects for grade 6 are: Amharic, Tigrinya, English, Mathematics, General Science and Social Studies; which cover about 73% of the weekly schedule.

### ***Post-intervention tests***

*Preparation and pilot testing of question*

Scores of end-of-intervention tests (of Immediate and Delayed post-test groups) were the major sources of quantitative data of the study. Sixty questions were prepared for each grade for the post-tests (Appendix A and B). Overall, the questions include 10 true or false, 10 fill in the blank, 30 multiple choice, and 10 short answer items. The questions were distributed into: Knowledge and Comprehension (20 items), Application (20 items) and Transfer (20 items), each administered as separate tests. While questions in the Knowledge and Comprehension test required students to recall or know facts, those of the Application test required applying what one learned in a slightly different situation (i.e. context transfer) or to a new situation not identical to the learning situation (i.e. near transfer). Finally, questions in the Transfer test required applying learning to situations quite dissimilar to the original situation (i.e. far transfer) (Haskell, 2001). The questions were developed according to the elementary science question development guide indicated in Victor and Kellough (2000). Two primary school science curriculum experts approved the content validities of the tests. The distribution of the items in each type is indicated in Table 20. The type and distribution of the questions were similar for both grades.

The questions for $5^{th}$ graders were pilot tested with a sample of 30 students from two non-participating classes of study school-1. Questions for $6^{th}$ graders were pilot tested in a similar fashion with a sample of 30 students from two non-study classes of this school. Questions that were only answered by a few students were revisited, and some modifications were made to make them clearer. The amount of time required to complete each test was also decided.

Table 20. Item distribution of the tests

| Item Type | Test Type | | | Total |
|---|---|---|---|---|
| | Know./Comp. | Application | Transfer | |
| True or False | 6 | 2 | 2 | 10 |
| Fill in the Blank | 6 | 2 | 2 | 10 |
| Multiple Choice | 6 | 12 | 12 | 30 |
| Short Answers | 2 | 4 | 4 | 10 |
| Total | 20 | 20 | 20 | 60 |

*Administering the tests*

Though the gross populations of the classes selected for the study were between 61 and 69, only those students around the legal ages for each grade were included in the quantitative study. According to Ethiopian education policy, the legal ages of 5$^{th}$ and 6$^{th}$ graders are $11^{1/12}$ and $12^{1/12}$ years, respectively. Thus, 5$^{th}$ graders with the ages of 10 and 13 years and 6$^{th}$ graders with the ages of 11 and 14 years were included. Then, they were assigned to Immediate and Delayed test-groups. For this purpose, the students were ranked based on PSP scores. Students with 'odd' ranks were assigned to Immediate test-groups and those with 'even' ranks were assigned to Delayed test-groups. The purpose of dividing the classes into Immediate and Delayed test-groups was to investigate the retention abilities of the students.

The intervention lasted for 14 and 16 weeks in grades 5 and 6, respectively. After the completion of the intervention, the students were given seven days to prepare for the tests. At the end of Day Seven, the students in the Immediate test-groups were told to come for the tests next day, and took the three tests one by one with about 30 minutes recess between each. The students in the Delayed test-groups took the same tests at the end of the 24$^{th}$ week after the completion of the intervention. The students in the Delayed test-groups were neither required nor informed to make additional preparations for the tests. The author and one participating teacher scored all the tests. The interrater reliabilities of the scores of the various groups were over 0.99. PSP and post-test scores were analyzed using one-way ANOVA followed by Post-hoc comparisons using LSD at significance level of $p \leq 0.10$. Findings of the quantitative analyses are presented below.

### ***Post-test performances of the Immediate test-groups***

#### *5th graders*

Scores of PSP, post-test scores of Knowledge and Comprehension, Application and Transfer tests as well as the Total post-test scores of the three classes (Individual learning, Pair learning and Comparison) were analyzed using one-way ANOVA. ANOVA on mean scores of PSP, (considered to be pre-test scores) revealed no differences in prior academic performances ($F_{(2, 81)} = 0.026$; $p \leq 0.974$) among the three classes (Table 21). Similarly, the mean Knowledge/Comprehension scores of the test-groups from the three classes revealed no statistically significant variation ($p \geq 0.1$).

Statistically significant differences were obtained with Application, Transfer and Total test scores (Table 22). The difference in mean Application scores between the Individual learning class (6.43; SD = 2.48) and the Comparison class (4.97; SD = 2.21) is significant at $p \leq 0.036$. Likewise, the difference in mean Application score between the test-group from the Pair learning class (6.22; SD = 2.51) and the Comparison class is significant at $p \leq 0.075$. Comparing the Total post-test scores, the difference between the mean score of the test-group from the Individual learning class (19.49; SD = 5.20) and that of the test-group from the Comparison class (16.34; SD = 5.34) is significant at $p \leq 0.039$. When we compare the post-test scores of the Immediate test-groups from Individual and Pair learning classes, statistically significant difference was evident only with the Transfer test score ($p \leq 0.092$), in favor of the test-group from Individual learning class.

Table 21. Mean (and SD) scores of 5th graders of Immediate test-groups and ANOVA summaries

| Variables | Mean Score (SD) of Treatments | | | ANOVA | |
|---|---|---|---|---|---|
| | Individual | Pair | Comparison | $F_{(2, 81)}$ | *p* |
| PS Performance (100%) | 61.45 (11.45) | 60.97 (9.54) | 60.84 (11.09) | .026 | .974 |
| Know./Comp. Test (25 pts) | 6.77 (2.36) | 6.77 (2.91) | 5.98 (2.77) | .772 | .465 |
| Application Test (25 pts) | 6.43 (2.84) | 6.22 (2.51) | 4.97 (2.21) | 2.601 | .080* |
| Transfer Test (25 pts) | 6.29 (1.97) | 5.31 (2.22) | 5.38 (2.54) | 1.807 | .171 |
| Total Score (75 pts) | 19.49 (5.20) | 18.30 (6.26) | 16.34 (5.33) | 2.223 | .115 |

***** **=** Differences are significant at $p \leq 0.10$.

Table 22. Comparison matrices of mean scores of 5th graders of Immediate test-groups using LSD

| | Variables | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PS Performance | | | Know./Comp. | | | Application | | | Transfer | | | Total | | |
| | IL | PL | CC | IL | PL | CC | IL | PL | CC | IL | PL | CC | IL | PL | CC |
| IL | 1 | | | 1 | | | 1 | | | 1 | | | 1 | | |
| PL | .864 | 1 | | .999 | 1 | | .755 | 1 | | .092* | 1 | | .423 | 1 | |
| CC | .832 | .965 | 1 | .277 | .284 | 1 | .036* | .075* | 1 | .125 | .904 | 1 | .039* | .202 | 1 |

NB: IL—Individual learning class; PL—Pair learning class; CC—Comparison class

***** **=** Differences are significant at $p \leq 0.10$.

### *6th graders*

Similar comparisons were made using the scores of 6th graders. One-way ANOVA showed that mean PSP scores of the test-groups from the Individual learning (61.29; SD = 9.77), Pair learning (61.86; SD 9.79) and Comparison (63.38; SD = 9.63) classes were not statistically different ($F_{(2, 79)} = 0.333$; $p \leq 0.717$), signifying prior school performances of the students in the three classes were similar. Also, the differences in mean Knowledge/Comprehension scores of the three test-groups were not statistically significant ($F_{(2, 79)} = 0.572$; $p \leq 0.567$) (Table 23).

On the other hand, variations in mean Application ($F_{(2, 79)} = 2.966; p \leq 0.057$), Transfer ($F_{(2, 79)} = 4.692; p \leq 0.012$), and Total ($F_{(2, 79)} = 3.086; p \leq 0.051$) test scores were statistically significant (Table 23). Post-hoc comparisons showed that significant differences ($p \leq 0.1$) in mean scores existed between the test-groups from the treatment classes and the Comparison class. Differences in mean post-test scores of the test-groups from of the Individual and Pair learning classes indicated no statistical significance ($p \geq 0.1$) (Table 24).

Table 23. Mean (and SD) scores of 6th graders of Immediate test-groups and ANOVA summaries

| Variables | Mean Score (SD) of Treatments | | | ANOVA | |
|---|---|---|---|---|---|
| | Individual | Pair | Comparison | $F_{(2, 79)}$ | *p* |
| PS Performance (100%) | 61.28 (9.77) | 61.86 (9.79) | 63.38 (9.63) | .333 | .717 |
| Know./Comp. Test (25 pts) | 11.82 (3.25) | 11.45 (3.39) | 10.85 (3.42) | .572 | .567 |
| Application Test (25 pts) | 7.48 (2.46) | 8.66 (2.74) | 6.95 (2.97) | 2.966 | .057* |
| Transfer Test (25 pts) | 7.78 (2.35) | 7.23 (2.28) | 5.91 (2.31) | 4.692 | .012* |
| Total Score (75 pts) | 27.09 (6.33) | 27.34 (5.83) | 23.69 (6.37) | 3.086 | .051* |

*** =** Differences are significant at $p \leq 0.10$.

Table 24. Comparison matrices of mean scores of 6th graders of Immediate test-groups using LSD

| | Variables | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PS Performance | | | Know./Comp. | | | Application | | | Transfer | | | Total | | |
| | IL | PL | CC | IL | PL | CC | IL | PL | CC | IL | PL | CC | IL | PL | CC |
| IL | 1 | | | 1 | | | 1 | | | 1 | | | 1 | | |
| PL | .833 | 1 | | .687 | 1 | | .126 | 1 | | .393 | 1 | | .882 | 1 | |
| CC | .443 | .549 | 1 | .299 | .491 | 1 | .493 | .020* | 1 | .005* | .030* | 1 | .053* | .026* | 1 |

NB: IL—Individual learning class; PL—Pair learning class; CC—Comparison class
*** =** Differences are significant at $p \leq 0.10$.

## *Post-test performances of the Delayed test-groups*

### *5th graders*

Prior school performance and post-test scores of the Delayed test-groups from treatment and comparison classes were compared using one-way ANOVA. Analyses of

PSP scores indicated no statistically significant variation among the means ($F_{(2, 63)}$ = 0.054; p ≤ .948). Similarly, neither ANOVA nor Post-hoc comparisons revealed any statistically significant differences in mean scores of the test-groups in any of the tests (Table 25 and 26).

Table 25. Mean (and SD) scores of 5th graders of Delayed test-groups and ANOVA summaries

| Variables | Mean Score (SD) of Treatments | | | ANOVA | |
|---|---|---|---|---|---|
| | Individual | Pair | Comparison | $F_{(2, 63)}$ | *p* |
| PS Performance (100%) | 62.32 (10.46) | 63.24 (9.47) | 62.25 (12.04) | .054 | .948 |
| Know./Comp. Test (25 pts) | 5.98 (2.57) | 5.37 (2.17) | 5.00 (1.88) | 1.151 | .323 |
| Application Test (25 pts) | 5.76 (2.23) | 5.42 (1.54) | 5.52 (1.53) | .202 | .818 |
| Transfer Test (25 pts) | 5.50 (2.39) | 5.95 (2.89) | 4.89 (2.09) | .983 | .380 |
| Total Score (75 pts) | 17.24 (5.28) | 16.74 (4.91) | 15.41 (3.81) | .931 | .399 |

Table 26. Comparison matrices of mean scores of 5th graders of Delayed test-groups using LSD

| | Variables | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PS Performance | | | Know./Comp. | | | Application | | | Transfer | | | Total | | |
| | IL | PL | CC | IL | PL | CC | IL | PL | CC | IL | PL | CC | IL | PL | CC |
| IL | 1 | | | 1 | | | 1 | | | 1 | | | 1 | | |
| PL | .780 | 1 | | .377 | 1 | | .546 | 1 | | .555 | 1 | | .729 | 1 | |
| CC | .984 | .768 | 1 | .138 | .597 | 1 | .655 | .859 | 1 | .399 | .170 | 1 | .188 | .368 | 1 |

NB: IL—Individual learning class; PL—Pair learning class; CC—Comparison class

### *6th graders*

The mean scores of each of the variables in this grade were analyzed using one-way ANOVA. Comparison of mean PSP scores revealed no statistically significant differences ($F_{(2, 77)}$ = 0.184; p ≤ 0.832). Likewise, ANOVA and Post-hoc comparisons revealed no statistically significant differences in mean scores of the test-groups in any of the tests (p ≥ 0.1) (Tables 27 and 28).

Table 27. Mean (and SD) scores of 6th graders of Delayed test-groups and ANOVA summaries

| Variables | Mean Score (SD) of Treatments | | | ANOVA | |
|---|---|---|---|---|---|
| | Individual | Pair | Comparison | $F_{(2, 77)}$ | $p$ |
| PS Performance (100%) | 61.24 (9.95) | 62.27 (10.53) | 62.83 (8.08) | .184 | .832 |
| Know./Comp. Test (25 pts) | 10.87 (3.86) | 10.25 (3.19) | 9.36 (2.57) | 1.304 | .277 |
| Application Test (25 pts) | 6.50 (2.61) | 6.41 (2.27) | 6.77 (1.69) | .187 | .830 |
| Transfer Test (25 pts) | 5.85 (2.69) | 6.29 (3.03) | 5.85 (2.31) | .241 | .787 |
| Total Score (75 pts) | 23.15 (7.85) | 22.95 (7.22) | 21.98 (4.48) | .246 | .783 |

Table 28. Comparison matrices of mean scores of 6th graders of Delayed test-groups using LSD

| | Variables | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PS Performance | | | Know./Comp. | | | Application | | | Transfer | | | Total | | |
| | IL | PL | CC | IL | PL | CC | IL | PL | CC | IL | PL | CC | IL | PL | CC |
| IL | 1 | | | 1 | | | 1 | | | 1 | | | 1 | | |
| PL | .696 | 1 | | .530 | 1 | | .883 | 1 | | .552 | 1 | | .910 | 1 | |
| CC | .552 | .829 | 1 | .114 | .321 | 1 | .664 | .556 | 1 | 1 | .552 | 1 | .515 | .583 | 1 |

NB: IL—Individual learning class; PL—Pair learning class; CC—Comparison class

### *Comparing performance of Immediate and Delayed test-groups*

*5th graders*

The purpose of comparing the performances of the Immediate and Delayed test-groups is meant to investigate the effects of the intervention on retention of learning. Comparisons of the mean PSP scores of the Immediate and Delayed test-groups of the two treatment classes and a comparison one showed that they are comparable (between 60.84; SD = 11.09 and 63.24; SD = 9.47) (Table 29). Assuming pre-intervention homogeneity of the test-groups in each class, subsequent comparisons based on post-test scores were made.

In the Individual learning and Comparison classes, no statistically significant differences were observed between the mean scores of the Immediate and Delayed test-groups in any of the tests ($p \geq 0.1$). In the Pair learning class, only the mean Knowledge/

Comprehension score of the Immediate test-group is statistically higher than that of the Delayed test-group ($F_{(1, 45)} = 3.180$; $p \leq 0.081$).

Table 29. Comparisons of the mean (SD) scores of Immediate and Delayed test-groups of 5th graders

| Treatment | §Test-group | PSP Mean (SD) | Know/Comp. Mean (SD) | Application Mean (SD) | Transfer Mean (SD) | Total Mean (SD) |
|---|---|---|---|---|---|---|
| Individual Learning | 1 (n = 30) | 61.45 (11.45) | 6.77 (2.36) | 6.43 (2.84) | 6.29 (1. 97) | 19.49 (5.20) |
| | 2 (n = 24) | 62.32 (10.46) | 5.98 (2.57) | 5.76 (2.23) | 5.50 (2.39) | 17.24 (5.28) |
| | $F_{(1, 48)}$ | 0.082 | 1.373 | 0.900 | 1.934 | 2.466 |
| | *p*-value | 0.776 | 0.247 | 0.347 | 0.170 | 0.122 |
| Pair Learning | 1 (n = 28) | 60.97 (9.54) | 6.77 (2.91) | 6.22 (2.51) | 5.31 (2.22) | 18.30 (6.26) |
| | 2 (n = 19) | 63.24 (9.47) | 5.37 (2.17) | 5.42 (1.54) | 5.95 (2.89) | 16.74 (4.91) |
| | $F_{(1, 45)}$ | 0.647 | 3.180 | 1.537 | 0.723 | 0.839 |
| | *p*-value | 0.425 | 0.081* | 0.222 | 0.400 | 0.365 |
| Comparison | 1 (n = 26) | 60.84 (11.09) | 5.98 (2.77) | 4.97 (2.21) | 5.38 (2.54) | 16.33 (5.33) |
| | 2 (n = 23) | 62.25 (12.04) | 5.00 (1.88) | 5.52 (1.53) | 4.89 (2.09) | 15.41 (3.81) |
| | $F_{(1, 53)}$ | 0.183 | 2.042 | 0.998 | 0.539 | 0.474 |
| | *p*-value | 0.671 | 0.160 | 0.323 | 0.466 | 0.494 |

§ = 1, Immediate; 2, Delayed

* = Differences are significant at $p \leq 0.10$.

## *6th graders*

The mean PSP scores of the six test-groups in the three classes range from 61.24 (SD = 9.95) to 63.38 (SD = 9.63) and are not significantly different, signifying that they have similar prior academic performance to begin with. In fact, the similarity of the mean scores of the two test-groups in each of the treatment classes is very apparent (Table 30).

Comparisons of the mean post-test scores of the Immediate test-groups and the Delayed test-groups disclosed that statistically significant mean score differences were observed in high-level thinking tests in the Individual ($F_{(1, 48)} = 7.136$; $p \leq 0.010$ for Transfer test) and Pair ($F_{(1, 57)} = 11.474$; $p \leq 0.001$ for Application test) learning classes, and in low-level thinking test in the Comparison class ($F_{(1, 53)} = 3.227$; $p \leq 0.078$ for Knowledge/Comprehension test). When we look at the mean Total scores of the groups in each of the treatment and the Comparison classes, mean differences are found to be statistically significant between the test-groups in the Individual ($F_{(1, 48)} = 3.659$; $p \leq 0.062$) and Pair ($F_{(1, 57)} = 6.545$; $p \leq 0.013$) learning classes (Table 30).

Table 30. Comparisons of the mean (SD) scores of Immediate and Delayed test-groups of 6th graders

| Treatment | [§]Test-group | PSP Mean (SD) | Know/Comp. Mean (SD) | Application Mean (SD) | Transfer Mean (SD) | Total Mean (SD) |
|---|---|---|---|---|---|---|
| Individual Learning | 1 (n = 23) | 61.28 (9.77) | 11.82 (3.25) | 7.48 (2.46) | 7.78 (2.35) | 27.09 (6.33) |
| | 2 (n = 26) | 61.24 (9.95) | 10.87 (3.86) | 6.50 (2.61) | 5.85 (2.69) | 23.15 (7.85) |
| | $F_{(1, 48)}$ | 0.000 | 0.986 | 1.802 | 7.136 | 3.659 |
| | *p*-value | 0.987 | 0.326 | 0.186 | 0.010* | 0.062* |
| Pair Learning | 1 (n = 30) | 61.86 (9.79) | 11.45 (3.39) | 8.66 (2.74) | 7.23 (2.28) | 27.34 (5.83) |
| | 2 (n = 28) | 62.27 (10.53) | 10.25 (3.19) | 6.41 (2.27) | 6.29 (3.03) | 22.95 (7.22) |
| | $F_{(1, 57)}$ | 0.024 | 1.920 | 11.474 | 1.830 | 6.545 |
| | *p*-value | 0.878 | 0.171 | 0.001* | 0.182 | 0.013* |
| Comparison | 1 (n = 29) | 63.38 (9.63) | 10.85 (3.42) | 6.95 (2.97) | 5.91 (2.31) | 23.69 (6.37) |
| | 2 (n = 26) | 62.83 (8.08) | 9.36 (2.57) | 6.77 (1.69) | 5.85 (2.31) | 21.98 (4.48) |
| | $F_{(1, 53)}$ | 0.052 | 3.227 | 0.073 | 0.009 | 1.308 |
| | *p*-value | 0.821 | 0.078* | 0.788 | 0.925 | 0.258 |

[§] = 1, Immediate; 2, Delayed

* = Differences are significant at $p \leq 0.10$.

## Discussion

The findings of the qualitative and quantitative data analyses shall be discussed in relation to each of the questions of the study.

### ***Did the intervention yield better overall learning outcomes?***

The study investigated whether the instructional intervention would increase learning outcomes among 5th and 6th grade students (10-14 years olds) in large class-size primary schools in Ethiopia. Non-participant observation data showed that the intervention was conducted as intended. It was also evident that the students in both grades were capable of stating their reflections metacognitively (Table 17), as student reflections recorded by the participating teachers strongly supported this assertion. Examination of the nature of the reflections suggests that students thought about the status of their prior conceptions in such a way that they restructured those conceptions.

Fifth grade students in the Immediate test-groups of the treatment classes achieved better in the post-intervention tests. The mean Total post-test score of the test-group from the Individual learning class (19.49, SD = 5.20) was significantly greater than that of the Comparison class (16.34, SD = 5.33) at $p \leq 0.039$ (Table 22). ANOVA and Post-hoc comparison using LSD showed that the three test-groups have the same mean PSP scores ($F_{(2, 82)} = 0.023$; $p \leq 0.977$) (Tables 21 and 22). Hence, it can be safely concluded that differences in the achievements on post-tests are accountable to the intervention.

The effect of the intervention seems to be more profound among 6$^{th}$ graders. To begin with, the mean PSP scores of the three test-groups were statistically comparable ($F_{(2,79)} = 0.333$; $p \leq 0.717$). Mean Total post-test scores of the test-groups from the Individual (27.09, SD = 6.33) and Pair (27.34, SD = 5.83) learning classes were significantly greater than that of the test-group from the Comparison class (23.69, SD = 6.37) at $p \leq 0.053$ and $p \leq 0.026$, respectively (Tables 23 and 24). These show that the metacognitive reflection strategy promoted the performance of the students.

The data from the Delayed test-groups revealed that the contribution of the metacognitive intervention was not statistically evident. Among 5$^{th}$ graders, the mean Total post-test scores of the Individual (17.24, SD = 5.28) and Pair (16.74, SD = 4.91) learning classes were not statistically greater than those from the Comparison class (15.41, SD = 3.81) (Tables 25 and 26). With 6$^{th}$ graders, the mean Total post-test score of the test-groups from the Individual (23.15, SD = 7.83) and Pair (22.95, SD = 7.22) learning classes were statistically comparable to the mean Total score of the test-group from the Comparison class (21.98, SD = 4.48) (Tables 27 and 28). These imply that the effect of the metacognitive instructional method was not apparent 24 weeks after the completion of the intervention.

Intervention studies that allow students to talk about their preconceptions and think about the status of those preconceptions to help them restructure their understandings yielded positive outcomes. For example, $6^{th}$ graders form Cyprus who were given supplemental refutation readings to standard instruction about energy performed better in immediate and delayed post-tests than their counterparts who were given supplemental expository readings, and who were taught through standard instruction (Diakidoy, Kendeou, & Ioannides, 2002). The expository text provided review of concepts covered during instruction and drew student attention to main ideas. The refutation text provided a review of concepts covered during instruction by drawing student attention to main ideas and potential alternative conceptions to facilitate restructuring.

Likewise, a study by Ozkan, Tekkaya, and Geban (2004) revealed that the learning gain ([mean post-test score] – [mean pre-test core]) of $7^{th}$ graders who received conceptual-change-text-oriented instruction on ecological concepts was significantly greater than the learning gain of their counterparts who were taught through traditional methods. In this case, the conceptual-text-oriented instruction was meant to elicit students' pre-instructional conceptions into public (classroom) scrutiny.

Furthermore, an instructional intervention with $10^{th}$ graders supported by conceptual change text designed for explaining students' misconceptions, sources of such misconceptions, why the misconceptions were incorrect, and informing the scientific conceptions, outperformed their counterparts who were taught through traditional methods (Cakir, Uzuntiryaki, & Geban, 2002). These imply that students as young as 6th graders can provide metacognitive reflections to address the status of their prior beliefs and thoughts for meaningful learning.

#### *Did treatment classes perform better in higher order thinking tests than comparison classes?*

Teaching strategies that consider learners' prior conceptions can help students develop higher level of understandings (Lee & Law, 2001). Studies indicate that metacognitive teaching/learning strategies promote deep thinking and meaningful learning (e.g. Blank, 2000; Georghiades, 2004; Rickey & Stacy, 2000). Thus, the second goal of this study was to find out if the intervention would help students in the treatment classes perform better in higher order thinking tests.

Among Immediate test-groups of 5th graders, no statistically significant variation was evident among the mean Knowledge/Comprehension test scores of the three test-groups ($F_{(2, 81)} = 0.772$, $p \leq 0.465$) (Table 21). Interestingly, statistically significant variations appeared with the mean Application test scores. The test-groups from both the Individual and Pair learning classes outperformed the test-group from the Comparison class in mean Application test score at $p \leq 0.036$ and $p \leq 0.075$, respectively. But there appeared no statistically significant difference between either of the test-groups from the treatment classes and the test-group from the Comparison class in mean Transfer scores. In general it is evident that the intervention has benefited students in tackling higher order thinking questions.

The mean Knowledge/Comprehension test scores of the three test-groups of 6th graders are statistically equivalent ($F_{(2, 79)} = 0.572$, $p \leq 0.567$) (Table 23). The mean

Application test score of the test-groups from the Individual learning class is significantly greater than the mean score of the test group from the Comparison class statistically ($p \leq 0.020$). In the case of the mean Transfer test scores, the contribution of metacognitive instruction is clearly evident (Table 24). Based on the scores of the Immediate test-groups, it clearly appears that the intervention has a noteworthy contribution in fostering primary school students' understanding to engage in higher order thinking science problems.

Nonetheless, when the performances of the Delayed test-groups of both grades are considered, no statistically distinct variations could be found. Mean Application and Transfer test scores of the three test-groups in grade 5 are comparable. Similarly, comparisons of higher order thinking test scores of the Delayed test-groups of 6$^{th}$ graders revealed that they have fairly homogenous performance. Thus, the effect of the metacognitive instructional strategy, which was apparently evident among the Immediate test-groups, is clearly diminished after 24 weeks.

***Did the intervention help the treatment classes to retain learned contents better than the comparison classes?***

Retention ability could be defined as ability to retain learned contents for a longer period of time or indefinitely. The preceding discussions show that the apparent effects of the intervention on overall performance as well as on the performances of higher order thinking tests among the Immediate test-groups diminished among the Delayed test-groups. Thus, the prediction for a contribution of the intervention on retention could not be supported using the data from 5$^{th}$ graders.

Post-test data from 6th graders also show a clear picture. The mean Total post-test scores of the Delayed test-groups of the Individual and Pair learning classes were statistically significantly lower than the mean Total post-test scores of their counterparts in the Immediate test-groups, at $p \leq 0.062$ and $p \leq 0.013$, respectively. But no significant difference was observed between the mean Total scores of the Immediate and Delayed test-groups of the Comparison class ($p = 0.258$) (Table 30). These imply that the higher post-test performance achieved by the Immediate test-groups of the treatment classes could not be maintained in the Delayed test-groups. Some researchers claim that metacognitive interventions could promote retention of learned contents (Adey & Shayer, 1993; Georghiades, 2000, 2004). Nevertheless, in this study the metacognitive instructional method played no apparent role in fostering student retention ability.

***Was the instructional method more effective in pair learning setting?***

Based on the premise that classroom social dynamics would facilitate (conceptual change) learning (Pintrich, 1999; Tyson, Venville, Harrison, & Treagust, 1997), the study investigated whether the intervention would benefit students of the Pair learning class more than those of the Individual learning class. When we begin with the immediate test-groups of 5th graders, it appears that the Individual learning class is relatively more benefited from the intervention. In fact, the Individual learning class did obtain significantly greater mean Transfer test score ($p \leq 0.092$). Nonetheless, when the overall post-test performances of both test-groups are considered, it is difficult to conclude that the learning setting has a profound effect. Observation of the post-test scores of 6th graders of both test-groups strengthens this assertion. In the case of the present study neither of the learning settings can be regarded as specially facilitating or hindering conceptual learning compared to the other settings. When students in the Pair learning class were asked to think, discuss, and state their reflections about a topic, the time they worked together was so brief that the dyad interaction did not have substantial benefit. Thus, each member of the dyad would state her/his reflections with little consultation with a colleague.

### *Did the intervention produce similar outcomes in both grades?*

The important finding of this study is that the present metacognitive instructional method could be successfully employed with primary school students (aged 10-14 years) in teaching science. Preceding discussions revealed that the effect of the intervention is consistently similar in both grades 5 and 6. In both grades:

(a) The contribution of the intervention is clearly evident among the Immediate test-groups but fades among the Delayed ones.

(b) The effect of the intervention is more profound with higher order thinking tests, while Knowledge/ Comprehension tests have limited contribution in differentiating the treatment classes from the comparison.

(c) The differences in the learning setting (Individual or Pair) did not yield any apparent difference in overall performance.

(d) Students were capable of making thoughtful pre- and post-instructional reflections about a topic.

One of the important known contributions of metacognitive instruction is fostering retention ability of learners. Undeniably the data analyses of the scores of the Immediate test-test-groups revealed that the intervention did promote meaningful learning, where students in the treatment classes have performed better in the Application and Transfer tests. Nevertheless, the effect was not apparent among the Delayed test-test-groups as was hoped. Thus, the finding that the effect of the intervention has diminished 24 weeks after the completion of the intervention could serve as source of hypotheses for further inquiry on the topic.

### *What other benefits did the intervention have?*

Two important inputs were apparent and are discussed as follows.

#### *Better student conceptual learning*

The basic tenet of contemporary science instruction strives to create a learning environment where students construct understandings and evaluate ideas, rather than passively accepting scientific information (Hogan, 1999; Yip, 2001). It is strongly argued that active involvement of students in their own learning for conceptual change would be achieved by including metacognitive strategies (Lehtelä, 2001). Studies on the role of metacognitive strategies in learning science focus on the contribution of such strategies on conceptual learning, constructing meanings, and inquiry learning. Metacognition empowers learners to recognize, evaluate and revise personal views (Baird, Fensham, Gunstone, & White, 1991). Oral and written discourse promotes conceptual change learning as learners bring their prior conceptions to scrutiny (Maria, 2000).

The Metacognitive Reflection for Conceptual Learning Model employed in this study was designed in such a way that students identify, evaluate, and correct their beliefs, assumptions, or understandings about the topics they are learning. Moreover, the model requires students to remain aware while they are engaged in such activities. An instructional context that provides students opportunities to verbally express, compare, criticize, evaluate, and communicate their conceptions and explanations fosters conceptual change learning (Hynd, Holschuh, & Nist, 2000; Maria, 2000; Mason, 1998). Thus, as Taber (2001) explains, students' prior conceptions and understandings are resources of conceptual development. For this reason, Pine, Messer, and John (2001) argue that incorrect ideas are too important to be ignored since they are the foundations on which new knowledge is built. A summary of non-participant observation revealed that over two-third of students' reflections were metacognitive and show reconstructions of beliefs and/or assumptions. Students' reflections recorded by the participating teachers support the data of non-participant observation.

Examination of the samples of pre- and post-instructional reflections indicated in Tables 18 and 19 shows that participating students have many incorrect ideas about the science topics in the curriculum. Studies on misconceptions among primary school children report similar findings (e.g. Pine, Messer, & John, 2001). It is clearly evident that the present metacognitive instructional model enabled students to examine and reconstruct their incomplete and/or incorrect ideas and assumptions, thus performing better on higher order thinking tests. The post-instructional reflections revealed students' dissatisfaction by the status (intelligibility, plausibility and fruitfulness) of their own prior conceptions and their commitments for restructuring or abandoning the incomplete or incorrect conceptions.

Interventions that allow students to think and reflect about the status of their prior conceptions have reported similar outcomes. For example, in one study where $5^{th}$ and $6^{th}$ graders (aged 11-12 years from Greece) were allowed to express their ideas about acid rain in a collaborative learning setting involving activities and experiments, they demonstrated better conceptual understanding than their counterparts taught through teacher lecturing and explanation (Marinopoulos & Stavridou, 2002). Likewise, a metacognitive instructional method called Metacognitive Learning Cycle, which allowed 7th graders to talk about the ideas they have and discuss the status of their conceptions in a 3-month ecology unit, demonstrated a better restructuring of their ecology understandings as compared to their counterparts who were taught through the Science Curriculum Improvement Study Cycle (Blank, 2000). An instructional intervention called Dual-Situated Learning that considers students' prior beliefs about science concepts creates dissonance with student prior knowledge and provides students with mental states to re-construct scientific view about the concept. A test of this instruction with 9th graders learning 'heat transfer' was found to have great potential for radical conceptual change (She, 2004).

Some of the post-instructional reflections of the students in the present research are crucial for their well-being and survival. Examples:

Reflections by 5th graders (Table 18)

- I used to believe that alcohol damages the intestine only. Now, I learned that it also damages the brain and other internal organs of our body (M12, IL).
- I used to believe that malaria infects us when our environment is not clean. Now, I understand that malaria transmits by mosquito (F11, IL).
- I used to believe that malaria infects us when there are swamps and grasses around our homes. Now, I understand that malaria infects us when we stung by ***Anopheles*** mosquito (M11, PL).

Reflections by 6th graders (Table 19)

- I used to believe that tuberculosis affects cigarette smokers only. Now, I realized that it could affect non-smokers and other animals (M13, IL).

- I thought that drinking polluted water is the only cause of cholera infection. Now, I learned that washing our bodies, clothes and food utensils using water polluted with cholera-causing microbes could cause cholera (F13, IL).
- We thought that all water is clean. Now, we realized that water can be polluted via various means, thus should be boiled for consumption (M11/12, PL).

These demonstrate that metacognitive reflection assists learners in revisiting their prior thoughts and revising them to learn in ways that allow them to adapt and survive in their communities. This is the ultimate goal of instruction, as argued by Dijkstra (2001). We could see that the students have considerable experience with the various topics addressed, scientific or otherwise, which could have been left in their mental repertoire without making meaningful effort to explain them.

*Better student involvement*

In primary schools of Ethiopia, teacher-centered teaching has been a tradition. Despite the commitments of the various stakeholders of education for a shift from teacher-centered instructional tradition to a learner-centered one, teacher-centeredness is still prevailing. School facilities and teacher expertise also are limited, delaying the shift to learner-centeredness. Thus, the present metacognitive instructional intervention serves as an important complement by advancing students' active involvement in minds-on activities. In these endeavors, students were required to change or reconstruct their pre-instructional beliefs or understandings. Such minds-on activities provide sufficient time for discourse that promotes thinking for thoughtful reflection. Moreover, students were encouraged to believe that their pre-instructional ideas, thoughts, assumptions, or beliefs are the foundations on which they can construct or reconstruct scientific understandings

(Pine, Messer, & John, 2001). Such encouragement elicits student motivation, which in turn facilitates conceptual change learning (Pintrich, 1999; Tyson, Venville, Harrison, & Treagust, 1997).

### Implications for classroom practice and research

The guiding objectives of this research were to supplement global science education research and practice in metacognition and complement the deficiencies in science instruction in Ethiopia's primary schools. The findings of the study supported the assertions of various studies that metacognitive instructional interventions yield encouraging outcomes even among primary school children. Nonetheless, the present metacognitive model played no significant role in promoting retention of learned contents six months after the completion of the intervention. Hence, we need further inquiry on the role of metacognition and metacognitive instructional strategies on retention.

Ethiopia's primary science education practice is faced with formidable hurdles to adapt up-to-date science instructional models. The problems include: (a) lack of facilities for hands-on science activities, (b) lack of appropriately designed textbooks (c) low teachers' pedagogical knowledge and subject matter expertise, (d) lack of instructional models for conceptual change learning, and (e) high student population per class. Thus, seeking an instructional model compatible with these problems would be of great significance. The present metacognitive reflection model, while not performing as well as hoped, did provide positive effects and helps fill the gap. Moreover, the model is suitable as it is simple and can be incorporated in the most traditional teaching methods and even employed by inexperienced teachers and students. Since the intervention did not work well in a cooperative learning setting, precautions are called for while employing the model under such conditions. And, regardless of the setting, students must be given sufficient time to think, discuss, evaluate, and revise their prior conceptions and state their reflections in order for desired conceptual change learning to take place.

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# ARTICLE 3

## METACOGNITIVE READING

## IN LEARNING PRIMARY SCHOOL SCIENCE

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## ABSTRACT

SBHATU, DESTA BERHE. **Metacognitive Reading in Learning Primary School Science.** (Under the Direction of Professor John E. Penick.)

*This study investigated the contribution of metacognitive reading activities in learning science among primary school students (age 10-14) in Mekelle, Ethiopia. Three classes of grade 5 and three classes of grade 6 participated. Students in each grade were assigned into two treatment classes (Individual and Pair learning) or a Comparison class. Instruction in the treatment classes was supported by metacognitive reading and reflection activities while the Comparison classes were taught through traditional methods. Students in Individual learning classes carried out reading assignments and classroom reflections individually, and those in Pair did the same in dyads. Observation notes and student and teacher reflections constituted the qualitative data. Prior school performance and post-test scores of Immediate and Delayed test-groups comprised quantitative data. Quantitative data analyses revealed no apparent contribution. The intervention had no effect in promoting student performance, ability with higher order thinking questions and retention. Qualitative data revealed that the metacognitive activities fostered student conceptual change learning and promoted student participation in reading as well as thinking and explaining their beliefs and understandings about science topics in class.*

## Introduction

Constructivism, inquiry, and conceptual change learning are known to be effective when reading and writing are incorporated in the process of instruction. Whether constructivism (in its various forms) or enculturation (situated learning) are the theoretical frames of reference for science instruction, the role of science reading remains fundamental. Along with inquiry, reading is becoming one of the essential components of science education research and practice. Over a decade ago Glynn and Muth (1994) wrote that reading and writing are important vehicles to promote scientific literacy, and recommended that science education researchers show how reading and writing can be used most effectively to support science learning. Now, metacognitive reading is gaining popularity as another powerful tool in science instruction and research.

## Reading and constructivism

While interactive-constructive models of discourse reveal the importance of language in science education, the quantity and quality of verbal interactions are low and unfocussed in science classrooms (Holliday, Yore, & Alvermann, 1994; Yore, Bisanz, & Hand, 2003). Reading also is known to be important for attaining scientific literacy and development of scientific thinking, but, as argued by various researchers, it is de-emphasized in science education (Armbruster, 1992/93; Willington, 2001; Yore & Shymansky, 1991). Explaining the limitations of research in science reading and writing, Yore and co-authors stated that, ‘Reading and writing research in science education was sparse during the early years of the *International Journal of Science Education* [1978-1993] because of the overwhelming desire to promote hands-on activities and to move away from science textbooks and worksheets’ (Yore, Bisanz, & Hand, 2003, p. 697).

Nonetheless, citing meta-analytic works of various researchers in 1980s, the authors found that hands-on activities without some form of minds-on supplemental activities were not as effective as promoted.

Even though science education research and practice began considering comprehension strategies, in addition to textbooks and designs of inquiry environments, many of the studies of science reading during 1978–1993 emphasized student reading skills (Yore, Bisanz, & Hand, 2003). They further found out that despite teacher attitude toward science reading becoming positive and more or less conforming to interactive-constructive models, explicit instruction of science reading comprehension in elementary and secondary classrooms was limited. During this period science education researchers began to consider reading in relation to the major psychological theory of learning in science education. Thus, science reading ‘evolved from text-driven models, to reader-driven models, and finally, to interactive reader and text models’ that ‘reflected the rejection of reading as taking meaning from the text and reading as readers creating meanings exclusively to the acceptance of the readers make sense of text’ (Yore, Bisanz, & Hand, 2003, p. 698). In this sense, science reading requires readers to employ concrete experiences, prior knowledge, cognitive operations, and language to create understanding (Yore & Shymansky, 1991).

The assumption that reading is a process of interaction between the reader and the text requires science teachers to help their students examine the sources, limits, and certainties of their knowledge as well as make meanings out of the texts in various ways, judge those ways against valuable evidence, and espouse a critical stance (Phillip & Norris, 1999). These authors further stated that the appropriation of semantic and syntactic relationships of a text depends upon the metacognitive strategies and the repertoire of knowledge readers bring from their world and what happens when their world and the world of paper meet. Hence, science reading has to be practiced in such a way that it involves both cognitive thinking (thinking about things) and metacognitive thinking (thinking about thoughts). A shift in reading strategies from the former to include the latter is essential (Olson, 1994). The practical implication is that the process of negotiating understandings about science concepts within the community of learners should include reading and writing activities in addition to classroom discussions. Negotiating of meanings or meaning making has to be carried out or supported by reading and writing of science texts (Keys, Hand, Prain, & Collins, 1999). The reading activities, in turn, need to employ metacognitive strategies.

### Reading and inquiry

Though doing and reading science are similar processes, drawing upon the same cognitive bases (Armbruster, 1992/93), science curricula usually fail to integrate reading and inquiry activities (Ediger, 2005). In fact, like good inquirers, good readers scrutinize their prior knowledge, form hypothesis, establish plans, evaluate understanding, describe patterns, compare and contrast, make inferences, draw conclusions, generalize, and evaluate sources (Armbruster, 1992/93). Like inquiry, reading is another way of acquiring scientific information (Ediger, 2005), thus science learning. A study that investigated the effectiveness of applying the learning cycle to science reading activity revealed that reading comprehension and scientific inquiry involve similar information processing strategies (Musheno & Lawson, 1999). Reading activities provide authentic, real-world contexts for activating and refining science processes skills (Glynn & Muth, 1994). Thus, reading proficiency of scientific texts would be supportive of learning through scientific inquiry. Reading for understanding of background information of scientific conceptions before carrying out experiments allows the learner to be more comprehensive and learn more (Nesbit & Rogers, 1997). One study reported that science texts (reading) presented in learning cycle format were more comprehensible for readers at all reasoning levels (Musheno & Lawson, 1999). The practical implication is that hands-on inquiry activities and reading, which support one another, must be balanced for students to get the real taste of science (Willington, 2001). Arguably, inquiry involves both hands-on and minds-on activities, where reading and writing are important minds-on endeavours.

### Reading and conceptual change learning

When learners fundamentally restructure their thinking about something, we say conceptual change (conceptual learning) has occurred (e.g. Dole, 2000). The theory of conceptual change learning or simply conceptual learning (which can sometimes be reduced safely to learning) is based on the idea that pre-instructional conceptions must be altered to match canonical scientific conceptions (Ridgeway & Dunston, 2000). Thus, for conceptual change to take place oral and written discourses are crucial (Maria, 2000). Hence, reading science texts from the perspective of conceptual change learning models helps learners to restructure their knowledge and thinking. Encouraging students to make their ideas explicit and compare them to others' ideas fosters scientific understanding (Chan, 2001).

Spence (1995) explained that reading of science texts involves the interaction of the prior knowledge, beliefs, and the text in constructing meaning and understanding. It is further stated that reading science texts 'involves accessing prior knowledge from long-term memory, interpretations for the text and sensory information from the environment, and interactively constructing meaning of these data in the working memory while responding to specific contextual influences' (Rivard & Yore, 1992, p. 3). Nevertheless, studies revealed that unless learners are guided and innovative reading strategies (such as metacognitive ones) are employed, mere reading did not lead to conceptual learning. The use of metacognitive strategies to enhance reading comprehension is reported to be beneficial to students, even under minimal teacher guidance (Koch, 2001). In addition to general metacognitive reading strategies, science readers need to consider conceptual demands pertinent to science. Thus, according to Spence (1995), 'readers must have knowledge about scientific enterprise, the concept under consideration, the scientific language, the patterns of argumentation, the canons of evidence, the science reading process, the science text, and the science reading strategies' (p. 5).

Conceptual change studies on science reading, however, tend to limit their focus on how text structures influence conceptual change learning (Holliday, Yore, & Alvermann, 1994), such as refutation versus expository text (e.g. Diakidoy, Kendeou, & Ioannides, 2002; Guzzetti, Williams, Skeels, & Wu, 1997; Palmer, 2003), conceptual change versus expository texts (e.g. Cakir, Uzuntiryaki, & Geban, 2002; Sungar, Tekkaya, & Geban, 2001; Tekkaya, 2003), difficulties or abilities of students when reading pictorial representations or images in science texts (e.g. Ametller & Pinto, 2002; Colin, Chauvet, & Viennot, 2002; Stylianidou, Ormerod, & Ogborn, 2002; Testa, Monroy, & Sassi, 2002), and format of textbooks (William & Yore, 1985).

Refutation texts are designed to state misconceptions and provide scientifically acceptable conceptions that refute the misconceptions (Guzzetti, 2000). The assumption behind refutation text is that once reading is regarded as an interactive process between the reader and the text, it would be legitimate to argue that student prior knowledge is as important as the textbook knowledge for conceptual change learning (Dole, 2000). Likewise, conceptual change texts are designed for explaining student misconceptions and their causes as well as why they are incorrect, and informing students about the scientific conceptions. They bring students' pre-instructional conceptions under scrutiny (Cakir, Uzuntiryaki, & Geban, 2002; Ozkan, Tekkaya, & Geban, 2004).

Nonetheless, the effects of refutation and conceptual change texts on conceptual change learning are not consistently positive. For example, an investigation of the effects of refutation text on conceptual change learning of physics showed that students failed to attend to the text critically and persisted with their preconceptions (Guzzetti, Williams, Skeels, & Wu, 1997). These authors claimed that either the refutation text was not effective or the reading strategies were not sufficient to lead to conceptual change. Guzzetti (2000) later contended that though refutation texts could create awareness in students that there ***are*** conflicting ideas, this awareness by itself would not lead to conceptual change unless it is followed by appropriate instructional strategies that promote conceptual change. Unless students' prior knowledge is brought to self-scrutiny, it impairs comprehension when it conflicts with scientific conceptions. Studies that support this argument are available in the literature. For instance, the use of an instructional strategy called Prior Knowledge Monitoring and Integration, which helps readers to monitor their changing understanding of science concepts by allowing them to:

(a) identify and record their everyday ideas, (b) compare them with textbook ideas, and (c) determine whether or not there is match/mismatch between those ideas, demonstrated conceptual change that can be regarded as significant (Dole, 2000).

As far as text structure is concerned, it is unlikely that all science textbooks across levels and nations would be designed to suit the characteristics of refutation or conceptual change texts. Moreover, refutation or conceptual change texts would not include all possible misconceptions students could hold from various sources. Therefore, studies on reading of science textbooks or trade books (not science texts designed for research purposes) reveal that a lot has yet to be done to make reading an effective and efficient instructional strategy. The best direction in science reading research should be toward seeking effective reading strategies for expository texts (where ideas and concepts are logically arranged in a predictable fashion and comparisons, descriptions, causation, etc are presented in a written piece), as that is the case of science textbooks. Moreover, the high educational spending of nations on science textbooks (Willington, 2001; Yore, 1991) obliges science educators to make proportionate efforts for developing comprehension strategies for such texts.

## Incorporating metacognitive science reading strategy

Students across levels encounter problems grasping understandings from readings of science texts (Best, Rowe, Ozuru, & McNamara, 2005; Peacock & Weedon, 2002). Limitations in reading comprehension hinder students in understanding and applying difficult ideas during science instruction (Ward & Wandersee, 2002). This is because, as Holliday, Yore, and Alvermann (1994) state, readers of science texts need to interactively process information by switching between text-based information and concurrent experiences on the one hand and personal knowledge, assumptions, and beliefs on the other hand. Thus, science instruction has to employ models of reading and practicing of meaning negotiation with the discourse of the textbook to promote the ability of students to understand concepts and incorporate them into their explanations (Wallace, 2004). Science classrooms must create contexts where students can be provided with opportunities to use prior knowledge and develop skills, regulatory operations, and strategies that will enhance their understandings of science texts and improve the effectiveness of the reading process (Yore & Shymansky, 1991). Nonetheless, teaching for effective reading is neglected in science classrooms (Yore, Bisanz, & Hand, 2003; Wallace, 2004). Since science students do not usually make efforts to employ reading and comprehension strategies, explicit strategy instruction and modelling are not only highly recommended but are also proven to be effective (e.g. Best, Rowe, Ozuru, & McNamara, 2005, Heselden & Staples, 2002; William & Yore, 1985; Willington, 2001).

For instance, Keys, Hand, Prain, and Collins (1999) employed a teacher template that consisted of a series of suggested activities that involved students in meaningful thinking, writing, reading, and discussion about laboratory concepts, and found learning gains. In another study, the use of well-established reading strategies helped two high school students to comprehend biological research articles (Brill, Falk, & Yarden, 2004). A study among Israeli $4^{th}$ graders indicated that students who used metacognitive reading guidance (called metacognitive awareness guidance–MCAG) outperformed a comparison group who were allowed to read and answer questions that followed the reading. They also outperformed a placebo group who read content instructions and text and answered questions that followed when they were convinced that they understood the text

(Guterman, 2002). Explicit instruction of a reading strategy called Concept-Oriented Reading Instruction (CORI) was reported to be beneficial in promoting intrinsic motivation, literacy strategy use, and conceptual understandings in science (Swafford & Bryan, 2000). CORI requires students to: observe and personalize, search and retrieve, comprehend and integrate, and communicate. Each of the activities requires a good deal of metacognitive thinking. Moreover, $3^{rd}$ and $5^{th}$ graders who received CORI demonstrated higher achievement than their counterparts who were taught through traditional instruction (Guthrie, Van Meter, McCann, Anderson, & Alao, 1996). These authors found that CORI increased conceptual learning in comparison to traditional instruction. Similarly, Guthrie et al. (2004) compared the effects of three instructional strategies, namely CORI, strategy instruction (SI), and traditional instruction (TI) on reading comprehension of science text among $3^{rd}$ and $5^{th}$ graders and found that the CORI group outperformed their counterparts.

**The need for this study**

We believed that metacognitive strategies of reading science would assist students in developing comprehension skills for constructing meanings, inquiring, and restructuring of understandings from texts across levels. Hence, we designed a reading checklist called Metacognitive Science Reading Checklist (MSRC) (Table 31), where its effectiveness in learning science among Ethiopian primary school students (i.e. grades 5 and 6, age 10-14 years) was investigated. The checklist was designed in such a way that students would develop science processes such as comparing and contrasting, inferring, predicting, and communicating so that they would make meanings out of science texts and/or restructure their conceptions by engaging in metacognitive thoughts and reflections before, during, and after reading tasks. The checklist is provided with guiding questions to help students to remain aware of the reading process.

Table 31. Metacognitive Science Reading Checklist

| Reading Phase | Reading Comprehension Guiding Questions |
|---|---|
| 1. Pre-Reading | • What does the heading/topic mean?<br>• What do I know about the heading/topic?<br>• What do I expect to know after reading the topic?<br>• *What reading strategies should I use? Why? |
| 2. Reading | • What is my reading telling me?<br>• To what point is my reading leading?<br>• Do I comprehend what I am reading?<br>• What are the main ideas of the topic? The supportive ideas?<br>• If I cannot comprehend, how should I read my text? |
| 3. Post-Reading | • Can I summarize the topic and tell to my friend? My teacher?<br>• Are the ideas congruent with what I know before reading?<br>• How are they similar or different?<br>• Did I learn what I expected to learn at the beginning? What?<br>• Did my reading strategies help me? How? |

* = The students know a repertoire of reading strategies such as slow reading, rereading, silent reading, and reading aloud, underlining, and taking short notes

Since much content is provided in expository science textbooks across all levels, students need to have effective reading strategies to learn successfully (Yore, Craig, & Maguire, 1998). What makes effective science reading skills so fundamental is that almost all of the words or terms in science texts are important. If one part of an argument is skipped or misunderstood, the remaining parts become incomprehensible (Koch, 2001). Thus, based on the argument that metacognitive knowledge provides insights into the awareness and control of science reading (Yore, Craig, & Maguire, 1998), science educators are trying to include metacognition strategies in science reading research.

Nevertheless, many such studies are restricted to secondary and university students (e.g. Brill, Falk. & Yarden, 2004; Guzzetti, Williams, Skeels, & Wu, 1997; Koch, 2001).

Hence, the present study investigates the effectiveness of a metacognitive reading strategy in learning primary science in Ethiopia. The study was believed to augment reading research in science education and was expected to support the efforts of enhancing primary science instruction by promoting learner-centeredness in populous classrooms of Ethiopia's primary schools. Since Ethiopian primary school science textbooks are exceptionally bulky, packed with theoretical contents, the reading checklist is believed to be of paramount importance.

## Purposes of the study

Based on the justifications presented above, this study examined the effectiveness of the Metacognitive Science Reading Checklist for learning primary science (grades 5 and 6) in the large and poorly enriched classrooms of Ethiopian schools. Moreover, the study looked at the effectiveness of the checklist under individual and pair cooperative learning settings. Thus, the present metacognitive instructional intervention addressed the following questions.

(1) As compared to more traditional instruction, did the intervention yield better overall learning gains among students of Ethiopia's large class-size primary schools (grade 5 and 6)?

(2) Did the treatment classes perform better on higher order thinking tests than did the comparison classes?

(3) Did the intervention help students in the treatment classes to better retain learned content than those in comparison classes?

(4) Was the instructional method more effective in pair learning setting as compared to individual learning setting?

(5) Did the intervention produce similar positive outcomes in both grades?

## Methodology

The study was conducted in two complete primary schools located in Mekelle (Ethiopia). During the period of the study the first school (school-3) enrolled 2300 students and the second one (school-2) had 3000. A 5th grade General Science teacher from the first school and a sixth grade one from second school participated in the study. The intervention began with 221 students (108 boys, 113 girls) of grade 5 from the first school and 195 students (107 boys, 88 girls) of grade 6 from the second one.

### *Participating teachers*

The 5th grade teacher was a 52-year old male with 27 years teaching experience. According to the current Ethiopian Education and Training Policy (ETP), effective as of 1994, his qualification allows him to teach in grades 1 to 4. However, he has been teaching General Science in grades 5 and 6 for the last 15 years. He had a total teaching load of 28 periods (40 minutes each) per week throughout the intervention period. He was teaching three classes of grade 5 and four classes of grade 6.

Likewise, the 6th grade teacher was a 49-year old male with 25 years experience. He was qualified to teach biological sciences in junior secondary schools, where he had taught for 16 years. However, according to the ETP of Ethiopia, he is required to teach sciences in upper primary grades (i.e. 5–8). Out of his nine years of teaching service in upper primary, he has been teaching grade 6 General Science for the last two years. During the present intervention, he had a total teaching load of 28 periods per week.

### *Pre-intervention training of participating teachers*

Both of the teachers participated in pre-intervention training and preparation of annual course and daily lesson plans of the contents covered during the intervention period. (Details on the training are indicated in the methodology section.) At the completion of the training, the teachers were assigned to teach using the Metacognitive Science Reading Checklist, and provided with guidelines for incorporating it. They were also instructed to write reflective journals about the intervention and record students' pre- and post-reading reflections when they employed the instructional method.

### *Participating students*

The majority of the students in both schools belong to medium to low-income families of outer-town neighbourhoods. There were three classes of grade 5 in the first school, all included in the study. The classes were assigned to: (a) Individual learning class, (b) Pair learning class and (c) Comparison class. Likewise, there were six classes of grade 6 in the second school from which three were randomly selected for the study. The three classes were assigned to: (a) Individual learning class, (b) Pair learning class and (c) Comparison class.

The students in the treatment classes were given a 40-minute training by their teacher on the use of the MSRC in reading science texts at the beginning of the intervention. The students were also instructed that they were going to have reading assignments for every lesson, whereby they would employ the checklist. Then, they were advised to study the checklist in such a way that as to use it automatically. The students were also instructed to take summary notes on pre- and post-reading understanding about reading topics as well as reconciling reflections during every reading assignment.

### *Course and lesson planning*

Details about the preparation of the annual course and daily lesson plans, as well as the descriptions of the contents covered during the intervention are indicated in the methodology section. Both participating teachers were involved in the preparation of annual course and daily lesson plans of the topics covered in the study. Three units, i.e. (a) Human Breathing System, (b) Human Nervous and Endocrine Systems, and (c) Animal Reproduction, were covered in grade 5. Likewise, four units, (a) Our Environment, (b) Human Diseases, (c) Physical Properties of Matter, and (d) Refraction, were covered in grade 6.

### *Incorporating the MSRC*

The format of the daily lesson plans used in the intervention included the following major activities with respect to the actual instruction. These were: (a) Introduction, (b) Presentation, (c) Stabilization, and (d) Evaluation. It was believed that metacognitive science reading activities are effective when a longer time is given for the reading sessions. Hence, the participating students were allowed to carry out the metacognitive reading activities within extended periods. The metacognitive reading activities were incorporated first by requiring students to take reading assignments for every forthcoming lesson and have summary notes in order to participate during instruction. Then, after the lessons were introduced (Introduction) as indicated in the lesson plan, the students were invited to be involved in the Presentation of the lesson.

During this stage, the teachers were guiding their students to (a) reflect on their pre-reading beliefs and understandings about the reading topic, (b) explain the main ideas and concepts of the topic after they read it, and (c) compare their pre-reading beliefs and post-reading understandings. The Introduction, Stabilization, and Evaluation of every lesson were presented as indicated in the format of the lesson plans with no modifications. Students in Individual learning classes were required to make the reading assignments and reflections individually, while those in the Pair learning classes were required to make their readings and reflections in pairs. Students in the Comparison class were given reading assignments, but they were neither given the checklist nor required to make any reflections. The modified lesson activities are indicated in Table 32.

Table 32. Lesson activities incorporating MSRC

| Activities | Treatment Classes | Comparison Class |
| --- | --- | --- |
| Homework | Students read forthcoming lesson using MSRC and have summary notes and reflections. | Students read forthcoming lesson as instructed by the teacher. |
| Introduction | Teacher introduces the lesson | Teacher introduces the lesson |
| Presentation | Teacher asks students to: (a) reflect on their pre-reading conceptions of the reading topic, (b) explain the main ideas the reading topic, and (c) compare their pre-reading conceptions and post-reading understandings. | Teacher teaches the lesson |
| Stabilization | Teacher summarizes the main points of the lesson. | Teacher summarizes the main points of the lesson. |
| Evaluation | Teacher presents evaluation questions. | Teacher closes lesson by presenting evaluation questions. |

### *Data sources*

Non-participant observation data and teacher reflections and student reflections, both recorded by the participating teachers, were the major sources qualitative data. Likewise, prior academic performance and post-intervention test scores were sources of quantitative data.

## Qualitative data collection, analyses, and findings

### *Non-participant observation*

Non-participant observation data were used (a) see whether the teachers were incorporating the metacognitive reading strategy properly whereby they encouraged the students to reflect on their pre- and post-reading understandings, (b) observe the capabilities of the students in providing such reflections, and (c) to record the pre-reading beliefs, thoughts or conceptions, and post-reading understandings. Observation data were collected using field notes, which were expanded immediately after the completion of each observation and written in computer files. Observation data from a total of 18 sessions conducted in the intervention classes of both grades were analysed.

#### *Did the lessons taught according to the guideline?*

Overall, nine observation sessions were carried out in treatment sections of each grade. Sorting and grouping of the instructional activities recorded in field notes disclosed that six instructional routines were apparent. These were: (i) Lesson Introduction, (ii) Reflection on Pre-reading Understandings, (iii) Post-reading Reflections, (iv) Lesson Stabilization, (v) Lesson Evaluation and (vi) Reading Assignment. In these routines, all of the four phases of classroom instruction are represented, where (ii) and (iii) denote Lesson Presentation.

According to the intervention plan, the students were required to make reflections on their pre-reading and post-reading understandings about lesson topics during the Presentation stages of the lessons. A summary of the nine observation sessions among 5$^{th}$ graders showed that reflections on pre-reading beliefs and post-reading understandings were parts of the instructional activities in six and nine of the lessons, respectively.

Likewise, a summary of the nine observation sessions in grade 6 indicated that reflecting on pre- and post-reading understandings were incorporated in six of the lessons. All of the lessons observed in both grades were completed by giving reading assignment on the forthcoming lessons as per the guideline introduced for the study. Thus, we can see that the intervention was fairly conducted as intended.

### *Were the students capable of making metacognitive reflections?*

When students were invited to state reflections about their pre-reading beliefs, thoughts, conceptions, or understandings, they often made them in reference to what they read in the assignment. This implies that the students did become conscious about the match or mismatch of their pre-reading beliefs or understandings and the contents they read. Thus, examination of the reflections on pre-reading understandings would help us to ascertain whether or not the students were making thoughtful reflections. Close examination of the reflections on pre-reading beliefs or understandings recorded during observation sessions revealed that they include metacognitive and non-metacognitive ones. The descriptions of metacognitive and non-metacognitive reflections are given elsewhere (Article 2). Metacognitive reflections about pre-reading beliefs or thoughts are reflections that indicate the awareness of students when stating statements on the beliefs they held that contradict to scientific conceptions. Examples of metacognitive reflections on pre-reading conceptions stated by 5$^{th}$ graders about insect reproduction are given as follows.

> I used to believe that insects grow by the help of rain (M12, IL)*.
> I thought that houseflies give live birth like humans (F11, IL).
> I thought that flies reproduce by wind [air] like birds (M12, IL).

* M or F = male or female, Number = age, IL = Individual learning class

On the other hand, non-metacognitive reflections are statements that indicate what students didn't know about a topic without implying whether or not they had a different understanding about that topic. Examples of non-metacognitive statements by 5th graders about the structure the nervous system are given below.

> I didn't know that the spinal cord is connected to the hypothalamus (M12, IL).
>
> I didn't realize that the spinal cord is connected to the brain (F11, PL)*.
>
> * PL = Pair learning class

The researcher collected a total 32 reflection statements on pre-reading beliefs, thoughts, or understandings in the two intervention classes of grade 5. The types of the reflections are summarized in Table 33. The summary disclosed that about 69% of the reflections were metacognitive. Likewise a total of 24 statements of reflections were recorded in grade 6. Study of these reflections revealed that 63% of them were metacognitive. From these accounts, we can see that the students were capable of stating metacognitive reflections.

Table 33. Summary of pre-reading reflections given by 5th and 6th graders

| Reflections on pre-reading conceptions | Treatment Classes | | | | | |
|---|---|---|---|---|---|---|
| | Grade 5 | | | Grade 6 | | |
| | Individual | Pair | Total | Individual | Pair | Total |
| Metacognitive | 10 (67%) | 12 (71%) | 22 (69%) | 9 (60%) | 6 (67%) | 15 (63%) |
| Non-metacognitive | 5 (33%) | 5 (29%) | 10 (31%) | 6 (40%) | 3 (33%) | 9 (37%) |
| Total | 15 (100%) | 17 (100%) | 32 (100%) | 15 (100%) | 9 (100%) | 24 (100%) |

### ***Teacher reflections***

The 5th grade teacher was writing some of his observations when using the metacognitive teaching methods. Translated excerpts of the teacher's reflections are included in the discussion section.

### *Student reflections*

The participating teachers recorded samples of pre- and post-reading reflections of their students in many of the lessons. Examination of the reflections supports the conclusion from the observation data. Examples of translated pre- and post-reading reflections are shown in tables 34 and 35.

Table 34. Rreflections on pre- and post-reading understandings by 5th graders

| Wk | Lesson Topic | Reflection on Pre-reading Beliefs | Reflections on Post-reading Understandings |
|---|---|---|---|
| 5 | The Brain | • I didn’t know that the brain has three parts (M10, IL).<br>• I assume that the brain has one part (M11, PL).<br>• I didn’t realize that the spinal cord is connected to the brain (F11, PL). | • I learned that the brain has three parts (M10, IL).<br>• I learned that the hypothalamus is connected to the spinal cord (F11, IL; M10, PL). |
| 6 | The Effect of Alcohol on the Nervous System | • I didn’t know any harmful effects of alcohol on nerves and the brain (M13, PL).<br>• I didn’t know that drinks have alcohol (F12, PL).<br>• I didn’t understand that alcohol damages our internal organs like liver, intestine and pancreas (M12, PL). | • I learned that alcohol damages the different parts of the brain (M13, PL).<br>• I understand that which drinks contain alcohol and which ones do not (F12, PL).<br>• I learned that alcohol damages different internal organs of our body (M12, PL). |
| 7 | Animal Reproduction | • I used to believe that insects grow by the help of rain (M12/13, IL).<br>• I thought that houseflies give live births like humans (M12, IL).<br>• I thought that houseflies reproduce by wind (air) like birds (M12, IL). | • I learned that insects reproduce by sexual means (M13, IL).<br>• I learned that houseflies reproduce by laying eggs (M12/12, IL). |
| 8 | Reproduction in Housefly | • I used to believe that insects are created from dirt (M14, PL).<br>• I thought insects are created from air (F12, PL).<br>• I thought insects are brought from somewhere else by wind (M11, PL). | • I learned that insects reproduce by sexual means (F13, M14, F12, PL).<br>• I learned that houseflies grow from eggs to adults (F12, M14, PL). |

Table 34. continued

| | | | |
|---|---|---|---|
| | Reproduction in Mosquito | • We used to believe that male mosquito transmits malaria (M14/12, PL).<br>• I didn't believe that there is male mosquito after all (M12, IL).<br>• I didn't know that female mosquito has anything to do with transmission of malaria (M12, IL). | • We learned that male mosquito feeds on saps of plants (M11/11, PL).<br>• I learned that male mosquito does not transmit malaria (M12, IL).<br>• I know that female mosquito transmits malaria (M12, IL). |
| 9 | Reproduction in Locust | • I used to believe that locusts are brought by wind (M13, IL).<br>• I used to believe that newly hatched locusts have wings (M12, IL; M11/13, PL).<br>• We used to believe that locusts could lay eggs everywhere (M10/13, PL).<br>• We used to believe that locusts are created from crops (M13/12, PL). | • I learned that locusts reproduce by laying eggs (M13, IL).<br>• I learned that the eggs of locusts hatch to wingless young (M12, IL).<br>• We learned that a female locust lays numerous eggs in sand holes (M13/10, PL). |
| 12 | Reproduction in Fishes | • I used assume that fishes give live births (M13, IL). | • I learned that fishes reproduce by laying eggs (M11, IL).<br>• I learned that there are male and female fishes (M12, IL). |
| 13 | Reproduction in Amphibians | • I didn't believe that there are male and female frogs (F11, IL) | • None |
| 14 | Reproduction in Birds | • I used to believe that birds give live births like humans (F11, IL).<br>• I didn't believe that bird reproduce by sexual means (F11, IL).<br>• I thought that all birds are females (F14, IL). | • I learned that birds reproduce by laying eggs (M12, IL).<br>• I learned that there are male and female birds (F14, IL). |

**Note:** F = Female, M = Male, IL = Individual learning, PL = Pair learning, M11 = 11 yr old male, M11/12 = 11 and 12 yr old males

Table 35. Rreflections of post-reading understandings by 6th graders

| Wk | Lesson topic | Reflections on post-reading understandings in relation to pre-reading beliefs |
|---|---|---|
| 5 | Diseases: Means of Transmission | • I used to believe that diseases are transmitted only via breathing. But now I understand that diseases can also be transmitted by water, food, contact and vectors (F11, IL).<br>• I thought that diseases are transmitted by air and sexual intercourse. I now knew that they could also be transmitted by food, water and contact (M12, IL).<br>• I knew about airborne diseases. But now I learned that diseases could also be transmitted by other means (M13, PL).<br>• I thought that all bacteria are harmful. Now I understand that there are also beneficial bacteria (M13, PL).<br>• I used to believe that bacteria and viruses are the only disease causing organisms. Now I learned that protozoa and rickettesia are also diseases causing organisms (M14, PL) |
| 6 | Amoebic Dysentery and Ascariasis | • I thought amoebic dysentery and ascariasis are transmitted simply by contact. Now I understand that these diseases are food borne diseases (M13, IL). |
| 7 | Bilharziasis | • I thought that bilharziasis would catch us when we drink polluted water. Now I understand that bathing in polluted water would also cause bilharziasis (M13, PL). |
| 8 | Food Hygiene and Feeding Habits | • I thought that food gets spoiled when touched by unclean hands or when flies rest on it. Now I understand that cockroaches and mice can also spoil food (F13, PL).<br>• I didn't know that vegetables are useful components in a diet (F12, IL).<br>• I thought sleeping immediately after eating is advisable. I learned that one has to stay for a while before going to bed immediately after feeding (M12, IL). |
| 9 | Diseases Transmitted by other Means: Malaria | • I used to hear about malaria. I thought it catches us when it is cold or when we sleep around moist locations, but I didn't know that it is transmitted by mosquito. I thought we caught malaria from the moisture (F13, PL). |
| 11 | Physical Properties of Matter: Volume | • I thought volume is the measure of water (F12, PL).<br>• I thought volume refers to a measure of an area upon which an object is placed (F12, PL).<br>• I thought volume means to hold or wrap (M12, PL). |
| 16 | Refraction: Lenses | • I thought lens is simply a mirror (M12, IL).<br>• I thought lenses only help see distant objects (F11, IL). |

**Note:** F = Female, M = Male, IL = Individual learning, PL = Pair learning, M11 = 11 yr old male, M11/12 = 11 and 12 yr old males

## Quantitative data collection, analyses, and findings

The three classes at 5th grade had between 72 and 75 students per class. Likewise, there were 64 to 67 students per class in grade 6. However, students who were far older than the legal ages of Ethiopia's education policy (i.e. $11^{1/12}$ and $12^{1/12}$ years for 5th and 6th graders, respectively) were excluded from the quantitative study. Thus, the age ranges of 5th and 6th graders included in the quantitative study were between 10 to 13 and 11 to 14 years, respectively. Student mean scores of the core subjects of the previous academic year, referred to as prior school performance (PSP) scores, were used as pre-test scores. The method of collection of the scores of the core subjects is explained in Article 2.

Once the students for quantitative study were identified, they were assigned into Immediate and Delayed test-groups based on the PSP scores. The post-tests measured the comprehension, application, transfer, and retention abilities of the students. Three tests containing 20 questions each were prepared. The first test contained knowledge and comprehension questions while the second and third tests contained application and transfer questions, respectively. Details about the descriptions and preparation of the questions, the method of assigning the students into Immediate and Delayed test-groups for testing, and the methods of piloting and administering the tests are given in Article 2.

The intervention lasted for 14 weeks in grade 5. Students in the Immediate test-groups sat for the tests at the end of the 15th week. In grade 6, on the other hand, the intervention was completed by the end of the 16th week, students in the Immediate test-groups took the tests at the end of the 17th week. The students in the Delayed test-groups of both grades sat for the same tests 24 weeks after the end of the intervention. One participant teacher and the author scored the test papers. The interrater reliabilities of the scores of the various test-groups were over 0.99. Scores of end-of-intervention tests of students (of the Immediate and Delayed test-groups) are the major sources quantitative data. PSP and post-test scores were analysed using one-way ANOVA followed by Post-hoc comparisons using LSD at an ***a priori*** significance level of $p \leq 0.10$. Findings of the quantitative analyses are presented below.

### ***Post-test performances the Immediate test-groups***

#### *5th graders*

Prior school performance scores and post-test scores of the participating students in the Immediate test-groups were analysed using one-way ANOVA followed by the Post-hoc comparison method. No statistically significant variations were observed ($p \geq 0.100$) as a result of ANOVA or the Post-hoc comparisons (Tables 36 and 37). When mean post-test scores of the three test-groups were examined, no consistent pattern was observed.

Table 36. Mean (and SD) scores of 5th graders of Immediate test-groups and ANOVA summaries

| Variables | Mean Score (SD) of Treatments | | | ANOVA | |
|---|---|---|---|---|---|
| | Individual | Pair | Comparison | $F_{(2, 81)}$ | $p$ |
| PS Performance (100%) | 59.80 (8.74) | 60.43 (9.38) | 63.76 (9.97) | 1.270 | .286 |
| Know./Comp. Test (25 pts) | 5.58 (1.97) | 6.44 (2.91) | 6.37 (2.07) | 1.366 | .261 |
| Application Test (25 pts) | 6.22 (2.84) | 5.69 (2.46) | 5.13 (1.83) | 1.282 | .283 |
| Transfer Test (25 pts) | 4.96 (2.09) | 4.90 (1.99) | 5.24 (2.59) | .128 | .880 |
| Total Score (75 pts) | 16.76 (4.66) | 17.03 (5.04) | 16.74 (4.44) | .106 | .900 |

Table 37. Comparison matrices of mean scores of 5th graders of Immediate test-groups using LSD

| | Variables | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PS Performance | | | Know./Comp. | | | Application | | | Transfer | | | Total | | |
| | IL | PL | CC | IL | PL | CC | IL | PL | CC | IL | PL | CC | IL | PL | CC |
| IL | 1 | | | 1 | | | 1 | | | 1 | | | 1 | | |
| PL | .696 | 1 | | .118 | 1 | | .446 | 1 | | .956 | 1 | | .706 | 1 | |
| CC | .134 | .226 | 1 | .212 | .799 | 1 | .114 | .354 | 1 | .652 | .670 | 1 | .988 | .691 | 1 |

NB: IL—Individual learning class; PL—Pair learning class; CC—Comparison class

*6th graders*

ANOVA with the scores of the Immediate test-groups of 6th graders indicated no statistically significant variations with PSP and post-test scores ($p \geq 0.100$) (Table, 38). Post-hoc comparisons showed no statistically significant differences between the scores of the test-groups (Table 39).

Table 38. Mean (and SD) scores of 6th graders of Immediate test-groups and ANOVA summaries

| Variables | Mean Score (SD) of Treatments | | | ANOVA | |
|---|---|---|---|---|---|
| | Individual | Pair | Comparison | $F_{(2, 82)}$ | *p* |
| PS Performance (100%) | 66.64 (10.08) | 65.61 (10.86) | 63.94 (11.84) | .455 | .636 |
| Know./Comp. Test (25 pts) | 12.22 (4.16) | 11.50 (4.24) | 10.98 (3.88) | .708 | .496 |
| Application Test (25 pts) | 7.06 (2.56) | 6.15 (2.10) | 6.93 (2.26) | 1.208 | .304 |
| Transfer Test (25 pts) | 5.93 (2.50) | 5.79 (2.19) | 5.28 (2.13) | .674 | .513 |
| Total Score (75 pts) | 25.22 (7.33) | 23.44 (6.18) | 23.19 (6.52) | .782 | .461 |

Table 39. Comparison matrices of mean scores of 6th graders of Immediate test-groups using LSD

| | Variables | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PS Performance | | | Know./Comp. | | | Application | | | Transfer | | | Total | | |
| | IL | PL | CC | IL | PL | CC | IL | PL | CC | IL | PL | CC | IL | PL | CC |
| IL | 1 | | | 1 | | | 1 | | | 1 | | | 1 | | |
| PL | .729 | 1 | | .506 | 1 | | .152 | 1 | | .818 | 1 | | .331 | 1 | |
| CC | .348 | .572 | 1 | .239 | .633 | 1 | .834 | .214 | 1 | .272 | .403 | 1 | .250 | .889 | 1 |

NB: IL—Individual learning class; PL—Pair learning class; CC—Comparison class

## ***Post-test Performances of the Delayed test-groups***

*5th graders*

ANOVA with mean PSP scores yielded high F-values ($F_{(2, \mathbf{81})} = 1.790$) (Table 40). Post-hoc comparisons disclosed that the mean difference between the test-groups from the Individual learning (59.91, SD= 9.53) and Comparison (64.70, SD = 8.98) classes was significant at $p \leq 0.071$ (Table 41). ANOVA with Application ($F_{(2, \mathbf{81})} = 2.896$; $p \leq$

0.061) and Total ($F_{(2, 81)}$ = 2.971; $p \leq 0.057$) scores yielded marked statistical variations (Table 40). Post-hoc comparisons showed that mean Knowledge/ Comprehension score of the test-group from the Individual learning (5.02, SD = 2.04) class was statistically lower than that of the test-group from Pair learning class (6.02, SD = 2.17) ($p \leq 0.059$). The mean Application score of the same test-group (4.61, SD = 1.83) is lower than the mean scores of the test-groups from Pair learning (5.72, SD = 1.86) and Comparison (5.38, SD = 2.64) classes at $p \leq 0.030$ and $p \leq 0.057$; respectively. Furthermore, the mean Total score of the test-group from the Individual learning class (14.03, SD = 4.39) is statistically lower than those from the Pair learning (16.32, SD = 3.82) ($p \leq 0.053$) and Comparison (16.73, SD = 5.12) ($p \leq 0.028$) classes (Table 41).

Table 40. Mean (and SD) scores of 5th graders of Delayed test-groups and ANOVA summaries

| Variables | Mean Score (SD) of Treatments | | | ANOVA | |
|---|---|---|---|---|---|
| | Individual | Pair | Comparison | $F_{(2, 81)}$ | *p* |
| PS Performance (100%) | 59.91 (9.53) | 61.15 (8.98) | 64.70 (10.38) | 1.790 | .173 |
| Know./Comp. Test (25 pts) | 5.02 (2.04) | 6.02 (2.17) | 5.73 (2.06) | 1.928 | .152 |
| Application Test (25 pts) | 4.61 (1.83) | 5.72 (1.86) | 5.62 (2.06) | 2.896 | .061* |
| Transfer Test (25 pts) | 4.40 (2.20) | 4.58 (2.04) | 5.38 (2.64) | 1.393 | .254 |
| Total Score (75 pts) | 14.03 (4.39) | 16.32 (3.82) | 16.73 (5.12) | 2.971 | .057 |

* = Differences are significant at $p \leq 0.10$.

Table 41. Comparison matrices of mean scores of 5th graders of Delayed test-groups using LSD

| | Variables | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PS Performance | | | Know./Comp. | | | Application | | | Transfer | | | Total | | |
| | IL | PL | CC | IL | PL | CC | IL | PL | CC | IL | PL | CC | IL | PL | CC |
| IL | 1 | | | 1 | | | 1 | | | 1 | | | 1 | | |
| PL | .626 | 1 | | .059* | 1 | | .030* | 1 | | .764 | 1 | | .053* | 1 | |
| CC | .071* | .172 | 1 | .190 | .592 | 1 | .057* | .844 | 1 | .120 | .196 | 1 | .028* | .729 | 1 |

NB: IL—Individual learning class; PL—Pair learning class; CC—Comparison class

* = Differences are significant at $p \leq 0.10$.

*6th graders*

One-way ANOVA followed by Post-hoc comparisons showed that PSP and post-test scores of the three test-groups demonstrated no statistically significant variations (Tables 42 and 43).

Table 42. Mean (and SD) scores of 6th graders of Delayed test-groups and ANOVA summaries

| Variables | Mean Score (SD) of Treatments | | | ANOVA | |
|---|---|---|---|---|---|
| | Individual | Pair | Comparison | $F_{(2, 70)}$ | *p* |
| PS Performance (100%) | 67.86 (10.39) | 65.96 (12.21) | 63.18 (10.80) | 1.137 | .327 |
| Know./Comp. Test (25 pts) | 10.93 (2.42) | 10.02 (3.89) | 9.88 (2.57) | .934 | .398 |
| Application Test (25 pts) | 5.52 (2.23) | 5.89 (1.84) | 6.38 (2.20) | 1.045 | .357 |
| Transfer Test (25 pts) | 5.28 (1.79) | 5.23 (1.72) | 5.50 (1.91) | .152 | .860 |
| Total Score (75 pts) | 21.72 (4.94) | 21.97 (6.14) | 21.75 (4.50) | .109 | .897 |

Table 43. Comparison matrices of mean scores of 6th graders of Delayed test-groups using LSD

| | Variables | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PS Performance | | | Know./Comp. | | | Application | | | Transfer | | | Total | | |
| | IL | PL | CC | IL | PL | CC | IL | PL | CC | IL | PL | CC | IL | PL | CC |
| IL | 1 | | | 1 | | | 1 | | | 1 | | | 1 | | |
| PL | .552 | 1 | | .295 | 1 | | .547 | 1 | | .923 | 1 | | .687 | 1 | |
| CC | .137 | .399 | 1 | .213 | .867 | 1 | .153 | .436 | 1 | .663 | .612 | 1 | .984 | .681 | 1 |

NB: IL—Individual learning class; PL—Pair learning class; CC—Comparison class

### ***Comparing the performances of Immediate and Delayed test-groups***

*5th graders*

Comparisons of mean scores of the Immediate and Delayed test-groups of each treatment class were made. The mean PSP scores of the Immediate (59.80; SD = 8.74) and Delayed (59.91; SD = 9.53) test-groups from the Individual learning class were statistically comparable ($F_{(1, 52)} = 0.002$; $p \leq 0.964$). Comparisons of mean post-test scores revealed statistically significant differences with Application ($F_{(1, 52)} = 6.154$; $p \leq$

0.016) and Total scores ($F_{(1, 52)} = 4.825$; $p \leq 0.033$), in favor of the Immediate group (Table 44).

Mean PSP scores of the Immediate and Delayed test-groups from the Paired learning and Comparison classes were statistically equivalent. Moreover, the mean scores of the three tests of the test-groups from the Paired learning and Comparison classes were equivalent, with no statistically significant difference.

Table 44. Comparisons of the mean (SD) scores of Immediate and Delayed test-groups of 5th graders

| Treatment | §Test-group | PSP Mean (SD) | Know/Comp. Mean (SD) | Application Mean (SD) | Transfer Mean (SD) | Total Mean (SD) |
|---|---|---|---|---|---|---|
| Individual Learning | 1 (N=25) | 59.80 (8.74) | 5.58 (1.97) | 6.22 (2.84) | 4.96 (2. 09) | 16.76 (4.66) |
| | 2 (N=28) | 59.91 (9.53) | 5.02 (2.04) | 4.61 (1.83) | 4.40 (2.20) | 14.03 (4.39) |
| | $F_{(1, 51)}$ | 0.002 | 1.033 | 6.154 | .890 | 4.825 |
| | *p*-value | 0.964 | 0.314 | 0.016* | 0.350 | 0.033* |
| Pair Learning | 1 (N=34) | 60.43 (9.38) | 6.44 (2.91) | 5.69 (2.46) | 4.90 (1.99) | 17.03 (5.04) |
| | 2 (N=30) | 61.15 (8.98) | 6.02 (2.17) | 5.72 (1.86) | 4.58 (2.04) | 16.32 (3.82) |
| | $F_{(1, 62)}$ | 0.097 | 0.578 | 0.002 | 0.404 | 0.406 |
| | *p*-value | 0.757 | 0.450 | 0.963 | 0.527 | 0.526 |
| Comparison | 1 (N=26) | 63.76 (9.97) | 6.37 (2.07) | 5.13 (1.83) | 5.24 (2.59) | 16.74 (4.44) |
| | 2 (N=26) | 64.70 (10.38) | 5.73 (2.06) | 5.62 (2.06) | 5.38 (2.64) | 16.73 (5.12) |
| | $F_{(1, 50)}$ | 0.110 | 1.230 | 0.791 | 0.040 | 0.000 |
| | *p*-value | 0.741 | 0.273 | 0.378 | 0.843 | 0.994 |

§ = 1, Immediate; 2, Delayed

* = Differences are significant at $p \leq 0.10$.

### *6th graders*

Comparisons of PSP scores of the Immediate and Delayed test-groups of the two treatment classes and the Comparison class disclosed that they have equivalent means. The differences between mean post-test scores of the two test-groups in the Individaul learning class were more pronounced than those of the test-groups in the Pair learning and Comparison classed (Table 45). In the Individual learning class, the mean

Application and Total scores of the Immediate test-group are greater than mean scores of the Delayed test-group at $p \le 0.020$ and $p \le 0.043$; respectively.

Table 45. Comparisons of the mean (SD) scores of Immediate and Delayed test-groups of 6th graders

| Treatment | §Test-group | PSP Mean (SD) | Know/Comp. Mean (SD) | Application Mean (SD) | Transfer Mean (SD) | Total Mean (SD) |
|---|---|---|---|---|---|---|
| Individual Learning | 1 (n = 29) | 66.64 (10.08) | 12.22 (4.16) | 7.06 (2.56) | 5.93 (2.50) | 25.22 (7.33) |
| | 2 (n = 27) | 67.86 (10.39) | 10.93 (2.42) | 5.52 (2.23) | 5.28 (1.79) | 21.72 (4.94) |
| | $F_{(1, 54)}$ | 0.201 | 2.162 | 5.726 | 1.242 | 4.311 |
| | *p*-value | 0.656 | 0.147 | 0.020* | 0.270 | 0.043* |
| Pair Learning | 1 (n = 26) | 65.61 (10.86) | 11.50 (4.24) | 6.15 (2.10) | 5.79 (2.19) | 23.44 (6.18) |
| | 2 (n = 22) | 65.96 (12.21) | 10.02 (3.89) | 5.89 (1.84) | 5.23 (1.72) | 21.97 (6.14) |
| | $F_{(1, 46)}$ | 0.011 | 1.557 | .216 | .949 | 1.788 |
| | *p*-value | 0.916 | .218 | .644 | .335 | .188 |
| Comparison | 1 (n = 30) | 63.94 (11.84) | 10.98 (3.88) | 6.93 (2.26) | 5.28 (2.13) | 23.19 (6.52) |
| | 2 (n = 24) | 63.18 (10.80) | 9.88 (2.57) | 6.38 (2.20) | 5.50 (1.91) | 21.75 (4.50) |
| | $F_{(1, 52)}$ | 0.060 | 1.446 | 0.830 | 0.163 | 0.848 |
| | *p*-value | 0.808 | 0.235 | 0.366 | 0.688 | 0.361 |

§ = 1, Immediate; 2, Delayed
* = Differences are significant at $p \le 0.10$.

## Discussion

### *Did the intervention yield better overall learning outcome among the treatment classes?*

The first question of the study was to investigate whether the Metacognitive Science Reading Checklist (MSRC) would increase science achievement among 5th and 6th graders (10-14 years olds). Observation data indicated that the intervention was carried out more or less as intended. Extracts of students' reflections on pre-reading and post-reading conceptions indicate that a majority of participating students were capable of making thoughtful reflections. Various prior studies reported similar findings. For example, a qualitative study among kindergartners, second, and third graders in which the student content area readings were guided by advance organizer and self-assessment strategies were able to access their prior knowledge, organize ideas, and make connections to understanding (Langford, Rizzo, & Roth, 2003). Moreover, a reading strategy containing activities that promote active thinking during reading, and provide a visual coding system to represent the thinking and promote metacognitive reflection of the reading process improved the reading skills and comprehension abilities among 6$^{th}$ graders (Barbe-Clevett, Hanley, & Sullivan, 2002).

In our case, quantitative analyses of the scores (of the various variables) of the Immediate test-groups of the three classes of 5$^{th}$ graders revealed no statistically significant differences ($p \geq 0.100$). Similarly, analyses of the scores of 6$^{th}$ graders indicated no statistically significant variations. Thus, no apparent contribution of the intervention on achievement can be inferred based on the Immediate test-groups of both grades.

In the Delayed test-groups of 5$^{th}$ graders, the mean PSP score of the test-group from the Comparison class is 4.79% and 3.55% greater than mean PSP scores of the test-groups from the Individual and Pair learning classes, respectively. In fact the difference between the mean PSP scores of the Delayed test-groups of the Individual learning and that of the Comparison class is statistically significant ($p \leq 0.071$). Similarly, the mean Total post-test score of the test-group from the Individual learning class is statistically lower ($p \leq 0.100$) than the groups from the Pair learning and Comparison classes. No variations were evident between the scores of the Pair and Comparison classes. In this case too, no contribution can be implied from the intervention. Analyses of the scores of 6$^{th}$ graders lead to similar conclusion.

### *Did treatment classes perform better in higher order thinking tests than comparison classes?*

Based on the assumption that metacognitive instructional interventions promote higher order thinking ability, the study predicted that students in the treatment classes would perform better in higher order thinking tests than those in the Comparison class. Analyses of the scores of the Immediate test-groups of both grades did not show any evidence supporting this prediction. Analyses of the Delayed test-groups of both grades also showed no advantage.

### *Did the intervention help the treatment classes to retain learned contents better than the comparison classes?*

Some studies have reported that metacognitive instructional interventions promote retention abilities of learners (e.g. Adey & Shayer, 1993; Georghiades, 2000, 2004; Spiegel & Barufaldi, 1994). Thus, it was predicted that the metacognitive science reading strategy would promote the retention ability of the students in the treatment classes. To test this prediction, we compared the scores of the Immediate and Delayed test-groups of each class. Had the differences between mean post-test scores of the Immediate and Delayed test-groups of the treatment classes been less marked as compared to the differences between the mean post-test scores of the two test-groups in the comparison classes, we would have argued that the intervention had some effect on retention. However, the analyses show otherwise. The Immediate test-groups from the treatment classes of $5^{th}$ graders had comparable mean Total score as those from the Comparison class. It is also indicated that the Immediate test-groups from the treatments classes of $6^{th}$ graders maintained their rank above the test-group from the Comparison class based on mean PSP score. These effects were clearly diminished among the Delayed test-groups, in both grades. Interestingly, similar trends are reported in the two articles accompanying this one.

### *Was the instructional method more effective in pair learning setting?*

Instructional interventions that foster cooperative learning advance student performance in science (e.g. Okebukola & Ogunniyi, 1984; Watson, 1991). Thus, another objective of study was to see if the intervention works better among the Pair learning settings. Though the Delayed test-groups from Pair learning classes are statistically better compared to their counterparts from the Individual learning classes, it is difficult to infer whether this difference is caused by the intervention or prior school performance.

The data from the Immediate test-group of 6$^{th}$ graders indicate that the Individual learning class has a higher mean Total score. But, it is suspected that this may be attributed to prior academic background. No conclusion implying positive effect of learning settings could be drawn from the Delayed post-test scores. In conclusion, no pronounced effect of the intervention on cooperative learning setting could be observed. In fact, instructional interventions focussing on the effect of cooperative learning do not always yield anticipated results (e.g. Tingle & Good, 1990).

### *Did the intervention produce similar outcomes in both grades?*

The study also tried to find out if the metacognitive science reading strategy gives similar positive outcomes regardless of grade. As per the preceding discussions, quantitative data analyses could not indicate that the intervention made any contribution. The predictions that would show that the participating students would become more metacognitive thinkers could not be supported by the quantitative study.

### *What did the qualitative data show?*

It is important to indicate whether the intervention makes other contributions to the participating students. A summary of observation data as well as excerpts of teachers' reflections and samples of students' reflections on their pre- and post-reading conceptions is included to examine whether the metacognitive instructional intervention had other advantages.

#### *Better student conceptual learning*

Dole (2000) argues that student prior knowledge is difficult to change by reading texts that are inconsistent with that knowledge unless they are taught to monitor changes in their thinking about scientific conceptions. Thus, the metacognitive reading checklist employed in the present study was to help students monitor their comprehension and thinking. It is designed to enable readers to be aware of the match/mismatch between their assumptions or beliefs and the conceptions indicated in the text as well as remain conscious while modifying or restructuring those assumptions or beliefs to suit the scientific ideas. Evidently quantitative analyses could not show an apparent contribution of the reading strategy on learning outcomes. On the other hand, study of the qualitative data shows that the intervention helped the students restructure their conceptions as expected. Interventions in which quantitative data analyses do not (strongly) support predictions, despite qualitative data indicating encouraging results, are available (e.g. Blank, 2000; Georghiades, 2004; Radcliffe, Caverly, Peterson, & Emmons, 2005). Table 34 shows examples of reflections on pre-reading assumptions or beliefs and post-reading understandings by $5^{th}$ graders, while Table 35 indicates the list of examples of post-reading reflections in relation to pre-reading assumptions and beliefs by $6^{th}$ graders.

In both cases, it is evident that the students had many unscientific or incomplete prior conceptions and were readily restructuring those conceptions. The existence of a multitude of misconceptions among primary school students is well documented (e.g. Pine, Messer, & John, 2000). In a course of appropriate instructional process, students brought their prior beliefs and assumptions forward and declared that they were modifying or abandoning those beliefs or assumptions and held the scientific ideas, as demonstrated in our study. As a matter of fact, many of the misconceptions that could be prevalent among Tigrinya speaking Ethiopian children were indicated. Marshall (1990) (as quoted in Qian & Guzzetti, 2000) indicated that students could hold misconceptions from their attempts to make sense of their physical environment, from social settings they belong to, or formal instruction. In the case of the present study, language appears to be another source of misconceptions. Below are some reflection statements that indicate student language as a source of misconceptions.

> I didn't believe that there is male mosquito after all (5$^{th}$ grade, M12, IL).
> I didn't believe that there are male and female frogs (5$^{th}$ grade, F11, IL).
> I thought that all birds are females (5$^{th}$ grade, F14, IL).
> I thought volume means to hold or wrap (6$^{th}$ grade, M12, PL).
> I thought lens is simply a mirror (6$^{th}$ grade, M12, IL).

In the language of the children, mosquitoes, frogs, and birds take the feminine pronoun 'she', and believe that these animals are females. Thus, talking about sexual reproduction of these animals to students who believe that they are all females would be of little help. Likewise, the terms 'volume' and 'lens' in the fourth and fifth statements, respectively, confound with day-to-day language of the students. Therefore, one needs to have an innovative strategy to enable the students to refute or restructure such misconceptions. It is clearly evident from the students' reflections on post-reading understandings that the metacognitive reading activities have helped them to address their prior beliefs or assumptions, and restructure their knowledge. A note by the 5th grade teacher strengthens this assertion.

> Students are stating that the reading strategy and the instructional approach accompanying it helped them to change their pre-reading understandings and beliefs and hold the scientific conceptions clearly. Some students are claiming that the checklist encouraged them to read more and helped them to provide their reflections without difficulty (Translation of 5th graders teacher's note, 16 Nov 2004).

*Better student involvement*

Better student involvement in a given instructional process is an important condition for any kind of meaningful active learning. Observation data and teachers' records of student reflections as well as reflection notes of the 5th grade teacher revealed that the involvement of the students were commendable. The students were actively engaging in the instructional processes. Students who could recognize weaknesses in their understanding when making reflections are more likely to engage in knowledge integration (Davis, 200). Indicating the involvement of the students, the 5th grade teacher made the following notes.

> Even though the metacognitive reading method is a new one, I am convinced that the method is getting helpful. Majority of the students are completing their reading assignments. If the students are allowed to use the method in the future, their reading abilities will boost. Higher ability students are eagerly following the checklist. In fact, they are using it for other subjects as well (Translation of 5th graders teacher's note, 29 Oct 2004).

> Students are claiming that the reading strategy is helpful because it: (1) encourages them to read and re-read the topics, thus enables them to understand the contents, (2) helps them to grasp the main points of the reading assignments clearly, and (3) enables them to do better in tests (Translation of 5th graders teacher's note, 03 Nov 2004).

Similarly, observation and teachers' journals indicate that the students were able to identify the important points or concepts of the topics of the various lessons during their reflections. Two summaries are indicated in the following figures.

| Topic: The Brain | Teacher's Note: 11 and 15 Oct 2004. |
|---|---|

**Individual Learning Class***

I learned/ understood/knew that:

- The size of the human brain is 1.5 kilograms.
- The brain of an adult contains 12 billion nerve cells.
- The brain has three parts.
- The cerebrum has many folds.
- The cerebrum helps us to remember, reason and learn.
- Cerebellum is located in the hind head.
- Cerebellum has some folds.
- Cerebellum controls the movements of body.
- Damage to cerebellum affects our bodily balance.
- Hypothalamus is connected to the spinal cord.
- Hypothalamus controls the physiological process of our body.

*The Pair learning class gave a more or less similar summary.

Figure 12. Students' reflections on post-reading understandings about a topic 'the Brain'

| Topic: Reproduction of Housefly | Teacher's Note: 24 Oct 2004. |
|---|---|

**Individual Learning Class**

I learned/ understood/knew that:

- Insects reproduce by sexual means.
- Insects develop through either complete or incomplete metamorphosis.
- Female housefly produces 100-200 eggs at a time.
- Houseflies have 4 stages of development.
- The eggs of the housefly hatches into larvae within 1-3 days.
- Housefly larva is changed to pupa in five days.
- The life cycle of housefly depends on environmental factors.

*The Pair learning class gave a more or less similar summary.

Figure 13. Students' reflections on post-reading understandings about 'Reproduction of Housefly'

These summaries show that the shift from more teacher-centeredness to more learner-centeredness can be realized by introducing metacognitive strategies. Naturally, metacognitive activities require students to be engaged in a lot of minds-on activities, which in turn leads to the domination of the classroom discourse by the students. The role of the teacher will, thus, be providing some guidance. This was more or less evident in our study.

### Implications for classroom practice and research

Despite the quantitative data failing to show the effect of the intervention clearly, the qualitative study disclosed that the method of instruction yielded an encouraging contribution in promoting conceptual change learning and fostering better student engagement. Thus, the commitment for a paradigm shift from more teacher-centeredness toward more learner-centeredness could be realized by using effective, metacognitive science reading strategies that demand minds-on engagement of students. Where increased class size, shortage or lack of science equipment and supplies and decreased development of inquiry science projects are prevalent, as in Ethiopian schools, we will be obliged to depend much more on textbooks (Yore, 1991). It goes without saying that adoption of the present Metacognitive Science Reading Checklist or other similar reading strategies in schools where science textbooks are the only available curricular input would be vital for learning science through negotiation of meanings, inquiry, and conceptual change.

While quantitative data analyses did not lead to a clear-cut conclusion, the qualitative data yielded promising results. Thus, it is worthwhile to repeat the study on a larger scale to reconcile the findings of the quantitative and qualitative data. In this case, it is worth noting that researchers need to recognize that the limitations of reading and comprehension skills among students may be a confounding factor.

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# APPENDICES

## Appendix A. Post-Intervention Tests (in Tigrinya)

### Grade 5

### Knowledge/Comprehension Test

**ናይ 5ይ ክፍሊ ናይ ሳይንስ ፈተና።**

ሽም ________________። ክፍሊ ___። ቁፅሪ ___። ፆታ ___። ዕድመ ___። ዝተፈቐደ ግዘ 30 ደ

**ቀዳማይ ክፋል፤ ሓቂ ወይ ሓሶት በሉ።**

_____ 1. ኣብ ውሽጢ ኣፍንጫና ዝርከቡ ሲሊያታት ናብ ውሽጢ እንትንፍሶ ኣየር ክመውቕ ይገብሩ።

_____ 2. ኣብ ሽጋራ ዝርከብ ሓደገኛ ኬሚካል ካርቦንሞኖኦክሳይድ ይብሃል።

_____ 3. ከባቢ ኣፍልቢ ካብ ከባቢ ከሽዐ ዝሽፍል ኣካል ስብነትና ዲያፍራም ይብሃል።

_____ 4. ደንድራይት ካብ ሓደ ዋህዮ መትኒ ናብ ካልእ ዋህዮ መትኒ መልእኽቲ ዘቐብል ኣካል እዩ።

_____ 5. ኣዛዚ ዋህዮ ካብ ዕትብቲ ዓንዲ ሑቐ መልእኽቲ ይቕበል።

_____ 6. ንህቢ ብባህላዊ መገዲ ክወልድ (ክራባሕ) እንተኾይኑ ቁፅሪ ሰራሕተኛ ንህቢ ኣስታት ብዕፅፊ ክውስኽ ኣለዎ።

**ካልኣይ ክፋል፤ ኣብቶም ክፍቲ ቦታታት ትኽክለኛ መልሲታት ምልኡ።**

7. መግቢ ናብ ሳንቡእ ከይኣቱ ዘከላኽል ኣካል ስርዓት ምትንፋስ ___________ ይባሃል።

8. ልውውጥ ኦክስጅንን ካርቦንዳይኦክሳይድን ዝካየደሉ፥ ዝንኣሰ ኣካል ሳንቡእ ___________ እዩ።

9. ኣብ ታይሮክሲን ሆርሞን ዝርከብ መኣድን ____________ ይብሃል።

10. ሆርሞናት ዘመንጭዉ ዕኪታት ____________ ይብሃሉ።

11. ዝቐልጠፈ መትናዊ ምላሽ ____________ ይብሃል።

12. ኣንበጣ ምስተጫጨሐ ካብ ዓብዩ ኣንበጣ ብ____________ ይፍለ።

**ሳልሳይ ክፋል፤ ካብቶም ዝቐረቡ 4 ምርጫታት እቲ ትኽክለኛ ምረፁ።**

___13. ንውሽጢ ኣብ እንትንፍሶ ኣየር፥ ዝበዝሐ መጠን ዘለዎ ጋዝ እንታይ እዩ?

- ሀ. ካርቦን ዳይኦክሳይድ
- ሐ. ኦክሲጅን
- ለ. ናይትሮጅን
- መ. ካርቦን ሞኖኦክሳይድ

___14. ንውሽጢ ኣብ እንትንፍሶ ኣየር ካብ ዝርክብ ኦክሲጅን ምስ ደምና ዝውሃሃድ ኣስታት___ እዩ።

- ሀ. ፍርቂ (1/2)
- ሐ. ርብዑ (1/4)
- ለ. ሲሶኡ (1/3)
- መ. ሕምሽኑ (1/5)

___15. ካብዞም ዝስዕቡ ዕምዲታት ሆርሞናትን ተግባራቶምን ትኽክለኛ መፃምዲ ዘይኮኑ ኣየኖት እዮም?

- ሀ. ፒቱታሪ ሆርሞናት፥ ዕብየት
- ሐ. ፓራት ሆርሞን ፥ ምቁፅፃር መጠን ካልሲየም

ለ. ኢንሱሊን ፥ ምምጣጥ መግቢ                መ. ኣድረናሊን ፥ ምቁፅፃር መጠን ኣዮዲን

___16. ሙሉእ ልውጠተ ቅርፀ ዘይብሉ ነፍሳት ኣየናይ እዩ?

ሀ. ሃመማ                                    ሐ. ጣንጡ

ለ. ኣንበጣ                                   መ. ባርኖስ

___17. ኣብ መንነ ሂወታዊ ዑደት ሃመማን ኣንበጣን ዘሎ <u>ቀንዲ</u> ኣፈላላይ እንታይ እዩ?

ሀ. ሃመማ ብመጠናዊ ለውጢ እንት ሓልፍ፣ ኣንበጣ ብቕርፃዊ ለውጢ ይሓልፍ።

ሐ. ሃመማ ብቕርፃዊ ለውጢ እንትሓልፍ፣ ኣንበጣ ብመጠናዊ ለውጢ ይሓልፍ።

ለ. ሃመማ ብ4ተ ደረጃ ዕብየት እንት ሓልፍ፣ ኣንበጣ ብ3ተ ደረጃ ይሓልፍ።

መ. ሃመማ ብ4ተ ደረጃ ዕብየት እንት ሓልፍ፣ ኣንበጣ ብ5ተ ደረጃ ይሓልፍ።

___18. ግዳማዊ ምርባሕ ዓሳን ጭንቁራዕን ኣብ ቀላያት/ዒላታት ይፍፀም። ኣብዚ ፍፃመ እዚ ጥቕሚ ማይ ዘይኮነ ኣየናይ እዩ?

ሀ. እንቁላሊሕ ናብ ዘርኢ ተባዕታይ ክጐዓዝ ይሕግዝ።

ሐ. እንቁላሊሕን ዘርኢ ተባዕታይን ክይነቕፁ ይገብር።

ለ. ዘርኢ ተባዕታይ ናብ ኣንፈት እንቁላሊሕ ብቐሊሉ ክሕምስ ይሕግዝ።

መ. ውልዶታት በግቡእ ክባዕሑ ይሕግዝ።

**ራብዓይ ክፋል፣ ነዞም ዝስዕቡ ሕቶታት ሓፂር መልሲ ሃቡ።**

19. ንደገ እንትንትንፍስ ኣብ ኣካላት ምትንፋስ ዝኸሰቱ ክልተ ለውጢታት ዘርዝሩ። እዚ ዝስዕብ ሰደቓ ተጠቐሙ።

| | ንደገ እንትንትፍስ እንታይ ይኸውን? |
|---|---|
| ዳያፍራም | |
| ኣፍልቢ | |
| ድፍኢት ኣየር | |

20. ኣብ መንነ ኣመሓላልፋ መትናዊን ሆረሞናዊን መልእኽቲታት ዘሎ ኣፈላላይ ጥቐሱ።

**Application Test**

**ናይ 5ይ ክፍሊ ናይ ሳይንስ ፈተና።**

ሽም ________________። ክፍሊ ___። ቁፅሪ ___። ፆታ ___። ዕድመ ___። ዝተፈቐደ ግዘ 35 ደ

**ቀዳማይ ክፋል፤ ሓቂ ወይ ሓሶት በሉ።**

_____ 1. ኣብ እዋን ኣርቲፊሻል ምትንፋስ ናብ ውሽጢ ሳንቡእ ተሓጋዛይ ዝኣቱ ኣየር ውሑድ ኦክሲጂን ዝሓዘ እዩ።

_____ 2. ብመጥባሕቲ ላልሽ (ጣፍይኡ) ዘወገደ ሰብ ንሕማም ሕፈስ ናይ ምቅላዕ ዕድሉ ዝዓበየ እዩ።

**ካልኣይ ክፋል፤ ኣብቶም ክፍቲ ቦታታት ትኽክለኛ መልሲታት ምልኡ።**

3. ካብ ሰለስቲኦም ዓይነታት መትኒ ኣብ ጫፍ ኣፃብዕቲ ዝርከብ _______ እዩ።

4. ኣብ ትግራይ ካብ ዝካየዱ ስራሕቲ ልምዓት ህማም ዓሶ ከስፋሕፍሕ ዝኽዕል ስራሕ ______ እዩ።

**ሳልሳይ ክፋል፤ ካብቶም ዝቐረቡ 4 ምርጫታት እቲ ትኽክለኛ ምረፁ።**

___ 5. ብሓደገኛ ጋዝ ንዝተዓፈነ ሰብ ብኣርቲፊሻል ረስፒረሽን ሓገዝ እንገብረሉ ምኽንያት እንታይ እዩ?

ሀ. ጭዋዳታት ኣዕፅምቲ ጉኒ ስሩዕ ስረሖም ክጅምሩ ንምሕጋዝ።

ለ. ትሕዝቶ ኣፍልቢ ኣስፊሕኻ ኣየር ክስሓብ ንምግባር።

ሐ. ሓንጎሉ ቀልጢፉ ኦክሲጅን ክረክብ ንምግባር።

መ. ትቦታት ስርዓት ምትንፋስ ክኽፈቱ ንምግባር።

___ 6. ካብዞም ዝስዕቡ ምሉእ ሓሳባት <u>ሓቂ ዘይኮነ</u> ኣየናይ እዩ?

ሀ. መትንፈሲ ትቦታት ተንቦኽቲ ምስ ናይ ዘይቶምቦኽቲ እንትናፃፀር ብቐሊሉ ይኳሳሕ።

ለ. ተንቦኽቲ ብስዓል ናይ ምትሓዝ ዕድሎም ካብ ናይ ዘይተንቦኽቲ ይበልፅ።

ሐ. ብኣፍንጫ ብጥንቃቐ ምትንፋስ ትቦታት ምትንፋስ ከይኳስሑ ይሕግዝ።

መ. ተንቦኽቲ ብስዓል ናይ ምትሓዝ ዕድሎም ካብ ናይ ዘይተንቦኽቲ ይንእስ።

___ 7. ኣብ ውሽጢ ሳንቡእ ተንቦኽቲ ዝበፅሕ ኣየር ምስ ኣብ ናይ ዘይተንቦኽቲ ሳንቡእ ዝበፅሕ እንትነፃፀር ___ እዩ።

ሀ. ዝውዓየ።

ለ. ዘይፀረየ።

ሐ. ዝዝሓለ።

መ. ዝደረቐ።

___ 8. ካብዞም ዝስዕቡ 3 ብትንፋስ ዝመሓላለፉ ሕማማት፥ ተመሳሳሊ ሕክምና ወይ መድሓኒት ዘድልዮም ኣየኖት እዮም?

ሀ. ስዓልን ኢንፍሉዌንዛን።

ለ. ስዓልን ሳንባ ነቀርሳን።

ሐ. ኢንፍሉዌንዛን ሳንባ ነቀርሳን።

መ. ስዓል፣ ኢንፍሉዌንዛን ሳንባ ነቀርሳን።

___ 9. ቀጺሎም ተሰሚሮም ዘለዉ 5 ፍፃመታት ስርዓት መትኒ ተመልከቲ (ተመልከት)።
(1) ኢድ ተስሒቡ። (2) መልእኽቲ ስምዒት ረስኒ ኣብ ዕትብቲ ዓንዲ ሑቐ በጺሑ። (3) ኣፃብዕቲ ርሱን ሓፂን ተንኪፈን። (4) ኣፃብዕቲ ርሱን ምትንካፈን ማእኸላይ ስርዓት መትኒ ፈሊጡ። (5) ኣፃብዕቲ ክስሓባ መልእኽቲ ኣብ ጭዋዳታት ኢድ በጺሑ። ትኽክለኛ ቅደም ስዓብ ኣየናይ እዩ?

ሀ. 3፥ 2፥ 4፥ 5፥ 1።
ሐ. 3፥ 1፥ 4፥ 2፥ 5።
ለ. 3፥ 4፥ 5፥ 2፥ 1።
መ. 4፥ 3፥ 5፥ 2፥ 1።

___ 10. ብህፃኑ ቅርቅርቱ ዝተሃስየ (ጉድኣት ዝበፅሖ) ሰብ ከጋጥሞ ዝኽእል ፀገም እንታይ ይመስለኩም?

ሀ. ፀገም ምዝካርን ፀገም ምዝራብን።
ሐ. ፀገም ትርግታ ልቢን ፀገም ምልሃይን።
ለ. ፀገም ምዝካርን ፀገም ትርግታ ልቢን።
መ. ፀገም ትርግታ ልቢን ፀገም ምትንፋስን።

___ 11. ካብዞም ዝስዕቡ 4ተ ሂወታዊ ተግባራት፥ ቆማት ሓንጎል ዘይቋፃፀሮ ተግባር ኣየናይ እዩ?

ሀ. ስምዒት ፅምኢ ማይ።
ሐ. ምምጣጥ መግቢ።
ለ. ምፅራይ ሽንቲ።
መ. ምስጓም (ምኻድ)።

___ 12. ሰታይ ሰብ እንትሰክር መጀመርታ ኮልተፍተፍን የብሎ። እንተወሲኹሉ ደርገፍገፍ የብሎ። ድሕሪ'ዚ ምስታይ እንተቐፂሉ የምልሶ (ንዓቐብ የብሎ)። ብ1ይ፣ 2ይን 3ይን ደረጃ ዝጥቅዑ ክፍሊታት ሓንጎሉ ኣየኖት እዮም?

ሀ. ቆማት፣ ዳሕረዋይ፣ ኣዛውሮ።
ሐ. ኣዛውሮ፣ ዳሕረዋይ፣ ቆማት።
ለ. ኣዛውሮ፣ ቆማት፣ ዳሕረዋይ።
መ. ቆማት፣ ኣዛውሮ፣ ዳሕረዋይ።

___ 13. ካብዞም ዝስዕቡ 4 መማረፂታት ትኽክል ዘይኮነ ኣየናይ እዩ?

ሀ. ፅሬት ከባቢናን ገዛናን እንትንሕሉ፥ ዓብዪ ሃመማ መራብሒ ስፍራ ከይረክብ ንገብር።
ሐ. ፅሬት ከባቢናን ገዛናን እንትንሕሉ፥ ላርቫ ሃመማ ሙቐትን ጠሊን ከይረክብ ንገብር።
ለ. ፅሬት ከባቢናን ገዛናን እንትንሕሉ፥ ፑፓ ሃመማ መግቢ ከይረክብ ንገብር።
መ. ፅሬት ከባቢናን ገዛናን እንትንሕሉ፥ እንቁላሊሕ ሃመማ መግቢ ከይረክብ ንገብር።

___ 14. እናበላዕኻ ምዝራብ፥ ናይ ምሕናቕ ሓደጋ ከኸትል ይኽእል እዩ። ምኽንያቱ ስለምንታይ ይመስለኩም?

ሀ. ኣየር ምስቲ እንበልዖ ሓቢሩ ናብ ጎሮሮና ስለዝኣቱ።
ሐ. መግቢ ናብ ሸምበቆ ኣየር ክኣቱ ስለዝኽእል።
ለ. ብኣፍና ዝኣቱ ኣየር ስለዘይውዒ።
መ. ካብ መጠን ንላዕሊ ኣየር ናብ ሳንቡእ ስለዝኣቱ።

___ 15. ርሱን ሓፂን ረጊፁ፥ ናይ ምቅፃል ስምዒት ዘይስምዖ ሰብ ፀገሙ እንታይ ይመስለኩም?

ሀ. መልእኽቲ ካብ እግሪ ናብ ዕትብቲ ዓንዲ ሑቖ ኣይበፅሕን።

ሐ. መልእኽቲ ካብ ኣዛዚ ዋህዮታት መትኒ፥ ናብ ጭዋዳታት እግሪ ኣይበፅሕን።

ለ. መልእኽቲ ካብ ዕትብቲ ዓንዲ ሑቖ፥ ናብ ኣዛዚ ዋህዮታት መትኒ ኣይበፅሕን።

መ. መልእኽቲ ኣብ ጭዋዳታት በፂሑ፥ ጭዋዳታት ክእዘዙ ኣይከኣሉን።

___ 16. ንደገ እንትንትንፍስ፥ ኣብ ሻምበቆ ኣየር ዝርከብ ኣየር ድፍኢቱ _____።

ሀ. ኣብ ውሽጢ ሳንቡእ ካብዘሎ ይንእስ።

ሐ. ኣብ ደገ ካብ ዘሎ ይንእስ።

ለ. ኣብ ውሽጢ ሳንቡእ ካብዘሎ ይበልፅ።

መ. ኣብ ደገ ምስዘሎ ማዕረ እዩ።

**ራብዓይ ክፋል፤ ነዞም ዝስዕቡ ሕቶታት ሓፂር መልሲ ሃቡ። (መልሲ ብድሕሪት)**

17. ብኣርቲፊሻል ረስፒረሽን ናብ ዝሕገዝ ሰብ ሳንቡእ ዝኣቱ ኣየርን ናብ ሳንቡእ ጥዑይ ሰብ ዝኣቱ ኣየርን ዘሎ መጠን ካርቦን ዳይኦክሳይድን ኦክሲጅንን ኣነፃፅሩ።

18. ካብ ባልዕ ባርኖስን ባልዕ ኣንበጣን ኣየናይ ምክልኻል ይቐልል? መልስኹም ብክልተ መርተያታት ደግፉዎ።

19. ከባቢና ዘይብክሉን፣ ብዙሕ ጉልበትን ገንዘብን ዘይሓትቱን ክልተ ሜላታት ምክልኻል ጣንጡ ጥቐሱ።

20. ኣብ መንጎ ኣገባብ ምርባሕ ጭንቁራዕን ጠበቕን ዘሎ ኣፈላላይ ግለፁ።

**Transfer Test**

**ናይ 5ይ ክፍሊ ናይ ሳይንስ ፈተና።**

ሽም ________________። ክፍሊ ___። ቁፅሪ ___። ፆታ ___። ዕድመ ___። ዝተፈቐደ ግዘ 35 ደ

**ቀዳማይ ክፋል፤ ሓቂ ወይ ሓሶት በሉ።**

_____ 1. ብኣፍናን ብኣፍንጫናን እንትንፍሶ ኣየር ኣብ ሳንቡእ ቅድሚ ምብፅሑ ተመሳሳሊ መጠነ ሙቐት ኣለዎ።

_____ 2. ዑደት ሂወት ጭንቁራዕ ኣዋርሕ ክወስድ ይኽእል።

**ካልኣይ ክፋል፤ ኣብቶም ክፍቲ ቦታታት ትኽክለኛ መልሲታት ምልኡ።**

3. ከም ዝሰኽረ ደርገፍገፍ ዝብል ሰብ _______ ዝተብሃለ ክፍሊ ሓንጎሉ ፀገም ዘለዎ ክኸውን ኣለዎ።

4. ኣብ መንነ ሰገናትን መናእሰይን ዘሎ ናይ ድምፂ ምጉርናን ኣፈላላይ ብምኽንያት ________ ሆርሞን ዝኸሰት እዩ።

**ሳልሳይ ክፋል፤ ካብቶም ዝቐረቡ 4 ምርጫታት እቲ ትኽክለኛ ምረፁ።**

___5. መሓሪ ኣስታት 2 ሜትሮ እዩ ቑመቱ። ኣብራሂም ድማ 1.25 ሜትሮ እዩ። ክልቲኦም ብተመሳሳሊ ግዘ ጓህሪ እንተረጊፆም፤ መን ቀልጢፉ ይስምዖ?

ሀ. መሓሪ። ሐ. ክልቲኦም ብሓንሳብ ይስመዖም።
ለ. ኣብራሂም። መ. ምተንባይ ኣይከኣልን።

___6. ስርዓት መትኒ ብተግባሩ (ብስርሑ) ______ ይመስል። ብቕርፁ ድማ ______ ይመስል።

ሀ. ርክብ ስልኪ / ኤሌክትሪክ። ሐ. ኤሌክትሪክ / ርክብ ስልኪ።
ለ. ርክብ ስልኪ / ማይ ቡንባ። መ. ኤሌክትሪክ / ማይ ቡንባ።

___7. እዚ ቀፂሉ ዝተሰመረ ኣንቀፅ ኣንብቡ።

<u>ኣኸዛን ሃንሳን ምሸት ምሸት ብኩራዝ የፅንዑ። እቲ ኩራዝ ኣብ ጥቓኣን ገይረን ስለዘፅንዓ ትኪ እቲ ኩራዝ ምስዝትንፍስኦ ኣየር ምስሓበን ኣይተረፈን። ጕሓት ጕሓት ገፀን እንትሕፀባ ኣኸዛ እንትትናፈጥ ኩሉሻብ ፀለሎ ተውፅእ። ሃንሳ ግና ተናፊጣ ፀለሎ ኣይተውፅእን።</u>

ካብ ክልቲኣን ብተነፃፃሪ መኒኣ ፅሩይ ኣየር ኣብ ሳንቡኣ ይበፅሕ?

ሀ. ኣኸዛ። ሐ. ኣፈላላይ የብለንን።
ለ. ሃንሳ። መ. ምትንባይ ኣይከኣልን።

___8. መስከረም ሃመማ ይበዝሑ። ሕዳር ድማ ይውሕዱ። ምኽንያቱ እንታይ ይመስለኩም?

ሀ. መስከረም ንምርባሕ ሃመማ ዝሰማማዕ ጠሊ እንትህሉ፤ ሕዳር ግና ደረቕ ኣየር ስለዝህሉ።
ሐ. መስከረም ንምርባሕ ሃመማ ዝሰማማዕ መጠነ ሙቐት እንትህሉ፤ ሕዳር ግና ቁሪ ስለዝኾነ።

ለ. መስከረም እኹል መግቢ እንትህሉ፤ ሕዳር ግና ሕፅረት መግቢ ስልዝህሉ።

መ. መስከረም ንምርባሕ ሃመማ ዝሰማማዕ መጠነ ሙቐትን ጠሊን እንትህሉ፤ ሕዳር ግና ትሑት መጠነ ሙቐትን ጠሊን ስለዝህሉ።

____9. ስዒቦም 3 ስድራቤታትን ገዛውቶምን ተመልኪቶም ኣለዉ።

<u>እንዳቦይ ተኽሉ፤ ቆርቆርን ኣናእሽቶይ መሳኹቲን ዘለዎ ህድሞ።</u>

<u>እንዳቦይ ሽኽና፤ ብመስተያት ዝተሰርሐ መሳኹቲን ስጡም ማዕፆን ዘለዎ ደብሪ።</u>

<u>እንዳቦይ ተስፉ፤ ብዲግዲጋ ዝተሰርሐ ገበላ (ደንበ)።</u>

ሰለስቲኦም ስድራቤታት ኣብ ዓሳው ከባቢ (ዓሶ ዝበዝሖ ከባቢ) ዝነብሩ እንተኾይኖም፣ እንዳመን ብቐሊሉ ብዓሶ ዝጥቅዑ ይመስለኩም?

ሀ. እንዳቦይ ተኽሉ።

ለ. እንዳቦይ ሽኽና።

ሐ. እንዳቦይ ተስፉ።

መ. ኩሎም ስድራ ቤታት።

____10. ቁፅሪ 9 ተመልከቱ። ኣብ ሰለስቲኦም ገዛውቲ ለይቲ ፍሓም እንተተናኺሱ፣ ብካርቦን ሞኖኦክሳይድ ናይ ምምራዝ ዝልዓለ ሓደጋ ክጋጥሞም ዝኽእል ስድራ ቤት እንዳመን ይምስለኩም?

ሀ. እንዳቦይ ተኽሉ።

ለ. እንዳቦይ ሽኽና።

ሐ. እንዳቦይ ተስፉ።

መ. ኩሎም ስድራ ቤታት።

____11. ብግዳማዊ መንገዲ ዝራባሕ ዓሳ ብዘበናዊ ሜላ ንምፍራይ፤ ዝልዓለ ውህደት እንቁላሊሕን ዘርኢ ተባዕታይን ንኽህሉ፥ ኣብ መራብሒ ሓፅቢ እንታይ ምግባር መድለየ?

ሀ. ሓመድ ምንፃፍ።

ለ. ፀግዒ-ፀግዒ ሑፃ ምምላእ።

ሐ. እቲ ሓፅቢ ክሳብ ኣፉ ምምላእ።

መ. ፀግዒ-ፀገዒ ኩሮት (ደቂቕቲ ኣእማን) ምምላእ።

____12. ንመፍረ እንቁላሊሕ ዝፌርያ ደርሁ ኣብ መግበን ናይ ግድን ______ ክህልዎ ይግባእ።

ሀ. ቆፅለመፅሊ።

ለ. ጥሑን ዓፅሚ።

ሐ. ምሽላ።

መ. ካሮት።

____13. ዘበናዊ ምርባሕ ኣናህብ እንትንሓስብ <u>ጠቓሚ ቅድመኹነት ዘይንብሎ</u> ኣየናይ እዩ?

ሀ. ፍልፍል ማይ ኣብ ጥቓ ቆፎ ምህላው።

ለ. ኣግራብ ዘለዎ ስፍራ ምምራፅ።

ሐ. ኣንፈት ቆፎ ምውሳን።

መ. ሓያል ንፋስ ዘይብሉ ስፍራ ምምራፅ።

____14. ኣብ ኣየር ዝርከብ ኦክሲጅን ኣስታት 21% እዩ። እዚ ምኳኑ ተሪፉ 10% እንተዝኸውን፥ ደምና ኩሉሻብ ዝኣኽሎ ኦክሲጅን ክረክብ እንታይ ክንገብር የብልናን?

ሀ. ብኣፍናን ብኣፍንጫናን ምትንፋስ።

ለ. ፍጥነትን ዕምቆትን ኣተነፋፍሳና ምውሳኽ።

ሐ. ብዙሕ ሓይሊ ካብዝጠልብ ስራሕ ምቑጣብ።

መ. ናብ ውሽጢ እንትንፍሶ ኣየር ኣብ ሳንቡእና ንነዊሕ ግዘ ክፀንሕ ምግባር።

___15. ነዳድን ተብኣሲን ሰብ ብብዝሒ ክፍልፍሎ ዝኽእል ሆርሞን እንታይ ክኸውን ይኽእል?

ሀ. ታይሮክሲን። ሐ. ኣድረናሊን።

ለ. ፓራት ሆርሞን። መ. ኢንሱሊን።

___16. ባልዕ ባርኖስ ብብዝሒ ከጋጥም ዝኽእለሉ ከባቢ እንታይ ዓይነት ይመስለኩም?

ሀ. ወይና ደጉዓ። ሐ. ቆላ።

ለ. ድጉዓ። መ. በረኽ ደጉዓ።

**ራብዓይ ክፋል፤ ነዞም ዝስዕቡ ሕቶታት ሓጺር መልሲ ሃቡ። (መልሲ ብድሕሪት)**

17. እዚ ቀፂሉ ተሰሚሩ ዘሎ ዓንቀፅ ኣንቢብኩም፥ ነቲ ስዒቡ ዝተመልከተ ሕቶ መልሱ።
<u>መሓሪ ናብ ቤት ትምህርቲ ብኣፍደገ እንዳቦይ በሪሁ ይመላለስ። እንዳቦይ በሪሁ ቀትሪ ዘይፍታሕ ግርጉር ከልቢ ኣለዎም። መሓሪ እዚ ስለዝፈልጥ ኣብ እንዳቦይ በሪሁ እንትበፅሕ እናፈርሐ እዩ ዝሓልፍ። ሓደ መዓልቲ ሰጋእ እናበለ እንትሓልፍ፥ እቲ ከልቢ ጨኸርከር ኢሉ ነብሐ። መሓሪ መፀኒ ኢሉ እግረይ ኣውፅእኒ በረረ</u>። ኣብዚ ዓንቀፅ እዙይ ዝተኻየዱ ፍፃመታት ስርዓት መትኒ ብቕደም ሰዓብ ዘርዝሩ።

18. እዚ ቀፂሉ ተሰሚሩ ዘሎ ዓንቀፅ ኣንቢብኩም፥ ነቲ ስዒቡ ዝተመልከተ ሕቶ መልሱ።
<u>ማማ ገርግስ ደርሁ ንምፍራይ ሓንቲ ደርሆ ዓደጋ። ቀፂለን 10 ጥዑያት እንቑቕሕታት ዓዲገን ኣሕቈፈኣ። ካብዞም 10 እንቑቕሕታት 3 ጥራሕ ተጫጪሖም። እቶም 7 ግና ኣጒሎም</u>። ከምዚ ዓይነት ፀገም ዘጋጥመሉ መእመናይ ምኽንያት ሃቡ።

19. ደርሁ ን21 መዓልቲ ይሓቑፉ። ይኹን እምበር ሓድሓደ ደርሁ ን23 መዓልቲ ይሓቑፉ። ናይዚ ኣፈላላይ ቀንዲ ምኽንያት እንታይ ይመስለኩም?

20. እዚ ቀፂሉ ተሰሚሩ ዘሎ ዓንቀፅ ኣንቢብኩም፥ ነቲ ስዒቡ ዝተመልከተ ሕቶ መልሱ።
<u>ማሙሽ ወዲ ሓደ ዓመት ህፃን እዩ። ኩዕስኡ ናብ ትሕቲ ዓራት እንትትኣትዎ፥ እናተቿሓኸ ብዘንጊ ስሒቡ የውፅኣ። ኣቡሽ እውን ታተ ምባል (ምኻድ) ዝጀመረ፥ ወዲ ሓደ ዓመት ህፃን እዩ። ኩዕስኡ ናብ ትሕቲ ዓራት እንትትኣትዎ፣ እናበኸየ ነዲኡ ኣውፅእለይ ይብለን</u>። ናይ ማሙሽ ሓንጎል ኣየናይ ክፍሊ ዝማዕበለ ይመስለኩም? ናይ ኣቡሽ ሓንጎልከ ኣየናይ ክፍሊ ዝማዕበለ ይመስለኩም?

**Grade 6**
**Knowledge/Comprehension Test**

### ናይ 6ይ ክፍሊ ናይ ሳይንስ ፈተና።

ሽም ____________________። ክፍሊ ____። ቁፅሪ ____። ፆታ ____። ዕድመ ____። ግዘ 30 ደ

### ቀዳማይ ክፋል፤ ሓቂ ወይ ሓሶት በሉ።

_____ 1. ሕማም ትራኮማ ምብዛሕትኡ ግዘ ካብ 10-15 ዓመት ዝዕድመኦም ሰገናት የጥቅዕ።

_____ 2. ምስ ነፋሲን ፈሳሲን እንትነፃፀር፣ ደረቕ ኣካል ትሕዝቶኡ ዘይንኪ እዩ።

_____ 3. ጨረር ብርሃን ካብ ማይ ናብ ኣየር ተገዲሙ እንትጉዓዝ ምስ ትኹል መስመር ዝነበሮ መጠን ኩርናዕ ይገፍሕ።

_____ 4. ዘይቲ-ብልዒ ውሱን ትሕዝቶን ቅርፂን ኣለዎ።

_____ 5. ኤድስ፣ ሳንባ ነቀርሳን ሕማም ሽኮርን ኩሎም ተመሓላለፍቲ ሕማማት እዮም።

_____ 6. ኣብ ማእኸል ርቕቕ ዝበለ፣ ኣብ ወሰን ድማ ርጉድ ዝበለ ሌንስ ኮንኬቭ ይብሃል።

### ካልኣይ ክፋል፤ ኣብቶም ክፍቲ ቦታታት ትኽክለኛ መልሲታት ምልኡ።

7. ሕማም ኒሞኒያ ብ ________ ዝዓይነቱ ሂወታዊ ዝመፅእ ሕማም እዩ።
8. ቀጢንን ቆፅለዋይን ውፅኣት ዝወፅኦ ሕሙም ብሕማም ________ ዝተትሓዘ ክኸውን ኣለዎ።
9. ዝኾነ ነገር ዝትሕዞ ናይ ቦታ መጠን ________ ይብሃል።
10. ኣብ ቀረባ ዘሎ ነገር ንምርኣይ ዘፀግመሉ ሰብ ካብ ________ ሌንስ ዝተሰርሐ መነፅር የድልዮ።
11. ሳይንሳዊ መዕቀኒ ፈሳሲ ____________ ይበሃል።
12. (ሓይሊ) ÷ (ስፍሓት) = ____________።

### ሳልሳይ ክፋል፤ ካብቶም ዝቐረቡ 4 ምርጫታት እቲ ትኽክለኛ ምረፁ።

___ 13. ካብዞም ዝስዕቡ ጋዛት ኣሲድ ዝናብ ዝፈጥሩ ኣየኖት እዮም?

| | |
|---|---|
| ሀ. ሳልፈር ዳይኦክሳይድን ካርቦን ሞኖኦክሳይድን። | ሐ. ናይትሮጅን ዳይኦክሳይድን ካርቦን ዳይኦክሳይድን። |
| ለ. ሳልፈር ዳይኦክሳይድን ናይትሮጅን ዳይኦክሳይድን። | መ. ካርቦን ሞኖኦክሳይድን ካርቦን ዳይኦክሳይድን። |

___ 14. ዘይበሰለ ስጋ ብምምጋብ ዝመፅእ ሕማም ኣየናይ እዩ?

| | |
|---|---|
| ሀ. ሓቢ። | ሐ. ጎንደራ። |
| ለ. ቢልሃርዚያ። | መ. ኣሚባዊ ተቕማጥ። |

___ 15. ምልክት መብዛሕቲኦም ሕማማት ዝኾነ ኣየናይ እዩ?

| | |
|---|---|
| ሀ. ተቕማጥ። | ሐ. ረስኒ። |
| ለ. ስዓል። | መ. ምንቅጥቃጥ። |

___ 16. ካብዞም ዝስዕቡ ኣርባዕተ ሕማማት እቲ ሓደ ካብ ሰለስቲኦም ብዝዓበየ ሂወታዊ ይመፅእ። ኣየናይ እዩ?

ሀ. ዓሶ።　　　　ሐ. ፖልዮ።

ለ. ንፍዮ።　　　　መ. ኤድስ።

___ 17. ዝዓበየ ኦፕቲካዊ ፃዕቺ ዘለዎ ኣካል ኣየናይ እዩ?

ሀ. ኣየር።　　　　ሐ. ማይ።

ለ. ዘይቲ-ብልዒ።　　　　መ. ጥርሙዝ።

___ 18. ቀፂሎም ካብዘለዉ 4 ብሽኩቲታት፥ ዝተፈልየ ትሕዝቶ ዘለዎ ብሽኩቲ ኣየናይ እዩ?

ሀ. 8 ሴንቲ ሜትር ወርዲ፣ 1 ሴንቲ ሜትር ቁመት፣ 1 ሴንቲ ሜትር ጎኒ ዘለዎ።　　　　ሐ. 2 ሴንቲ ሜትር ወርዲ፣ 4 ሴንቲ ሜትር ቁመት፣ 1 ሴንቲ ሜትር ጎኒ ዘለዎ።

ለ. 2 ሴንቲ ሜትር ወርዲ፣ 2 ሴንቲ ሜትር ቁመት፣ 2 ሴንቲ ሜትር ጎኒ ዘለዎ።　　　　መ. 2 ሴንቲ ሜትር ወርዲ፣ 3 ሴንቲ ሜትር ቁመት፣ 3 ሴንቲ ሜትር ጎኒ ዘለዎ።

**ራብዓይ ክፋል፤ ንዞም ዝስዕቡ ሕቶታት ሓፂር መልሲ ሃቡ።**

19. ፎሮፎር ንምክልኻል ክንገብሮም ዝግበኣና ጥንቃቐታት ሰለስተ ዘርዝሩ።

20. ሕማም እንታይ ማለት እዩ?

**Application Test**

**ናይ 6ይ ክፍሊ ናይ ሳይንስ ፈተና።**

ሽም ________________። ክፍሊ ___። ቁፅሪ ___። ፆታ ___። ዕድመ ___። ዝተፈቐደ ግዜ 45 ደ

**ቀዳማይ ክፋል፤ ሓቂ ወይ ሓሶት በሉ።**

_____ 1. ፃዕቂ ማይ ኣብ 5 °Cን ኣብ 70 °Cን ማዕረ እዩ።

_____ 2. እንታይነት ሓደ ሕማም ብሓደ ምልክት ብርግፀኝነት ምፍላጥ ይከኣል።

**ካልኣይ ክፋል፤ ኣብቶም ክፍቲ ቦታታት ትኽክለኛ መልሲታት ምልኡ።**

3. ናብ ክልተ ሴንቲ ሜትር ርጕድ ግድግዳ ዘለዎን፥ ማይ ዝመልአን ብርጭቆ ኣገዲምካ ዝበርሀ ላምባዲና ዝፈጥሮ ጨረር፥ ኣብ ድሕሪ እቲ ብርጭቆ እንትብፅሕ __________ ግዘ ይዕፀፍ።
4. ኣብ ቤት ክርስቲያን፣ ቤት ማእሰርቲን እንዳሓዘንን ምስ ብዙሓት ሰባት ብምድቃስ __________ ብዝብሃል ሕማም ክንልከፍ ንኽእል።

**ሳልሳይ ክፋል፤ ካብቶም ዝቐረቡ 4 ምርጫታት እቲ ትኽክለኛ ምረፁ።**

___ 5. ኣብ ትግራይ በዝሒ ህዝቢ ንክውስኽ ካብ ዝገብሩ ምኽንያታት እቲ ቐንዲ (ዋና) ምኽንያት ኣየናይ እዩ?

ሀ. መጢንካ ዘይምውላድ። ሐ. ሓደ ሰብኣይ ካብ ብዙሓት ኣንሽቲ ምውላድ።

ለ. ትሕቲ ዕድመ ምምርዓው። መ. ፖሊሲ ስነ ህዝቢ ዘይምህላው።

___ 6. ካብዞም ዝስዕቡ 4 ባህሪታት ስነ-ህዝቢ፥ እቲ ዝዓበየ ማሕበራዊ ፀገም ዘኸትል ኣየናይ እዩ?

ሀ. ቁፅሪ ምውላድ ካብ ቁፅሪ ሞት ምብላፅ። ሐ. ከባቢያዊ ኣፈላላይ በዝሒ ህዝቢ ምህላው።

ለ. ቁፅሪ ተጠወርቲ ምብዛሕ። መ. መጠን ስድራቤት ምውሓድ።

___ 7. ኣብ ኣየር ዝርከብ ካርቦንዳይኦክሳይድ ኣስታት 0.03% እዩ። እዚ መጠን እዚ ናብ 0.06% ልዕል እንተዝብል፤ እንታይ ዓይነት ከባቢያዊ ፀገም ምተዓዘብና?

ሀ. ሙቐት ከባቢ ምንካየ። ሐ. ሙቐት ከባቢ ምወሰኽ።

ለ. ፀፍሒ ባሕሪ ትሕት ምባል። መ. ትርጉም ዘለዎ ለውጢ ኣይንዕበን።

___ 8. ኣብ ከተማ መቐለ፥ <u>ቐንዲ (ዋና) ምኽንያት</u> ብኽለት ዝስተ ማይ ክኸውን ዝኽእል ኣየናይ እዩ?

ሀ. ፀረ-ባልዕን ፀረ-ፃህያይን ኬሚካላት። ሐ. ካብ ፋብሪካታት ዝፈስሱ ኬሚካላት።

ለ. ካብ ሽቓቕት ዝልሑኽ (ዝፈስስ) ርስሓት። መ. ኣሲድ ዝናብ።

___ 9. ካብዞም ዝስዕቡ ኣርባዕተ ሃፍቲታት ተፈጥሮ እቲ ሓደ እቶም ዝተረፉ ሰለስተ ሃፍቲታት ተፈጥሮ ብምዕቃብ ክዕቀብ ዝኽእል እዩ። ኣየናይ ይመስለኩም?

ሀ. ሓመድ። ሐ. ኣግራብ።

ለ. ማይ። መ. እንስሳ ዘገዳም።

___ 10. ንትምሃሮ 6ይ ክፍሊ ናይ ምጥቃዕ ዕድሉ ዝንኣሰ ሕማም ኣየናይ እዩ?

ሀ. ኮሌራ። ሐ. ጨለውታ።

ለ. ንፍዮ። መ. ኢንፍሉዌንዛ።

___ 11. ዝዓበየ ትሕዝቶ ዘለዎ ኣካል ኣየናይ እዩ?

ሀ. 100 ግራም ክብደት፣ 10 ግራም/ሲ.ሜ$^3$ ፃዕቒ ዘለዎ ኣካል። ሐ. 500 ግራም ክብደት፣ 100 ግራም/ሲ.ሜ$^3$ ፃዕቒ ዘለዎ ኣካል።

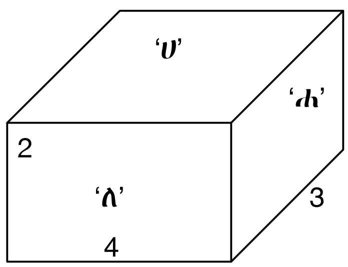
ለ. 1000 ግራም ክብደት፣ 50 ግራም/ሲ.ሜ$^3$ ፃዕቒ ዘለዎ ኣካል። መ. 50 ግራም ክብደት፣ 25 ግራም/ሲ.ሜ$^3$ ፃዕቒ ዘለዎ ኣካል።

___ 12. ፍጥነት ነፋሪት ኣበይናይ ብራኽ ይበልፅ?

ሀ. ኣብ 6000 ሜትሮ ልዕሊ ፀፍሒ ባሕሪ። ሐ. ኣብ 8000 ሜትሮ ልዕሊ ፀፍሒ ባሕሪ።

ለ. ኣብ 7000 ሜትሮ ልዕሊ ፀፍሒ ባሕሪ። መ. ኣብ 9000 ሜትሮ ልዕሊ ፀፍሒ ባሕሪ።

___ 13. እዚ ዝስዕብ 2 ሴንቲ ሜትር ብ 4 ሴንቲ ሜትር ብ 3 ሴንቲ ሜትር ጣውላ ተመልከቱ።




እዚ ጣውላ በይናይ ገፁ ኣብ ማይ እንትኣትዩ ዝዓበዬ መንሳፈፊ ሓይሊ (ቦያንት ፎረስ) ይፈጥር?

ሀ. ብ "ሀ"። ሐ. ብ "ሐ"።

ለ. ብ "ለ"። መ. ብኹሉ ማዕረ'ዩ።

___ 14. ኣብ ቑፅሪ 13 ዘሎ ስእሊ ተመልከቱ። እቲ ጣውላ በይናይ ገፁ ዝዓበየ ፀቕጢ ይፈጥር?

ሀ. ብ "ሀ"። ሐ. ብ "ሐ"።

ለ. ብ "ለ"። መ. ብኹሉ ማዕረ'ዩ።

___ 15. እዚ ምስሊ "ë" ብኮንቬክስ ሌንስ እንትተንፀባረቑ እንታይ ይመስል?

ሀ. û ሐ. ù

ለ. é መ. ë

___ 16. ቀፂሎም ናይ 4 ኮንቬክስ ሌንሳት ርጉድ ተመልኪቶም ኣለዉ። ዝነውሐ ርሕቐት ኣካባይ ነጥቢ ዝፈጥር ሌንስ ክንደይ ሚሊ ሜትር ርጉድ ዘለዎ እዩ?

ሀ. 8 ሚሊ ሜትር። ሐ. 12 ሚሊ ሜትር።

ለ. 10 ሚሊ ሜትር። መ. 14 ሚሊ ሜትር።

**ራብዓይ ክፋል፤ ንዞም ዝስዕቡ ሕቶታት ሓጺር መልሲ ሃቡ። (መልሲ ብድሕሪት)**

17. (ሀ) ኣብ መዓልቲ 35 ግዘ ዘውፅኦ (ዘቕምጦ)፣ ጭዋዳታቱ ዝቕንዞን ኣዒንቱ ንውሽጢ ዝኣተዋን ሰብ ሕማሙ እንታይ እዩ? (ለ) እዚ ሕሙም፥ ሕክምና ክሳብ ዝረክብ፥ ባዕሉ፣ ስድራቤቱን ጎረባብቱን እንታይ እንታይ ጥንቃቐታት ክግብሩ ይግባእ?

18. ኣብዚ እዋን ኣብ ትግራይ ብዙሓት ግድባትን ሆሮዩታት ይስርሑ ኣለዉ። ይኹን እምበር ግድባትን ሆሮዩታትን ንዝተወሰኑ ሕማማት ምስፍሕፋሕ ምኽንያት ክኾኑ ይኽእሉ እዮም። (ሀ) ብምኽንያት ግድባትን ሆሮዩታትን ክስፋሕፍሑ ዝኽእሉ ክልተ ሕማማት ጥቐሱ? (ለ) መከላኸሊ ሜላታት ክልቲኦም ሕማማት ኣሕፅር ኣቢልኩም ዘርዝሩ።

19. ማማ ገርግስ ብቁልቲ ከብቁላ ሓደ ኪሎ ባልደንን (ዓልቋይ) ኣብ ሰለስተ ሊትሮ ማይ ዘፍዚፈን። ኣስታት 150 ግራም ዝኸውን ባልደንን ፈለማ ሰፈፍ ኢሉ። እዚ 150 ግራም ባልደንን ፈለማ ሰፈፍ ዝበለሉ ምኽንያት እንታይ ይምስለኩም? ሓጺር መልሲ ሃቡ።

20. ናይ 20 ግራም ዕፉን ትሕዝቶ 10 ሴ$^3$ እዩ ንበል። ናይ 30 ግራም ባልደንን ትሕዝቶ ድማ 20 ሴ$^3$ እዩ ንበል። ፃዕቒ ዕፉንዶ ፃዕቒ ባልደንን ይበልፅ? ብኸመይ?

**Transfer Test**

**ናይ 6ይ ክፍሊ ናይ ሳይንስ ፈተና።**

ሽም ____________________። ክፍሊ ___። ቁፅሪ ___። ፆታ ___። ዕድመ ___። ግዘ 45 ደቒቕ

**ቀዳማይ ክፋል፤ ሓቒ ወይ ሓሶት በሉ።**

_____ 1. ኣብ ከባቢ መቐለ፥ ካብ ብኽለት ዝስተ ማይ ብኽለት ሓመድ ዝበለፀ ከተሓሳስብና ይግባእ።

_____ 2. ዝዓበየ ዓቐን ፃዕቒ ዘለዎ ኣካል ዝዓበየ ዓቐን ፀቕጢ ይህልዎ።

**ካልኣይ ክፋል፤ ኣብቶም ክፍቲ ቦታታት ትኽክለኛ መልሲታት ምልኡ።**

3. ብምኽንያት ተደጋገምቲ ድርቂታት፥ ህፃናት ሃገርና ብሕማማት _____ ክጥቅዑ ፀኒሖም እዮም።

4. ኣብ ከተማታት ናይ ዝስተ ማይ ፅርየት ዝሕለወሉ ዝውቱር ሜላ _____ እዩ።

**ሳልሳይ ክፋል፤ ካብቶም ዝቐረቡ 4 ምርጫታት እቲ ትኽክለኛ ምረፁ።**

___ 5. ኣብ ኢትዮጵያ ኣዝዩ ከተሓሳስበና ዘይግባእ ፀገም ከባቢ ኣየናይ እዩ?

ሀ. በዝሒ ህዝቢ።
ለ. ብኽለት ማይ።
ሐ. ብኽለት ኣየር።
መ. ብርሰት ኣግራብ።

___ 6. ኣስታት 47% ህዝቢ ኢትዮጵያ ኣብ መንነ ዕድመ ክልል 15-64 ዓመት ይርከብ። ኣብዚ እዋን ንሃገርና ኣብ ሓደጋ ኣእትይዋ ዝረከብ ሕማም ኢችኣይቪ/ኤድስ ነዚ ኣሃዝ (47%) ብኽመይ ይቕይሮ?

ሀ. የውርዶ።
ለ. የደይቦ።
ሐ. ከይወርድ ይገብሮ።
መ. ርኡይ ለውጢ ኣይምፅእን።

___ 7. ኣሰራርሓ እዞም ቀፂሎም ተመልኪቶም ዘለዉ 3 ገዛውቲ ተመልከቱ።

ቀዳማይ ገዛ፤ <u>ሕድሕዱ 5 ኪሎ ብዝምዘን፥ 20 ሴንቲ ሜትር ጎኒ፤ 40 ሴንቲ ሜትር ወርዲን 15 ሴንቲ ሜትር ቁመት ብዘለዎ ብሎኬት ዝተነደቐ እዩ</u>።

ካልኣይ ገዛ፤ <u>ሕድሕዱ 7 ኪሎ ብዝምዘን፥ 20 ሴንቲ ሜትር ጎኒ፤ 40 ሴንቲ ሜትር ወርዲን 15 ሴንቲ ሜትር ቁመት ብዘለዎ እምኒ ዝተነደቐ እዩ</u>።

ሳልሳይ ገዛ፤ <u>5 ኪሎ ብዝምዘን ብሎኬትን 7 ኪሎ ብዝምዘን እምንን እናተዛነቐ ዝተነደቐ እዩ</u>።

ሰለስቲኦም ገዛውቲ ድልዱል መሰረት ኣብዘይብሉ ዋልካ መሬት ዝተነደቑ እንተኾይኖም፣ ቀልጢፉ ክነቅዕ ዝኽእል ገዛ ኣየናይ እዩ?

ሀ. ቀዳማይ ገዛ።
ለ. ካልኣይ ገዛ።
ሐ. ሳልሳይ ገዛ።
መ. ኩሎም ንተመሳሳሊ ሓደጋ ዝተሳጥሑ እዮም።

___ 8. እዚ ዝስዕብ ኣንቀፅ ኣንብቡ።

<u>ኣብ እግሪ ጎቦ መሰቦ ሓደ ዓብዪ ግድብ ንምስራሕ መደብ ኣሎ ንበል። እቲ ግድብ እንትመልእ ማይ ብዝፈስሰሉ ኣንፈት 30 ሜትሮ ዝቑመቱን 40 ሜትሮ ዝንውሓቱን መንደኞ ምስራሕ የድሊ ንበል። ቑመት እቲ መንድኞ ከምዘሎ ኮይኑ፣ ኣብ ቅርፂ እቲ መንደኞ እዞም ዝስዕቡ 4 ሓሳባት ቀሪቦም፤</u>

<u>ቀዳማይ ሓሳብ፤ ፍርቂ ክቢ ክኸውን (ማለት ◡)</u>።

<u>ካልኣይ ሓሳብ፤ ቀጥታ መስመር ክኸውን (ማለት —)</u>።

<u>ሳልሳይ ሓሳብ፤ ፍርቂ ርቡዕ ኩርናዕ ክኸውን (ማለት ⊔)</u>።

<u>ራብዓይ ሓሳብ፤ 60 ዲግሪ ዝኹርንዑ ጫፍ ክኸውን (ማለት V)</u>።

መሃንዲስ እንተኮይንኪ (እንተኾይንካ) ኣየናይ ሓሳብ ትቕበሊ (ትቕበል)?

ሀ. ቀዳማይ ሓሳብ። ሐ. ሳልሳይ ሓሳብ።

ለ. ካልኣይ ሓሳብ። መ. ራብዓይ ሓሳብ።

___ 9. ፈላጣት ድሕንነት መጉዓዝያ፥ ዘወርቲ ኣናእሸቶይ መኻይን መሳኺቲ መኻይኖም ምሉእ ንምሉእ ዓፅዮም ነዊሕ መገዲ ከይዝወሩ ይመኽሩ።ምኽንያቱ እንታይ ይመስለኩም?

ሀ. ብሓያል ሙቐት ደንዚዞም ነብሶም ከይስሕቱ። ሐ. ካብ ሞተር ዝልሑኽ ካርቦንዳይኦክሳይድ ከይዕፍኖም ።

ለ. ብሓያል ሙቐት ደንዚዞም ከይታኸሱ። መ. ካብ ሞተር ብዝልሑኽ ካርቦንሞኖ ኦክሳይድ ተዓፊኖም ነፍሶም ከይስሕቱ።

___ 10. ኣብ ዕቀባ ሃፍቲ ተፈጥሮን ከባቢን ሃገርና <u>ኣወንታዊ ግደ ዘይብሉ (ማለት ጠቓሚ ዘይኮነ)</u> ኣየናይ እዩ?

ሀ. ሓይሊ ሃይድሮኤሌክትሪክ ምፍልፋል። ሐ. ልማዳዊ ምርባሕ ከፍትን ጠለበጊዕን።

ለ. ምስፍሕፋሕ መስኖ። መ. ብዙሕ መፍረዪ (ሰራሕተኛ) ህዝቢ ምህላው።

___ 11. ሓደ ግድሚ ብተኽሊታት ንምልባስ መፅናዕቲ እንትግበር፥ ኣብ መወዳእታ ዝስራሕ እንታይ ይመስለኩም?

ሀ. ዓይነት ሓመድ እቲ ግድሚ ምፅናዕ። ሐ. መጠን ዝናብ እቲ ግድሚ ምፅናዕ።

ለ. ኣብቲ ግድሚ ዝፀድቁን ዝዓብዩን ኩሎም ዓይነታት ተኽሊታት ምፍላጥ። መ. ኣብቲ ግድሚ ቀልጢፎም ዝዓብዩ ዓይነታት ተኽሊታት ምምራፅ።

___ 12. ኣብ ዓለምና በብእዋኑ ሓደሽቲ ሕማማት ይመፁ። ልዕሊ 6.2 ቢሊዮን ህዝቢ ኣብ ዝነብረላ ዓለምና ኣታሓሳሳቢነት ሓደሽቲ ሕማማት ዝዓበዩ ዝኸውን እቶም ሕማማት ብ ___ ዝመሓላለፉ እንተኾይኖም እዮም።

ሀ. ብመግቢ። ሐ. ብምትንኻፍ።

ለ. ብማይ። መ. ብትንፋስ (ብኣየር)።

___ 13. ዋጋ ዘይቲ-ብልዒ ብሊትሮን ብኺሎን ማዕረ እንተኾይኑ፣ ካብዞም ዝስዕቡ ነጋዶ ዘይቲ-ብልዒ ኣየናይ ቀልጢፉ ይህፍትም?

ሀ. ብኺሎ ዓዲጉ ብኺሎ ዝሸይጥ። ሐ. ብኺሎ ዓዲጉ ብሊትሮ ዝሸይጥ።

ለ. ብሊትሮ ዓዲጉ ብሊትሮ ዝሸይጥ። መ. ብሊትሮ ዓዲጉ ብኺሎ ዝሸይጥ።

___ 14. ካብዞም ዝስዕቡ ኸባቢታት መቐለ ዝነኣሰ ፀቕጢ ኣየር ዘለዎ ኸባቢ ኣየናይ እዩ?

ሀ. እንዳየሱስ። ሐ. ሓወልቲ።

ለ. ባሎኒ (መቐለ ስታዲየም)። መ. ደጀን (ምምሕዳር)።

___ 15. ሕሩጭ መስተያት፣ ሕሩጭ ብሩር፣ ሕሩጭ ወርቂን ሕሩጭ ሓፂንን ኣሎኩም ንበል። ካብ ሕድሕዶም ሓደ ማንካ ሕሩጭ ኣብ ማይ ዝመልአ ነዊሕ ጥርሙዝ እንተኣእቲኹም፥ ኣየናይ ቀልጢፉ ዝግ ይብል?

ሀ. ሕሩጭ መስተያት። ሐ. ሕሩጭ ብሩር።

ለ. ሕሩጭ ወርቂ። መ. ሕሩጭ ሓፂን።

___ 16. ኣብ መብዛሕቶም ስድራቤታት መቐለ ዝተለምደን፥ ኩሉ ክገብሮ ዝኽእልን ሜላ ኣተዓቓቕባ መግቢ ኣየናይ እዩ?

ሀ. ኣብ መዝሓሊ ምቕማጥ። ሐ. ምቑንጣይን ምንቃፅን።

ለ. ኬሚካል ምውሳኽ። መ. ምእሻግ።

**ራብዓይ ክፋል፤ ነዞም ዝስዕቡ ሕቶታት ሓፂር መልሲ ሃቡ። (መልሲ ብድሕሪት)**

17. ፅርየት ዝስተ ማይ ክንሕልወሎም ካብ ዝግብኡና ሜላታት ሓደ ምፍላሕ እዩ። ኩሎም ነበርቲ ገጠራትን ኣናእሽቶይ ከተማታትን ኢትዮጵያ ዝሰትዩዎ ማይ ዘፍልሑ እንተዝኾኑ፥ ኣብ ሃፍታት ተፈጥሮ ሃገርና እንታይ ፀገም ምተዓዘብና?

18. ድኽነት ኣብ ምምሕልላፍ ሕማማት ዘለዎ ፅዕንቶ (ግደ) ሓፂር ርኢቶ ፅሓፉ።

19. ብሰላምታ ብምጭብባጥ ክመሓላለፉ ዝኽእሉ 3 ሕማማት ዘርዝሩ። ንሕድሕዶም 2 ሜላታት ምክልኻል ጥቐሱ።

20. ፀገም ምርኣይ ምስ ምእራግ (ምሽንጋል) ብኸመይ ከምዝተሓሓዝ ሓፂር መብርሂ ፅሓፉ።

## Appendix B. Post-Intervention Test (English Translation)

**Grade 5**
**Knowledge/Comprehension Test**

**Part 1. True or False**

____ 1. The cilia on the wall of nasal cavity serve to warm the inhaled air.

____ 2. The toxic chemical in tobacco is called carbon monoxide.

____ 3. Diaphragm separates the abdominal cavity and the thoracic cavity.

____ 4. The transmission of nervous message between two nerve cells takes place via dendrites.

____ 5. Motor neurons receive messages from the spinal cord.

____ 6. A doubling of the population of workers precedes the traditional reproduction of honeybee.

**Part 2: Fill in the Blank**

7. The part of human breathing system that prevents food from getting into the lungs is called _______________.
8. The exchange of $O_2$ and $CO_2$ in the lungs takes place between _______________ and capillaries.
9. The mineral found in thyroxin is called _______________.
10. The glands that secrete hormones are collectively referred to as _______________.
11. The fastest nervous response is called _______________.
12. The newly hatched locust differs form an adult by its _______________.

**Part 3: Choosing**

____ 13. The gas with the highest percentage in an inhaled air is ________.

A. Carbon dioxide C. Oxygen

B. Nitrogen D. Carbon monoxide

____ 14. Of the 21% $O_2$ in the inhaled, ________ gets into the blood stream.

A. Half of it C. Some of it

B. All of it D. Most of it

____ 15. Which one of the following pairs of “hormone—function” is incorrect?

A. Pituitary hormones—growth C. Parathormone—control of Ca content

B. Insulin—food absorption D. Adrenaline—control of iodine content

____ 16. Which one of the following insects does not undergo complete metamorphosis?

A. House fly
B. Locust
C. Mosquito
D. Moth

____ 17. What is the main difference between the life cycle of a housefly and a locust?

A. The stages of a housefly vary in size whereas that of a locust vary in structure
B. A housefly passes through 4 stages whereas a locust passes through 3 stages
C. The stages of a housefly vary in structure whereas that of a locust vary in size
D. A housefly lies its eggs in dirt whereas a locust lies its eggs in moist sand

____ 18. External fertilization of fish and frog takes place in aquatic environments. One of the following is not the use of water in external fertilization.

A. Helps tadpoles grow properly
B. Helps sperm swim toward egg
C. Keeps eggs and sperms from drying
D. Helps egg swim toward sperm

**Part 4: Give Short Answers**

19. Write the changes in the organs of breathing during exhalation. Complete the following Table.

| | What happens during exhalation? |
|---|---|
| Diaphragm | |
| Thoracic Cavity | |
| Air Pressure | |

20. How does a nervous message transmit? How about a hormonal message?

**Application Test**

**Part 1. True or False**

____ 1. The air forced into the lungs of a victim in artificial breathing contains lower $O_2$ content.

____ 2. A person whose pancreas is surgically removed would most likely develop goiter.

**Part 2: Fill in the Blank**

3. Out of the three types of neurons, _______________ is likely found in fingertips.
4. One of the development projects being carried out in Tigrai that increases the spread of malaria is _______________.

**Part 3: Choose the Correct Answer from the 4 Alternatives**

____ 5. The purpose of providing artificial breathing to help a victim who inhaled toxic gas is to _______.

A. Enable rib muscles to resume their functioning
B. Increase the volume of lungs to inhale air
C. Provide oxygen to the brain quickly
D. Open the breathing tubes

____ 6. Which one of the following statements <u>is false</u>?

A. Smokers are more susceptible to allergies of breathing tract than nonsmokers
B. Smokers are more likely to be affected by common cold than nonsmokers
C. Breathing through the nostrils reduce breathing tract allergies
D. Smokers are less likely to be affected by common cold than nonsmokers

____ 7. The air that reaches the lungs of smokers is ___ than the air that reaches the lungs of nonsmokers.

A. Warmer
B. Less clean
C. Cooler
D. Drier

____ 8. Which of the following respiratory diseases require similar treatment and medication?

A. Common cold and Influenza
B. Common cold and Tuberculosis
C. Influenza and Tuberculosis
D. Common cold, Influenza & Tuberculosis

____ 9. Refer the five processes of nervous system underlined below. (1) Hand withdrawn. (2) Sense of hotness reached the spinal cord. (3) Finger touched hot metal. (4) The stimulus reached the CNS and interpreted. (5) Message reached the arm that orders the muscles to contract/relax. Which one of the following is the correct sequence?

A. 3, 2, 4, 5, 1
B. 3, 4, 5, 2, 1
C. 3, 1, 4, 2, 5
D. 3, 2, 1, 5, 4

____ 10. A person who is seriously injured his/her forehead during his/her childhood can face difficulty in ___.

A. Remembering and Speech
B. Remembering and Heartbeat
C. Heartbeat and Dancing
D. Heartbeat and Breathing

____ 11. Which one of the following bodily processes is not controlled by hypothalamus?

A. Thirsty
B. Secreting urine
C. Food absorption
D. Walking

____ 12. A drunk faces difficulty seeing and speaking at the beginning. If he continues drinking, he would no more walk properly. If he fails to stop drinking at this stage, he may lose consciousness and begin vomiting. In this scenario, which of the parts of the brain are affected 1$^{st}$, 2$^{nd}$ and 3$^{rd}$?

A. Hypothalamus, Cerebellum, Cerebrum
B. Cerebrum, Hypothalamus, Cerebellum
C. Cerebrum, Cerebellum, Hypothalamus
D. Hypothalamus, Cerebellum, Cerebrum

____ 13. Which one of the following statements is false?

A. Cleaning our household and environment denies adult houseflies from getting reproductive spaces
B. Cleaning our household and environment denies housefly pupae from getting food
C. Cleaning our household and environment denies housefly larvae from getting moisture and warmth
D. Cleaning our household and environment denies housefly egg from getting food

____ 14. Speaking while eating is an unsafe practice. Why?

A. Air gets into esophagus with the food
B. The air inhaled via the mouth is dry
C. Food can chock into breathing tubes.
D. Excess air is inhaled

____ 15. If someone who steps on a hot metal could not feel it, s/he may have one of the following problems. Identify it.

A. Nervous message from the foot fails to reach the spinal cord

B. Nervous message from the spinal cord fails to reach the motors neurons

C. Nervous message from motor neurons fails to reach to the leg muscles

D. Failure of the leg muscles to respond after receiving nervous message

____ 16. During exhalation, the air pressure in the trachea is ____?

A. Less than the air pressure in the lungs

B. Greater than the air pressure in the lungs

C. Less than the air pressure in the atmosphere

D. Equal to the air pressure of the atmosphere

**Part 4: Give Short Answers**

17. Compare the amount of oxygen and carbon dioxide in the air inhaled by a normal person and in that forced into a victim during artificial breathing.

18. Which one of the following is easier to control? Infestation of armyworm or locust? Write two supporting ideas.

19. Write two simple and environment-friendly methods of controlling mosquitoes.

20. Write the differences between the reproduction of frog and lizard.

**Transfer Test**

**Part 1. True or False**

____ 1. The air inhaled through the nostrils would have the same temperature as that inhaled through the mouth before reaching the lungs.

____ 2. The life cycle of a frog can take months to complete.

**Part 2: Fill in the Blank**

3. A person who walks like a drunken may have a problem in his/her __________.
4. The vocal difference between children and youth is because of _________ hormones.

**Part 3: Choosing**

____ 5. Assume that Mehari is about 2 meters tall. And Ibrahim is about 1.25 meters tall. If both of these persons step on a hot object, who will feel it first?

A. Mehari
B. Ibrahim
C. Both
D. It is difficult to infer

____ 6. The nervous system is functionally analogous to _____ and structurally analogous to _____.

A. telecommunication … electricity
B. electricity … telecommunication
C. telecommunication … water pipes
D. electricity … water pipes

____ 7. Read the underlined paragraph below.

<u>Axeza and Hannesa study their lessons in the evening using lamplight. Since they place the lamplight near to them, they inhale a good deal of smoke from the lamplight. Axeza removes some soot from her nose every morning. But Hannesa does not</u>.

Which one of these girls do you think inhales relatively unclean air?

A. Axeza
B. Hannesa
C. No difference
D. It is difficult to infer

____ 8. Housefly infestation is high in September. But it is low in November. What do you think is the reason for this difference?

A. The temperature and moisture in September are optimum for reproduction, whereas in November the weather is cold and dry
B. Food supply is high in September but low in November
C. The temperature in September is optimum for reproduction, whereas it is cooler in November
D. The moisture in September is optimum for reproduction, whereas it is direr in November

____ 9. Following are three families and the descriptions of their living rooms.

Teklu's Living Rooms: Hut with very small windows.

Shekna's Living Rooms: Villa with airtight glass windows.

Tesfu's Living Rooms: Wooden fenced, partly open shelter.

If we assume that three of the families live in mosquito-infested locality, which one of them will most likely be affected by malaria?

A. Teklu's
B. Shekna's
C. Tesfu's
D. All are equally at risk

____ 10. Refer to Q 9. If coal is burnt in all of the living rooms of the families at night, which one of them will most likely be poisoned by CO?

A. Teklu's
B. Shekna's
C. Tesfu's
D. All are equally at risk

____ 11. Which one of the following designs of a pond for fish culture would ensure high rate of external fertilization?

A. Bedding of the pond with soil
B. Placing small rocks around the edge
C. Filling the pond with water
D. Placing sand around the edge

____ 12. The feed of poultry used for egg production should contain __________.

A. Vegetables
B. Crushed bones
C. Sorghum
D. Carrot

____ 13. Which one of the following is not an important consideration when planning aviculture?

A. Distance to source of water
B. Distance to vegetation
C. Wind speed of the site
D. Direction of the hive

____ 14. Oxygen comprises about 21% of the air. Had the amount of oxygen in the air been 10%, what would we do to obtain sufficient oxygen?

A. Inhale air through the nostrils and the mouth
B. Increase the rate and depth of breathing
C. Reduce activities that demand extra energy
D. Hold inhaled air in the lungs for more time

____ 15. The hormone that would most likely be excreted excessively by a tempered person is?

A. Thyroxin
B. Parathormone
C. Adrenaline
D. Insulin

____ 16. The infestation of moth would be highly likely in:

A. *Woyna-Degu'a* C. *Qola*

B. *Degu'a* D. Alpine

**Part 4: Give Short Answers**

17. Read the following paragraph and answer the question that follows.
Mehari goes to school by the front of Mr. Berihu's house. Mr. Berrihu has got an aggressive dog, which is kept chained during daytime. Mehari, however, is anxious when walking in front of Mr. Berihu's house. One day, the dog started barking when Mehari reaches about the front of Mr. Berihu's house. At that time, Mehari scared to death and run swiftly.
Write the sequence of neural processes in this scenario.

18. Read the following paragraph and answer the question that follows.
Mrs. Gargis bought one hen to start home based poultry. Then, she bought 10 eggs from an open market, and let the hen incubate them. Out of the 10 eggs, only 3 chickens were hatched whereas the other seven were spoiled.

What do you think is the reason for hatching only 3 chickens? Give a brief answer.

19. Chickens incubate their eggs for about 21 days. However, some chickens may incubate for 22 to 23 days. What is the reason for such kind of differences?

20. Read the following assumption and answer the question that follows.
Mamush is a one-year-old baby. When his ball rolls under the bed, he crawls and gets a long stick and pulls the ball out. Abush is also a one-year-old baby. He began toddling. But, when his ball rolls under the bed, he cries for help.

Which part of Mamush's brain do you think is more developed? And which part of Abush's brain do you think is more developed?

**Grade 6**

**Knowledge/Comprehension Test**

**Part 1. True or False**

____ 1. Trachoma usually affects children of 10-15 years old.

____ 2. Compared to that of gas and liquid, the volume of solid does not change.

____ 3. When light ray travels from water to air at an angle, the angle between a perpendicular line and the ray widens.

____ 4. Edible oil has definite volume and definite shape.

____ 5. AIDS, tuberculosis and diabetes are communicable diseases.

____ 6. A lens that is thinner in the middle and thicker at the edge is called concave lens.

**Part 2. Fill in the Blank**

7. The causative agent of pneumonia is ________.
8. The diseases of a patient with thin and green dysentery would probably be ________.
9. ________ represents the space occupied by an object.
10. The lens that aids a person with a problem of seeing far objects is called ________.
11. The unit for measuring liquids is called ________.
12. (Mass) ÷ (Area) =________.

**Part 3: Choosing**

____ 13. Which of the following gaseous compounds would result in acid rain?

A. Sulfur dioxide and carbon monoxide
B. Sulfur dioxide and nitrogen dioxide
C. Nitrogen dioxide and carbon monoxide
D. Carbon monoxide and carbon dioxide

____ 14. Which one of the following diseases would be resulted by eating raw meat?

A. Tapeworm
B. Bilharzias
C. Ascariasis
D. Amoebic dysentery

____ 15. Which one of the following is the symptom of many diseases?

A. Dysentery
B. Coughing
C. Elevated body temperature
D. Shivering

____ 16. One of the following four diseases is caused by an organism, which is larger than that of the others?

A. Malaria
B. Small pox
C. Polio
D. AIDS

____ 17. Which one of the following substances has the highest optical density?

A. Air  
B. Oil  
C. Water  
D. Glass

____ 18. Which one of the following biscuits has a different volume?

A. Biscuit 1, with 8 cm length, 1 cm height, 1 cm width  
B. Biscuit 2, with 2 cm length, 2 cm height, 2 cm width  
C. Biscuit 3, with 2 cm length, 4 cm height, 1 cm width  
D. Biscuit 4, with 2 cm length, 3 cm height, 3 cm width

**Part 4: Give Short Answer**

19. Write three methods of prevention and treatment of dandruff infection.

20. What is disease?

**Application Test**

**Part 1. True or False**

____ 1. The density of water at 5 °C and 70 °C is the same.

____ 2. The type a disease can be definitely known from a single symptom.

**Part 2. Fill in the Blank**

3. Rays of light that pass through a 2-centimeter thick of bottle that contains water refracts ______________ times when reaching the other side of the bottle.
4. Sleeping with many people in places like churches, prisons, etc can expose someone to ______________.

**Part 3: Choosing**

____ 5. The major factor for uncontrolled population increase in Tigrai State is ____?

A. Lack of birth control practice  
B. Underage marriage  
C. Polygamy  
D. Lack of population policy

_____ 6. Which one of the following demographic factors creates major social problem?

A. High birth rate and low death rate
B. Higher number of dependents
C. Regional population disparity
D. Smaller family size

_____ 7. Carbon dioxide constitutes about 0.03% of the air. What would happen if the percentage rises to 0.06?

A. Environmental temperature drops
B. Sea level increases
C. Environmental temperature increases
D. No significant change would be apparent

_____ 8. Which one of the following substances is the major cause of water pollution in Mekelle town?

A. Herbicides and insecticides
B. Leakage of sewerage
C. Industrial pollutants
D. Acid rain

_____ 9. Which one of the following four natural resources would be conserved through conserving the other three?

A. Soil
B. Water
C. Vegetation
D. Wild animals

_____ 10. Which one of the following diseases is least likely to affect grade six children?

A. Cholera
B. Small pox
C. Typhus
D. Influenza

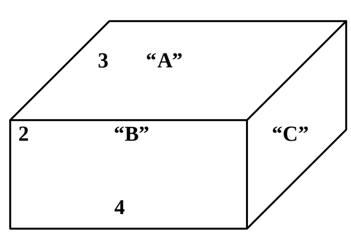
_____ 11. Which one of the following blocks has the largest volume?

A. A block of 100g weight & 10g/cc density
B. A block of 1000g weight & 50g/cc density
C. A block of 500g weight & 100g/cc density
D. A block of 50g weight & 25g/cc density

_____ 12. The highest speed of an airplane would be at _________ meters above sea level.

A. 6000
B. 7000
C. 8000
D. 9000

_____ 13. Refer to the following figure of a wooden block of 2 cm by 4 cm by 3 cm.



Which face of the wooden block would yield the highest buoyant force if placed on water surface?

A. [A] C. [C]

B. [B] D. There would be no difference

____ 14. Refer to the figure in Question 13. Which face of the block would exert the greatest pressure?

A. [A] C. [C]

B. [B] D. All faces exert the same pressure

____ 14. What is the image of “ë” if it is reflected by convex lens?

A. û C. ù

B. é D. ë

____ 15. Following are four measures of thickness of convex lenses. Which measures would correspond to a lens with the longest focal length?

A. 8 mm C. 12 mm

B. 10 mm D. 14 mm

**Part 4: Give Short Answers**

17. (A) What is the name of the disease of a patient with chronic dysentery who visits the latrine 35 times a day, suffering from muscle spasm and is with deepening eye and cheeks? (B) What should the patient, his family and his neighborhood do until he gets medical treatment?

18. Currently various water conservation dams and wells are being executed in Tigrai State. The importance of water conservation is apparent. However, water conservation dams and wells could lead to the spread of some diseases. (a) List two diseases that could be spread as the result of water conservation projects. (b) Write the modes of prevention of each disease briefly.

19. Mama Gergis put 1kg of beans in 3 liters of water to germinate it. About 150g of the beans floated in the beginning. Write the reason briefly why the 150g beans floated in the beginning?

20. Assume that a 20g seeds of maize has a volume of $10mm^3$. And assume that a 30g seeds of bean has a volume of $20mm^3$. Compare the density of the seeds of maize and bean.

**Transfer Test**

**Part 1. True or False**

____ 1. Soil pollution is more serious problem than water pollution around Mekelle.

____ 2. An object with greater density would exert greater pressure.

**Part 2. Fill in the Blank**

3. Because of recurrent droughts, children of our country are suffered by ________ diseases.
4. The usual method of water treatment in cities and towns is ________.

**Part 3: Choosing**

____ 5. Which one of the following environmental problems is not important in Ethiopia?

A. Overpopulation  C. Air pollution

B. Water pollution  D. Deforestation

____ 6. About 47% of Ethiopia's population lies between the age of 15 and 64 years. How would the HIV/AIDS pandemic affect this percentage (47%)?

A. It lowers the percentage.  C. It keeps the percentage from getting lowered

B. It increases the percentage.  D. It has no apparent effect

____ 7. Read the method of construction of the following 3 houses.

House 1: Is built using 20cm x 40cm x 15 cm blocks weighing 5 kg each.

House 2: Is built using 20cm x 40cm x 15 cm blocks weighing 7 kg each.

House 3: Is built using 20cm x 40cm x 15 cm blocks weighing 5 kg and 7 kg of equal proportions.

If all of the houses lack good foundation, which one would crack easily and early?

A. House 1  C. House 3

B. House 2  D. All will face to the same problem

____ 8. Read the following paragraph.

Assume that there is a plan to build a dam of 30 meters high and 40 meters long at the foot of mount *Mesebo*. And, assume that the following four ideas were presented on the shape the dam without changing the volume.

Idea 1: Half circle, *i.e.*, ∪

Idea 2: Straight line, *i.e.*, —

Idea 3: Half Square, *i.e.*, ⊔

Idea 4: 60 ° Angular, *i.e.*, V

If you were an engineer, which ideas would you choose?

A. Idea 1 C. Idea 3

B. Idea 2 D. Idea 4

____ 9. Transport safety personnel advise people not to tightly close windows of their cars when driving for long hours. What do you think is the danger of tightly closing windows when driving for long hours?

A. Passing out by high heat C. $CO_2$ poisoning leaking from the engine

B. Falling asleep by high heat D. CO poisoning leaking from the engine

____ 10. Which one of the following does not play positive role in environmental conservation efforts in Ethiopia?

A. Generation of hydroelectricity C. Traditional livestock production

B. Expansion of irrigation D. High population of productive citizens

____ 11. Which one of the following considerations should be addressed last when planning to reforest a locality?

A. Studying the soil of the locality C. Studying the precipitation of the locality

B. Studying the vegetation of the locality D. Selecting plants that establish and grow in the locality quickly

____ 12. New communicable diseases emerge in the world every time. Which kinds of such diseases would be more dangerous in the world with a population of 6.2 billion?

A. Those which transmit by food C. Those which transmit by contact

B. Those which transmit by water D. Those which transmit by breathing (air)

____ 13. If the price of edible oil were the same in liter and in kilo, which one of the following merchants would get rich quicker? Those who buy in ________ and sell in ________.

A. kilo … kilo C. kilo … liter

B. liter … liter D. liter … kilo

____ 14. Which one of the following localities in Mekelle would have the smallest measure of air pressure?

A. Enda Jesus
B. Baloni (Mekelle Stadium)
C. Hawolti
D. Dejen

____ 15. Assume that you are provided with dust particles of Glass, Silver, Gold and Iron. Which of the particles would settle faster when poured into a glass of water?

A. The glass particles
B. The gold particles
C. The silver particles
D. The iron particles

____ 16. Which one of the following methods of food preservation is practiced by endogenous families in Mekelle?

A. Freezing
B. Addition of preservatives
C. Drying
D. Canning

**Part 4: Give Short Answers**

17. Boiling is one of the methods of treatment of potable water. If all dwellers of rural and suburban communities of Ethiopia boil potable water, what environmental problems would be evident?

18. Comment on the effects of poverty in the transmission diseases.

19. List three diseases that can be transmitted by hand shaking. Give two methods of prevention for each one.

20. Explain how sight problems are related to aging.

## Appendix C. Test Scores of Students Completed Post-intervention Tests

**Note:**

**§**Gender (F = female, M = male), Age, Treatment (1 = Individual learning class, 2 = Pair learning class, 3 = Comparison class), Test-Group (1 = Immediate, 2 = Delayed), Prior School Performance score (100%), Knowledge/Comprehension test score (25 pts), Application test score (25 pts), Transfer test score (25 pts), Total post-test score (75 pts) **§**

### GRADE FIVE

### Graphic Organizers: School-1

**§**F, 13, 1, 1, 59, 11, 10, 12, 33§ F, 13, 1, 1, 59.1, 4, 4, 4, 12§ M, 11, 1, 1, 65.9, 6, 5, 2, 13§ F, 11, 1, 1, 67.8, 8, 8, 6, 22§ F, 11, 1, 1, 69.9, 8, 2, 5, 15§ F, 10, 1, 1, 70.6, 6, 6, 8, 20§ F, 11, 1, 1, 54.3, 5, 4, 4, 13§ F, 11, 1, 1, 64.3, 6, 1, 2, 9§ M, 10, 1, 1, 52.1, 6, 2, 2, 10§ M, 11, 1, 1, 74.7, 7.5, 5, 2, 14.5§ F, 12, 1, 1, 80.8, 4, 7, 8, 19§ F, 13, 1, 1, 43.67, 9.5, 8, 6, 23.5§ F, 10, 1, 1, 46.9, 13, 12, 5, 30§ F, 12, 1, 1, 65.1, 4, 6, 2, 12§ M, 11, 1, 1, 74.3, 6, 10, 5, 21§ M, 11, 1, 1, 68.7, 9, 3, 8, 20§ M, 13, 1, 1, 85.7, 4, 7, 2, 13§ F, 11, 1, 1, 62.2, 4, 5, 5, 14§ F, 13, 1, 1, 55.2, 6, 5, 2, 13§ M, 10, 1, 1, 50.6, 6, 6, 7, 19§ F, 12, 1, 1, 54.8, 5, 7, 3, 15§ M, 11, 1, 1, 57.5, 14, 6.5, 8, 28.5§ M, 13, 1, 1, 58.2, 8, 2, 2, 12§ M, 13, 1, 1, 48.5, 7, 8, 2, 17§ F, 13, 1, 1, 52.7, 3, 5, 3, 11§ F, 12, 1, 1, 53.9, 10, 7, 7, 24§ F, 13, 1, 1, 56.6, 5, 3, 2, 10§ M, 12, 1, 1, 49.6, 4, 8, 3, 15§ F, 13, 1, 2, 45.25, 6, 4, 0.5, 10.5§ F, 13, 1, 2, 47.2, 4, 4.5, 7, 15.5§ F, 12, 1, 2, 49.3, 2, 6, 5, 13§ F, 11, 1, 2, 49.7, 7, 7, 3, 17§ F, 11, 1, 2, 51, 4, 5, 3, 12§ F, 10, 1, 2, 54.1, 6, 6, 4, 16§ F, 13, 1, 2, 54.4, 4, 5, 6, 15§ F, 13, 1, 2, 56.1, 4, 7, 4, 15§ M, 12, 1, 2, 57, 3, 3, 3, 9§ F, 11, 1, 2, 58, 10, 6, 3, 19§ F, 12, 1, 2, 58.7, 5, 4, 2, 11§ M, 11, 1, 2, 59, 8.5, 3, 8, 19. 5§ F, 13, 1, 2, 62.1, 4, 4, 6, 14§ M, 10, 1, 2, 62.6, 6, 2, 2, 10§ F, 11, 1, 2, 62.9, 5, 6, 4, 15§ M, 11, 1, 2, 64, 5, 4, 4, 13§ M, 12, 1, 2, 65.7, 7, 5, 6, 18§ F, 11, 1, 2, 69.7, 7, 8, 5, 20§ F, 13, 1, 2, 70.4, 4, 5, 6, 15§ M, 11, 1, 2, 74.5, 8, 5, 6, 19§ F, 13, 1, 2, 75.4, 7.5, 5.5, 8, 21§ F, 11, 1, 2, 80.3, 9, 6, 4, 19§ M, 11, 1, 2, 84.6, 11.5, 6.5, 4, 22§ M, 11, 1, 2, 87.6, 14.5, 7, 8, 29.5§ F, 12, 2, 1, 84.5, 8.5, 8, 7.5, 24§ F, 12, 2, 1, 65.1, 5, 5, 4, 14§ F, 12, 2, 1, 70.7, 7, 6, 8, 21§ M, 12, 2, 1, 69.4, 5, 2, 8, 15§ F, 12, 2, 1, 62.2, 8, 7, 7, 22§ M, 12, 2, 1, 83.2, 14, 6, 6.5, 26.5§ M, 13, 2, 1, 69.1, 7, 3, 6, 16§ M, 12, 2, 1, 54.6, 5, 3, 4, 12§ M, 13, 2, 1, 55.1, 8, 2, 2, 12§ F, 11, 2, 1, 61.6, 7, 4, 2, 13§ M, 12, 2, 1, 63.2, 7, 4, 7, 18§ M, 12, 2, 1, 58.9, 8, 9.5, 7, 24.5§ M, 13, 2, 1, 47.2, 3, 6, 2, 11§ F, 12, 2, 1, 68.1, 6, 7, 6, 19§ F, 12, 2, 1, 67.7, 10, 6, 8, 24§ F, 12, 2, 1, 48.5, 4, 4, 4, 12§ M, 11, 2, 1, 51.6, 4, 7, 4, 15§ F, 13, 2, 1, 41.92, 4, 10, 3, 17§ F, 12, 2, 1, 68.8, 8, 11, 11, 30§ F, 12, 2, 1, 75.5, 9, 7, 8, 24§ F, 13, 2, 1, 53.6, 4, 4, 1, 9§ F, 12, 2, 1, 80.9, 7.5, 5, 5, 17.5§ F, 13, 2, 1, 60.2, 5, 5.5, 7, 17.5§ M, 13, 2, 1, 67, 6, 5, 6, 17§ F, 12, 2, 1, 57.4, 5, 7, 5, 17§ F, 13, 2, 1, 57.7, 8, 4, 3, 15§ F, 12, 2, 1, 87.9, 13, 9, 10, 32§ F, 12, 2, 2, 44.08, 7.5, 4, 7, 18.5§ M, 12, 2, 2, 48.4, 4, 2, 3, 9§ M, 12, 2, 2, 51.1, 3, 7, 4, 14§ F, 12, 2, 2, 52.1, 5, 3, 4, 12§ F, 12, 2, 2, 53.7, 4, 2, 6, 12§ F, 13, 2, 2, 55.1, 6, 1, 4, 11§ M, 13, 2, 2, 57.1, 3, 6, 3, 12§ F, 13, 2, 2, 57.5, 4, 7, 4, 15§ F, 10, 2, 2, 59, 3, 4, 6, 13§ M, 12, 2, 2, 61, 3, 5, 7, 15§ F, 11, 2, 2, 61.8, 8, 7, 4, 19§ F, 13, 2, 2, 62.7, 5, 5, 3, 13§ M, 12, 2, 2, 64.9, 7, 4, 7, 18§ M, 12, 2, 2, 65.7, 6, 11, 5, 22§ M, 13, 2, 2, 67.6, 10, 11, 11.25, 32.25§ F, 12, 2, 2, 68, 6, 10, 9, 25§ M, 12, 2, 2, 69, 4, 5, 5, 14§ F, 11, 2, 2, 69.4, 3, 11, 9, 23§ F, 12, 2, 2, 70.2, 6, 9, 6, 21§ F, 11, 2, 2, 77.1, 9.5, 11, 8.25, 28.75§ F, 11, 2, 2, 81.1, 3, 6, 4, 13§ M, 11, 2, 2, 84.4, 4, 8, 7, 19§ M, 13, 2, 2, 84.7, 7, 7, 5.25, 19.25§ M, 12, 2, 2, 88.8, 16.5, 9, 11.5, 37§ F, 11, 3, 1, 80.5, 10, 9, 9, 28§ F, 11, 3, 1, 65.5, 5, 3, 4, 12§ F, 11, 3, 1, 64.4, 4, 3, 6, 13§ M, 12, 3, 1, 91.9, 13, 8, 10, 31§ F, 10, 3, 1, 61.5, 7, 5, 4, 16§ F, 13, 3, 1, 48.1, 4, 5, 8, 17§ F, 10, 3, 1, 67.8, 8, 9, 8, 25§ F, 13, 3, 1, 76.7, 3, 8.5, 5, 16.5§ F, 10, 3, 1, 70.2, 6, 6.5, 8, 20.5§ F, 11, 3, 1, 53.9, 7, 7, 5, 19§ M, 11, 3, 1, 85.9, 8.5, 8, 6, 22.5§ F, 13, 3, 1, 50.5, 4, 2, 5, 11§ F, 13, 3, 1, 59.4, 4, 4, 4, 12§ F, 12, 3, 1, 65.3, 7, 5, 7, 19§ F, 12, 3, 1, 70.8, 9, 9, 4, 22§ F, 10, 3, 1, 57.7, 8, 3, 6, 17§ F, 11, 3, 1, 75.1, 7, 5, 4, 16§ M, 10, 3, 1, 82.7, 5, 10, 2, 17§ M, 11, 3, 1, 89.8, 11, 10, 2, 23§ M, 12, 3, 1, 62.16, 8, 4, 7, 19§ M, 13, 3, 1, 54.3, 5, 6, 6, 17§ F, 13, 3, 1, 49.3, 1, 6, 4, 11§ F, 13, 3, 2, 45.75, 6, 5, 7, 18§ M, 11, 3, 2, 53.58, 5, 3, 4, 12§ F, 13, 3, 2, 54.2, 6, 4, 3, 13§ F, 10, 3, 2, 54.8, 6, 7, 5, 18§ F, 12, 3, 2, 57.8, 2, 7, 2, 11§ M, 12, 3, 2, 59.6, 2, 6, 5, 13§ M, 11, 3, 2, 62, 7, 5, 8, 20§ F, 12, 3, 2, 63.3, 10, 13, 8, 31§ F, 13, 3, 2, 65.5, 5, 9, 2, 16§ M, 11, 3, 2, 65.7, 6, 4, 4, 14§ M, 11, 3, 2, 67.5, 7, 5, 4, 16§ F, 12, 3, 2, 68.09, 11, 12, 8, 31§ M, 10, 3, 2, 70.4, 5, 7, 4, 16§ F, 11, 3, 2, 74, 4, 6, 3, 13§ F, 13, 3, 2, 76.5, 9, 4, 3, 16§ M, 13, 3, 2, 79, 8, 6, 8, 22§ M, 11, 3, 2, 82, 2, 4, 6, 12§ F, 11, 3, 2, 84.8, 12, 7, 3, 22§ F, 13, 3, 2, 86.1, 6, 13, 11.25, 30.25§ F, 13, 3, 2, 90, 7, 10, 12, 29§

**Graphic Organizers: School-2**

§F, 12, 1, 1, 47.08, 6, 8, 6, 20§ M, 12, 1, 1, 50.1, 5, 6, 3, 14§ F, 12, 1, 1, 52.19, 5, 3, 3, 11§ M, 11, 1, 1, 52.99, 5, 5, 4, 14§ F, 13, 1, 1, 53.6, 6, 5, 2, 13§ M, 10, 1, 1, 53.9, 7, 6, 3, 16§ F, 11, 1, 1, 54.39, 4, 5, 1, 10§ M, 11, 1, 1, 56.1, 6, 6, 6, 18§ F, 11, 1, 1, 57.4, 3, 3, 6, 12§ F, 11, 1, 1, 58.1, 9.5, 5, 5, 19.5§ F, 11, 1, 1, 58.95, 5, 9, 4, 18§ M, 11, 1, 1, 59.3, 8, 4, 5, 17§ F, 12, 1, 1, 59.59, 6, 4, 3, 13§ F, 10, 1, 1, 60.3, 6, 6, 3, 15§ M, 11, 1, 1, 60.39, 8, 3, 6, 17§ F, 11, 1, 1, 60.79, 4, 3, 3, 10§ M, 11, 1, 1, 62, 7, 4, 5, 16§ F, 13, 1, 1, 62.1, 5, 5, 5, 15§ M, 11, 1, 1, 62.8, 4, 6, 4, 14§ M, 13, 1, 1, 64.8, 4, 4, 0.5, 8.5§ F, 11, 1, 1, 68.7, 5, 6, 3, 14§ M, 11, 1, 1, 69.7, 7, 5, 6, 18§ F, 11, 1, 1, 71.3, 9, 9, 8, 26§ M, 12, 1, 1, 73.2, 7, 7, 4, 18§ F, 11, 1, 1, 76, 10, 9, 5, 24§ F, 11, 1, 1, 79.3, 8, 9, 8, 25§ M, 11, 2, 1, 37.9, 5, 1, 2, 8§ M, 11, 2, 1, 51.4, 7, 6, 5, 18§ M, 11, 2, 1, 52.1, 5, 5, 5, 15§ M, 11, 2, 1, 53.1, 4, 6, 7, 17§ F, 11, 2, 1, 53.4, 4, 5, 3, 12§ F, 11, 2, 1, 54.5, 4, 4, 5, 13§ F, 11, 2, 1, 54.9, 6, 5, 2, 13§ M, 13, 2, 1, 56.5, 4, 4, 5, 13§ F, 11, 2, 1, 56.9, 8, 5, 7, 20§ M, 12, 2, 1, 56.9, 4, 2, 6, 12§ M, 12, 2, 1, 57.3, 6, 2, 7, 15§ F, 10, 2, 1, 57.5, 6, 7.5, 9, 22.5§ F, 10, 2, 1, 58.6, 12, 6, 7, 25§ F, 13, 2, 1, 59.4, 6, 3, 2, 11§ F, 11, 2, 1, 60.7, 6, 4, 5, 15§ M, 11, 2, 1, 61, 4, 5, 3, 12§ F, 11, 2, 1, 61.2, 4, 3, 2, 9§ M, 10, 2, 1, 61.2, 6, 6, 4, 16§ M, 12, 2, 1, 61.8, 6, 6.5, 6, 18.5§ M, 11, 2, 1, 61.9, 7, 2, 2, 11§ F, 11, 2, 1, 62.4, 5, 2, 5, 12§ F, 11, 2, 1, 62.9, 8, 5, 5, 18§ F, 11, 2, 1, 64.8, 5, 4, 6, 15§ F, 11, 2, 1, 65.5, 11, 4, 6, 21§ F, 11, 2, 1, 69.2, 7, 5, 6, 18§ M, 11, 2, 1, 69.7, 7.5, 6, 5, 18.5§ M, 12, 2, 1, 71.8, 11.5, 6, 5, 22.5§ M, 11, 2, 1, 73.2, 8, 11, 5, 24§ M, 12, 2, 1, 82.1, 5, 4, 4, 13§ M, 13, 2, 1, 83.9, 8, 7, 7.5, 22.5§ M, 12, 3, 1, 49.08, 3, 3, 4, 10§ F, 12, 3, 1, 49.9, 8, 5, 2, 15§ F, 12, 3, 1, 53.9, 4, 5, 5, 14§ M, 12, 3, 1, 54.3, 3, 2, 4, 9§ M, 11, 3, 1, 54.8, 7, 4.5, 7, 18.5§ M, 12, 3, 1, 57, 4, 6, 6, 16§ F, 11, 3, 1, 57.3, 5, 4, 4, 13§ M, 12, 3, 1, 57.7, 1, 4, 4, 9§ M, 11, 3, 1, 58.3, 7, 3, 3, 13§ F, 12, 3, 1, 58.6, 5, 2, 4, 11§ F, 13, 3, 1, 58.9, 5, 5, 7, 17§ F, 13, 3, 1, 59.3, 4, 5, 3, 12§ M, 11, 3, 1, 60.1, 5, 5, 5, 15§ M, 11, 3, 1, 60.3, 4, 4, 2, 10§ M, 12, 3, 1, 60.6, 6, 5, 5, 16§ F, 11, 3, 1, 61.16, 6, 4, 4, 14§ M, 12, 3, 1, 61.5, 6, 2, 4, 12§ F, 13, 3, 1, 61.8, 6, 5, 3, 14§ M, 12, 3, 1, 64.1, 6, 4, 5, 15§ M, 11, 3, 1, 64.7, 4, 3, 4, 11§ M, 11, 3, 1, 66.5, 4, 5, 6, 15§ M, 12, 3, 1, 66.8, 8, 7, 5, 20§ F, 11, 3, 1, 67.9, 5, 5, 3, 13§ M, 11, 3, 1, 69.5, 9, 7, 1, 17§ M, 11, 3, 1, 72.3, 5, 6, 4, 15§ M, 11, 3, 1, 81.9, 6, 2, 5, 13§ M, 10, 3, 1, 87.5, 10, 5, 5, 20§ F, 11, 3, 1, 88.4, 8, 10, 5.5, 23.5§

**Metacognitive Reflection: School-4**

§M, 11, 1, 1, 53.00, 6, 9, 5, 20§ F, 13, 1, 1, 44.58, 5, 2, 7, 14§ M, 10, 1, 1, 71.10, 10, 9, 4, 23§ F, 10, 1, 1, 58.50, 4, 4, 5.25, 13.25§ M, 11, 1, 1, 51.20, 3, 6, 9, 18§ F, 11, 1, 1, 65.90, 10, 12.5, 6, 28.5§ M, 10, 1, 1, 95.50, 10, 7, 6, 23§ F, 10, 1, 1, 68.70, 10, 7, 8, 25§ M, 10, 1, 1, 70.40, 10, 9, 8.5, 27.5§ M, 11, 1, 1, 72.30, 10, 10, 6.5, 26.5§ F, 11, 1, 1, 75.60, 9, 9.5, 5, 23.5§ M, 11, 1, 1, 51.44, 2, 2, 6, 10§ M, 12, 1, 1, 50.40, 6, 3, 7, 16§ M, 13, 1, 1, 60.60, 6, 6, 8.25, 20.25§ F, 12, 1, 1, 55.20 , 8.5, 5, 4, 17.5§ F, 10, 1, 1, 56.80 , 6, 8, 5, 19§ M, 11, 1, 1, 62.60 , 5, 6, 6, 17§ F, 10, 1, 1, 60.30 , 7, 10, 7, 24§ M, 13, 1, 1, 48.90 , 4, 5, 6, 15§ M, 10, 1, 1, 67.10 , 7, 11, 10.5, 28.5§ M, 13, 1, 1, 53.70 , 7, 2, 5, 14§ M, 12, 1, 1, 55.40 , 5, 3, 5, 13§ M, 11, 1, 1, 48.20 , 5, 3, 3, 11§ M, 10, 1, 1, 81.80 , 7, 6, 7, 20§ M, 10, 1, 1, 52.10 , 4, 5, 9.5, 18.5§ F, 11, 1, 1, 57.10 , 6, 7, 5, 18§ F, 12, 1, 1, 63.60 , 7, 8.5, 8, 23.5§ F, 10, 1, 1, 69.30, 7, 7.5, 5, 19.5§ F, 12, 1, 1, 49.40 , 6, 4, 4, 14§ F, 12, 1, 1, 72.90 , 10.5, 6, 7.25, 23.75§ F, 10, 1, 2, 48.20 , 5, 8, 2, 15§ M, 10, 1, 2, 50.40 , 3, 6, 5, 14§ F, 11, 1, 2, 51.30 , 6, 4, 4, 14§ F, 10, 1, 2, 51.50 , 4, 4, 3, 11§ F, 10, 1, 2, 52.90, 7, 10, 6, 23§ F, 11, 1, 2, 53.20 , 5, 4, 2, 11§ F, 11, 1, 2, 53.80 , 3, 5, 5, 13§ F, 11, 1, 2, 55.40 , 8, 1, 2, 11§ M, 10, 1, 2, 55.60 , 5, 5, 5, 15§ F, 12, 1, 2, 57.00 , 4, 6, 7, 17§ F, 11, 1, 2, 57.50 , 6, 3, 4, 13§ M, 12, 1, 2, 58.60 , 4, 4, 5, 13§ F, 13, 1, 2, 60.40 , 8, 5, 3, 16§ F, 12, 1, 2, 63.60 , 12, 6, 10, 28§ F, 13, 1, 2, 64.60 , 3, 7.5, 6, 16.5§ M, 11, 1, 2, 66.10 , 5, 5, 4, 14§ M, 11, 1, 2, 69.10 , 7, 3, 7, 17§ F, 10, 1, 2, 70.10 , 7, 6, 4, 17§ F, 10, 1, 2, 70.80 , 5, 9.25, 7, 21.25§ M, 12, 1, 2, 71.40 , 6, 6, 6, 18§ M, 10, 1, 2, 72.80, 7, 6.25, 8, 21.25§ F, 10, 1, 2, 73.80, 6, 6.25, 8, 20.25§ M, 10, 1, 2, 77.10 , 4, 10, 9, 23§ F, 9, 1, 2, 90.40 , 13.5, 8, 10, 31.5§ M, 10, 2, 1, 51.20, 7, 6, 5, 18§ F, 10, 2, 1, 55.00 , 6.5, 5, 5, 16.5§ M, 12, 2, 1, 51.80, 4, 5, 2, 11§ F, 10, 2, 1, 77.20, 12.5, 11.5, 6, 30§ F, 11, 2, 1, 58.20, 7, 7.5, 4, 18.5§ M, 10, 2, 1, 68.30, 3, 5, 6, 14§ F, 12, 2, 1, 69.70, 6, 6, 6, 18§ F, 10, 2, 1, 66.80, 10.5, 10, 4, 24.5§ M, 11, 2, 1, 60.20, 2, 6, 3, 11§ M, 13, 2, 1, 64.40, 7, 4, 7, 18§ M, 13, 2, 1, 46.08, 10.5, 7.25, 2, 19.75§ M, 12, 2, 1, 69.10, 4, 4, 5, 13§ M, 11, 2, 1, 60.72, 5, 8, 5, 18§ F, 14, 2, 1, 53.75, 4, 4, 3, 11§ M, 9, 2, 1, 62.40, 8, 7, 7.5, 22.5§ M, 13, 2, 1, 56.00, 5, 2, 6, 13§ M, 12, 2, 1, 49.60, 6.5, 5, 2, 13.5§ F, 10, 2, 1, 74.60, 9, 8, 7, 24§ F, 9, 2, 1, 56.20, 8.5, 8, 4, 20.5§ M, 10, 2, 1, 52.80, 3, 4, 8, 15§ F, 10, 2, 1, 71.10, 5, 3, 6, 14§ M, 10, 2, 1, 55.40, 7.5, 6, 5, 18.5§ M, 13, 2, 1, 50.67, 8.5, 5, 5, 18.5§ M, 11, 2, 1, 54.40, 5, 3, 2, 10§ F, 11, 2, 1, 62.80, 8.5, 7, 9, 24.5§ M, 10, 2, 1, 61.70, 7, 8, 6, 21§ M, 12, 2, 1, 59.00, 4.5, 6, 7, 17.5§ F, 10, 2, 1, 88.00, 14.5, 13, 11.25, 38.75§ M, 11, 2, 2, 47.92, 4, 5, 6, 15§ M, 11, 2, 2, 50.30, 1, 4, 5, 10§ M, 11, 2, 2, 53.90, 5, 6, 5, 16§ M, 10, 2, 2, 54.90, 7, 5, 2, 14§ M, 10, 2, 2, 55.30, 3, 5, 4, 12§ M, 10, 2, 2, 56.00, 6, 6, 5, 17§ F, 11, 2, 2, 58.60, 4, 4, 5, 13§ F, 13, 2, 2, 59.90, 6, 4, 7.25, 17.25§ M, 11, 2, 2, 61.60, 6, 5, 4, 15§ F, 10, 2, 2, 62.30, 4, 6, 11, 21§ F, 10, 2, 2, 62.60, 9, 4, 3, 16§ F, 10, 2, 2, 63.60, 2, 5, 2, 9§ F, 10, 2, 2, 65.70, 6, 7, 9, 22§ M, 12, 2, 2, 69.60, 5, 5, 5, 15§ M, 10, 2, 2, 70.80, 6, 6, 5, 17§ F, 10, 2, 2, 74.00, 5, 7, 9, 21§ F, 10, 2, 2, 76.40, 6, 6, 4, 16§ F, 10, 2, 2, 77.00, 10, 10, 10.5, 30.5§ F, 10, 2, 2, 81.20, 7, 3, 11.25, 21.25§ M, 11, 3, 1, 53.20, 3, 5, 3, 11§ F, 11, 3, 1, 50.20, 5, 7, 2, 14§ M, 13, 3, 1, 57.30, 6, 4, 4, 14§ M, 12, 3, 1, 68.50, 4, 6, 6, 16§ F, 11, 3, 1, 44.58, 6, 1, 3, 10§ M, 11, 3, 1, 56.20, 5, 4, 6, 15§ M, 12, 3, 1, 61.70, 9, 7, 3, 19§ M, 12, 3, 1, 51.40, 2, 5, 4, 11§ M, 12, 3, 1, 58.90, 4, 6, 5, 15§ M, 12, 3, 1, 77.60, 8, 3, 7.25, 18.25§ M, 12, 3, 1, 76.20, 12, 8, 11.25, 31.25§ F, 12, 3, 1, 56.42, 7, 1, 9.25, 17.25§ M, 12, 3, 1, 83.10, 9.5, 8.25, 6, 23.75§ F, 11, 3, 1, 62.10, 6, 8, 4, 18§ F, 11, 3, 1, 66.40, 6, 4, 8, 18§ F, 12, 3, 1, 57.90, 4, 5, 5, 14§ M, 12, 3, 1, 62.70, 4, 4, 3, 11§ F, 13, 3, 1, 51.92, 6, 7, 7, 20§ M, 10, 3, 1, 73.40, 8, 1, 10.25, 19.25§ F, 13, 3, 1, 45.33, 4, 5, 3, 12§ M, 10, 3, 1, 86.80, 13, 7, 8, 28§ F, 11, 3, 1, 63.50, 8, 5, 7, 20§ F, 11, 3, 1, 55.10, 6, 4, 4, 14§ M, 10, 3, 1, 53.80, 5, 2, 6, 13§ F, 11, 3, 1, 58.00, 3, 8, 2, 13§ M, 13, 3, 1, 49.60, 2, 4, 3, 9§ M, 13, 3, 2, 44.67, 4, 4, 2, 10§ F, 12, 3, 2, 48.08, 4, 5, 3, 12§ F, 12, 3, 2, 50.00, 6, 3, 5, 14§ M, 13, 3, 2, 50.50, 3, 5, 4, 12§ F, 13, 3, 2, 51.58, 4, 7, 6, 17§ F, 11, 3, 2, 53.00, 5, 4, 6, 15§ F, 12, 3, 2, 53.70, 3, 6, 3, 12§ F, 12, 3, 2, 55.30, 2, 5, 1, 8§ F, 12, 3, 2, 56.20, 2, 4, 4, 10§ M, 11, 3, 2, 57.90, 5, 5, 3, 13§ F, 12, 3, 2, 58.40, 4, 8, 6, 18§ M, 12, 3, 2, 59.80, 6, 7, 4, 17§ F, 11, 3, 2, 62.00, 4, 8, 4, 16§ M, 12, 3, 2, 62.30, 6, 7, 4, 17§ M, 12, 3, 2, 63.20, 6, 8, 4, 18§ F, 11, 3, 2, 65.80, 9, 6, 9.25, 24.25§ M, 11, 3, 2, 67.60, 7, 5, 5, 17§ F, 11, 3, 2, 69.70, 3, 3, 7, 13§ M, 12, 3, 2, 72.10, 6, 6, 6, 18§ M, 11, 3, 2, 75.50, 6, 4, 9.25, 19.25§ M, 11, 3, 2, 78.40, 5, 5, 5, 15§ M, 11, 3, 2, 84.20, 9, 7, 4, 20§ F, 13, 3, 2, 91.90, 6, 5, 8, 19§

**Metacognitive Reading: School-3**

§F, 12, 1, 1, 47.33, 5, 6.5, 4, 15.5§ M, 13, 1, 1, 47.7, 7, 4, 4, 15§ M, 12, 1, 1, 48.6, 8, 5, 4.25, 17.25§ M, 12, 1, 1, 49, 3, 2, 2, 7§ M, 13, 1, 1, 49.6, 6, 5, 3, 14§ M, 13, 1, 1, 51, 6, 3, 1, 10§ F, 13, 1, 1, 53.8, 4, 2, 3, 9§ F, 11, 1, 1, 54, 5, 5.5, 3, 13.5§ M, 12, 1, 1, 54.7, 5, 6, 4, 15§ M, 13, 1, 1, 55.4, 5, 5.5, 4, 14.5§ F, 13, 1, 1, 58.2, 7, 6, 7, 20§ F, 11, 1, 1, 58.78, 4, 7.5, 6, 17.5§ F, 11, 1, 1, 60.5, 4, 3, 6, 13§ F, 11, 1, 1, 61, 7, 6, 3, 16§ M, 12, 1, 1, 61.5, 2, 4, 8, 14§ M, 12, 1, 1, 62.5, 9, 14, 5, 28§ F, 11, 1, 1, 64.1, 5, 5, 9.5, 19.5§ M, 10, 1, 1, 64.2, 2, 7.5, 8, 17.5§ F, 10, 1, 1, 65.4, 6.5, 10.5, 5, 22§ F, 11, 1, 1, 67.2, 5, 6.5, 8, 19.5§ M, 13, 1, 1, 67.6, 4.5, 7.5, 4.25, 16.25§ M, 12, 1, 1, 68.1, 5, 11, 5.25, 21.25§ F, 11, 1, 1, 70, 10, 5, 4.5, 19.5§ M, 12, 1, 1, 76.4, 7.5, 9.5, 5, 22§ F, 12, 1, 1, 78.3, 7, 8, 7.25, 22.25§ F, 11, 1, 2, 47.58, 5, 2, 2, 9§ M, 11, 1, 2, 48.1, 4, 2, 3, 9§ F, 11, 1, 2, 48.67, 4, 4, 3, 11§ M, 13, 1, 2, 49.2, 5, 4, 3, 12§ F, 11, 1, 2, 49.75, 6, 4, 2, 12§ M, 11, 1, 2, 50, 7, 2, 5, 14§ F, 12, 1, 2, 52.6, 5, 3, 4, 12§ F, 12, 1, 2, 53.5, 3, 5, 7, 15§ M, 13, 1, 2, 54, 3, 6, 5, 14§ F, 11, 1, 2, 54.5, 6, 4, 5, 15§ F, 11, 1, 2, 55.4, 5, 2, 3, 10§ F, 11, 1, 2, 55.6, 4, 5, 4, 13§ F, 13, 1, 2, 57.2, 3, 3, 5, 11§ M, 11, 1, 2, 58.4, 3, 4, 4, 11§ M, 12, 1, 2, 59.3, 2, 4, 3, 9§ M, 12, 1, 2, 60.8, 3, 6, 3, 12§ F, 13, 1, 2, 61.02, 6, 4, 2, 12§ M, 11, 1, 2, 62.1, 8, 4, 5, 17§ M, 12, 1, 2, 62.6, 8.5, 7, 10, 25.5§ M, 12, 1, 2, 64.1, 5, 4, 7, 16§ F, 12, 1, 2, 64.5, 3, 5, 2, 10§ M, 11, 1, 2, 65.6, 7, 10, 4, 21§ M, 11, 1, 2, 67.6, 4, 7, 1, 12§ M, 13, 1, 2, 67.6, 3, 4, 6, 13§ M, 12, 1, 2, 69.8, 9.5, 6, 5.25, 20.75§ F, 11, 1, 2, 74.7, 8, 5, 4, 17§ F, 11, 1, 2, 76.9, 3, 6, 6, 15§ M, 12, 1, 2, 86.4, 7.5, 7, 10, 24.5§ M, 12, 2, 1, 44.4, 5, 5, 4.5, 14.5§ F, 11, 2, 1, 46.7, 2, 5, 3, 10§ F, 13, 2, 1, 47.17, 7, 4, 4, 15§ F, 14, 2, 1, 49.33, 4, 4.5, 2, 10.5§ M, 12, 2, 1, 50.67, 4, 7.5, 4, 15.5§ M, 12, 2, 1, 51, 8.5, 5, 6, 19.5§ F, 10, 2, 1, 51.4, 3, 3, 3, 9§ M, 13, 2, 1, 52.5, 5.5, 7.5, 6, 19§ M, 11, 2, 1, 53.5, 8, 6, 3, 17§ F, 12, 2, 1, 54.6, 7, 5, 5, 17§ F, 12, 2, 1, 55, 5, 2, 4, 11§ M, 10, 2, 1, 56.1, 4, 7, 3, 14§ F, 13, 2, 1, 56.7, 5, 7.75, 3, 15.75§ M, 12, 2, 1, 57, 11, 10, 6, 27§ M, 13, 2, 1, 58.2, 6, 10.5, 4, 20.5§ F, 10, 2, 1, 58.6, 7, 4, 5, 16§ M, 11, 2, 1, 58.9, 5, 7, 5, 17§ F, 11, 2, 1, 59.7, 5, 3.5, 6, 14.5§ F, 12, 2, 1, 60.6, 5, 3, 1, 9§ M, 12, 2, 1, 61.3, 4, 7, 2, 13§ F, 13, 2, 1, 62.2, 6, 4, 4, 14§ F, 13, 2, 1, 63, 5.5, 2.5, 4, 12§ F, 12, 2, 1, 63.2, 9, 2.5, 4, 15.5§ F, 12, 2, 1, 63.6, 4, 3, 7, 14§ M, 11, 2, 1, 64.8, 6, 4, 5, 15§ M, 11, 2, 1, 66.9, 9.5, 7.5, 4, 21§ M, 10, 2, 1, 67.7, 9.5, 7, 8.25, 24.75§ F, 11, 2, 1, 69.5, 6, 5, 7.5, 18.5§ F, 12, 2, 1, 70.1, 13.5, 4, 7, 24.5§ M, 13, 2, 1, 71.1, 8.5, 6.5, 7, 22§ M, 12, 2, 1, 72.1, 5, 11.5, 4.5, 21§ M, 12, 2, 1, 75.6, 6, 4, 9, 19§ F, 13, 2, 1, 76.3, 10, 9.75, 7, 26.75§ M, 11, 2, 1, 85.2, 9.5, 8, 9, 26.5§ M, 13, 2, 2, 45.7, 8.5, 6, 4, 18.5§ M, 12, 2, 2, 47, 5, 8, 2, 15§ M, 13, 2, 2, 50.4, 4, 6, 0.5, 10.5§ F, 11, 2, 2, 51.4, 5, 8, 3, 16§ M, 13, 2, 2, 52.4, 6, 4, 4, 14§ F, 10, 2, 2, 52.9, 5, 7, 2, 14§ M, 12, 2, 2, 54.4, 5, 6, 5, 16§ F, 12, 2, 2, 54.7, 6, 3, 7, 16§ F, 12, 2, 2, 55.6, 7, 6, 4, 17§ F, 11, 2, 2, 56.3, 6, 4, 5, 15§ F, 13, 2, 2, 56.9, 8, 4, 4, 16§ M, 11, 2, 2, 57.8, 7, 8, 5, 20§ F, 12, 2, 2, 58.5, 3, 5, 6, 14§ F, 11, 2, 2, 58.8, 5, 2, 4, 11§ F, 12, 2, 2, 59.3, 4, 7, 4, 15§ F, 12, 2, 2, 60, 3, 7, 7, 17§ M, 11, 2, 2, 61.1, 7, 4, 5, 16§ M, 13, 2, 2, 61.8, 6, 4, 5, 15§ F, 12, 2, 2, 62.76, 5, 6, 3, 14§ F, 11, 2, 2, 63.3, 6, 3, 6, 15§ F, 12, 2, 2, 64.8, 8, 7, 6, 21§ F, 12, 2, 2, 65.3, 3, 4, 5, 12§ F, 11, 2, 2, 67.3, 4, 5, 3, 12§ M, 12, 2, 2, 68.3, 6, 4, 2, 12§ F, 12, 2, 2, 70.1, 9, 5, 3, 17§ F, 11, 2, 2, 71, 6, 7, 3, 16§ M, 11, 2, 2, 71.7, 9.5, 7.5, 5, 22§ M, 11, 2, 2, 74.8, 8, 9, 9, 26§ F, 12, 2, 2, 75.7, 6, 9, 6, 21§ M, 12, 2, 2, 84.4, 9.5, 6, 10, 25.5§ F, 11, 3, 1, 42, 4, 4, 9, 17§ M, 13, 3, 1, 46.8, 4, 5, 2, 11§ M, 11, 3, 1, 50.5, 4, 4, 1, 9§ F, 11, 3, 1, 51.4, 6, 4, 2, 12§ F, 11, 3, 1, 56.4, 4, 3, 4, 11§ F, 11, 3, 1, 56.7, 6, 4, 2, 12§ F, 11, 3, 1, 57.4, 4, 4, 8.25, 16.25§ F, 11, 3, 1, 58.4, 6, 4, 5, 15§ M, 11, 3, 1, 59.7, 5, 4, 5, 14§ F, 13, 3, 1, 60.4, 7, 4, 6, 17§ M, 11, 3, 1, 61.1, 6, 3, 3, 12§ M, 11, 3, 1, 62, 7, 6.5, 4, 17.5§ F, 11, 3, 1, 62.6, 7, 5, 5, 17§ F, 11, 3, 1, 64.6, 4, 3, 5, 12§ F, 11, 3, 1, 65.3, 5, 9, 5, 19§ M, 11, 3, 1, 67, 6.5, 8, 6, 20.5§ F, 12, 3, 1, 68, 8, 4, 11, 23§ F, 12, 3, 1, 69, 8, 9, 7, 24§ M, 11, 3, 1, 69.8, 9, 5, 6, 20§ M, 11, 3, 1, 70.9, 5, 7, 7, 19§ M, 11, 3, 1, 72, 5, 5, 3, 13§ F, 11, 3, 1, 73.5, 9.5, 4, 4, 17.5§ F, 11, 3, 1, 74.1, 7, 8, 7, 22§ F, 11, 3, 1, 75.1, 9.5, 4, 4, 17.5§ M, 11, 3, 1, 80, 12, 6, 4, 22§ M, 12, 3, 1, 83.1, 7, 7, 11, 25§ F, 12, 3, 2, 46.5, 6, 3, 4, 13§ M, 11, 3, 2, 50.4, 3, 4, 2, 9§ M, 12, 3, 2, 50.7, 7, 5, 3, 15§ M, 11, 3, 2, 54.5, 1, 3, 2, 6§ M, 11, 3, 2, 56.4, 5, 10, 4, 19§ F, 12, 3, 2, 56.5, 4, 6, 4, 14§ F, 11, 3, 2, 57.3, 5, 2, 4, 11§ M, 13, 3, 2, 58.3, 6, 5, 5, 16§ M, 11, 3, 2, 59.5, 4, 4, 3, 11§ M, 12, 3, 2, 60.1, 6, 6, 3, 15§ F, 12, 3, 2, 60.7, 6, 6, 3, 15§ F, 11, 3, 2, 61.9, 6, 7, 6, 19§ F, 12, 3, 2, 62.5, 6, 3, 4, 13§ F, 12, 3, 2, 63.6, 5, 5, 5, 15§ M, 13, 3, 2, 65, 6, 9, 5, 20§ M, 11, 3, 2, 66.7, 6, 6, 12, 24§ F, 12, 3, 2, 67.4, 3, 8, 6, 17§ M, 11, 3, 2, 68.5, 4, 7, 6, 17§ F, 11, 3, 2, 69, 6, 6, 6, 18§ F, 12, 3, 2, 70.6, 4, 7, 9, 20§ M, 11, 3, 2, 73.2, 7, 3, 6, 16§ M, 12, 3, 2, 74, 6, 6, 3, 15§ M, 11, 3, 2, 75.8, 9, 5, 7, 21§ M, 11, 3, 2, 80.3, 8.5, 4, 9, 21.5§ M, 11, 3, 2, 84, 9.5, 7, 8, 24.5§ M, 11, 3, 2, 88.8, 10, 9, 11, 30§

## GRADE SIX

### Graphic Organizers: School-1

§M, 12, 1, 1, 68, 13, 10, 7, 30§ F, 12, 1, 1, 47.5, 13, 5, 6.5, 24.5§ F, 12, 1, 1, 59.58, 8, 9.5, 9, 26.5§ M, 12, 1, 1, 78.58, 17, 12, 6, 35§ F, 12, 1, 1, 44, 3, 4, 3, 10§ F, 14, 1, 1, 46.17, 4, 7, 2, 13§ F, 12, 1, 1, 54.58, 6.5, 7, 4, 17.5§ F, 14, 1, 1, 51.5, 11, 5.5, 5, 21.5§ M, 13, 1, 1, 46.75, 10.5, 8, 3, 21.5§ F, 14, 1, 1, 53.42, 10, 7, 7, 24§ F, 12, 1, 1, 51.42, 9, 8, 4, 21§ F, 12, 1, 1, 56.58, 9, 9, 5, 23§ M, 12, 1, 1, 67.33, 10, 5.5, 9.5, 25§ M, 13, 1, 1, 82.58, 14, 13.5, 11, 38.5§ M, 12, 1, 1, 55.92, 7.5, 6.5, 3, 17§ F, 12, 1, 1, 64.17, 9.5, 10, 9, 28.5§

F, 12, 1, 1, 48.58, 6.5, 7.5, 8, 22§ M, 13, 1, 1, 57.17, 13.5, 7, 5.5, 26§ M, 13, 1, 1, 58.8, 9, 6, 6, 21§ M, 13, 1, 1, 74.33, 16, 7, 11, 34§ F, 12, 1, 1, 59.5, 10, 7, 8.5, 25.5§ F, 14, 1,1, 90.08, 16, 13.25, 10.5, 39.75§ M, 13, 1, 1, 87.5, 20, 17.25, 9, 46.25§ M, 13, 1, 2, 45.92, 11.5, 7, 5, 23.5§ F, 13, 1, 2, 46.42, 5, 5, 2.5, 12.5§ M, 13, 1, 2, 47.42, 10.5, 6, 7, 23.5§ F, 13, 1, 2, 48, 7.5, 10, 4.5, 22§ F, 13, 1, 2, 48.92, 7, 6, 3, 16§ M, 12, 1, 2, 51.17, 12, 4, 4.5, 20.5§ F, 13, 1, 2, 54.42, 11, 3, 3, 17§ F, 13, 1, 2, 56.17, 6, 6.5, 5.5, 18§ F, 12, 1, 2, 57.17, 11, 9, 5, 25§ M, 13, 1, 2, 58.08, 10, 5, 8, 23§ M, 12, 1, 2, 59, 11, 5, 4, 20§ F, 12, 1, 2, 59.5, 12, 10, 13, 35§ F, 14, 1, 2, 59.58, 6, 5, 2, 13§ M, 12, 1, 2, 61.08, 10, 5, 6.5, 21.5§ M, 12, 1, 2, 64.17, 11, 6, 7.5, 24.5§ M, 13, 1, 2, 64.75, 11, 5, 4, 20§ F, 13, 1, 2, 67.58, 8.5, 8, 5.5, 22§ M, 12, 1, 2, 70.67, 16, 7, 7, 30§ F, 14, 1, 2, 72.5, 11, 7, 4, 22§ M, 12, 1, 2, 81.25, 14.5, 6, 6.5, 27§ F, 13, 2, 1, 43.42, 5, 3, 0.5, 8.5§ M, 13, 2, 1, 68.75, 17, 5, 4, 26§ F, 12, 2, 1, 55.33, 14, 8, 4, 26§ F, 14, 2, 1, 50.08, 15.5, 5, 3, 23.5§ F, 13, 2, 1, 70.67, 12, 6, 4, 22§ F, 10, 2, 1, 70.17, 10, 8, 5, 23§ M, 12, 2, 1, 70, 11.5, 4, 5, 20.5§ M, 13, 2, 1, 89.83, 19.5, 11, 11.25, 41.75§ F, 12, 2, 1, 55.83, 8, 8, 6, 22§ F, 13, 2, 1, 52.92, 11, 6, 4, 21§ F, 12, 2, 1, 65.42, 13, 10.5, 7, 30.5§ F, 11, 2, 1, 59.33, 10.5, 6, 5.5, 22§ M, 12, 2, 1, 48.58, 16.5, 10, 7, 33.5§ M, 10, 2, 1, 75.08, 18.5, 10, 10, 38.5§ F, 12, 2, 1, 52.08, 7, 5, 6, 18§ F, 13, 2, 1, 56.83, 6.5, 7, 7, 20.5§ F, 13, 2, 1, 79.67, 15.5, 7, 8, 30.5§ F, 12, 2, 1, 61, 10, 8, 6, 24§ M, 12, 2, 1, 57.08, 5.5, 3, 3, 11.5§ F, 14, 2, 1, 53.58, 12, 3, 3, 18§ M, 14, 2, 1, 60.58, 9, 3, 4, 16§ M, 13, 2, 1, 50.67, 9.5, 6, 7, 22.5§ F, 13, 2, 1, 49.5, 15, 7, 3, 25§ F, 12, 2, 2, 45.83, 6.5, 8.5, 6, 21§ F, 12, 2, 2, 48.42, 5, 7, 9, 21§ F, 14, 2, 2, 48.42, 5, 4, 6, 15§ M, 11, 2, 2, 48.75, 8, 6, 3.5, 17.5§ F, 12, 2, 2, 50.08, 4.5, 5, 5, 14.5§ F, 12, 2, 2, 50.17, 9, 6, 4, 19§ F, 12, 2, 2, 50.58, 6.5, 4, 6, 16.5§ F, 14, 2, 2, 52.08, 5.5, 6, 1, 12.5§ F, 12, 2, 2, 54, 7, 3, 4, 14§ F, 14, 2, 2, 55.58, 7.5, 7, 5, 19.5§ M, 14, 2, 2, 56, 7, 5.5, 2, 14.5§ M, 12, 2, 2, 57.08, 7.5, 8, 6.5, 22§ F, 13, 2, 2, 60, 7.5, 8.5, 6.5, 22.5§ F, 13, 2, 2, 60.92, 9, 8, 6, 23§ M, 11, 2, 2, 62.92, 11.5, 11, 6, 28.5§ M, 11, 2, 2, 65, 8, 8, 6, 22§ F, 12, 2, 2, 67.5, 10, 5, 5, 20§ F, 12, 2, 2, 68.83, 16.5, 12, 9, 37.5§ M, 12, 2, 2, 70, 11, 9, 6, 26§ F, 10, 2, 2, 70.58, 15.5, 10, 5, 30.5§ M, 11, 2, 2, 73, 9.5, 6.5, 4.5, 20.5§ F, 11, 2, 2, 75.5, 12.5, 12, 9, 33.5§ M, 11, 2, 2, 82.08, 7, 3, 6.5, 16.5§ F, 13, 3, 1, 56.33, 6.5, 7, 3, 16.5§ F, 12, 3, 1, 51.42, 11, 6, 3.5, 20.5§ F, 12, 3, 1, 76.58, 10, 5, 6, 21§ M, 12, 3, 1, 85.67, 11, 7, 5, 23§ M, 12, 3, 1, 43.58, 11.5, 12, 4, 27.5§ M, 12, 3, 1, 58.25, 11, 7, 6.5, 24.5§ M, 13, 3, 1, 72.58, 14, 7, 9, 30§ M, 14, 3, 1, 52.5, 8, 5, 5, 18§ M, 14, 3, 1, 53.5, 13, 7, 5, 25§ M, 11, 3, 1, 74.92, 15, 13, 11.5, 39.5§ M, 12, 3, 1, 62, 10, 8, 9, 27§ M, 12, 3, 1, 59.58, 7.5, 4, 7, 18.5§ F, 12, 3, 1, 83.58, 16, 7, 3, 26§ F, 12, 3, 1, 63.42, 9, 8, 7, 24§ F, 14, 3, 1, 83.83, 14, 7, 10, 31§ F, 12, 3, 1, 46.33, 7, 8, 4, 19§ F, 12, 3, 1, 65.75, 7, 2, 8, 17§ F, 12, 3, 1, 59.33, 9.5, 8, 6, 23.5§ M, 13, 3, 1, 56.83, 5, 9, 2, 16§ F, 11, 3, 1, 49.75, 9, 6, 5, 20§ M, 12, 3, 1, 84.67, 11.5, 7, 5.5, 24§ F, 12, 3, 1, 48.67, 6, 7, 5.5, 18.5§ F, 12, 3, 1, 55.42, 9, 9, 6, 24§ F, 12, 3, 1, 68.08, 9, 7, 5, 21§ M, 11, 3, 1, 51, 8, 2, 4.5, 14.5§ M, 12, 3, 2, 45.42, 8, 7, 5.5, 20.5§ F, 13, 3, 2, 48.83, 5, 5, 7, 17§ F, 11, 3, 2, 51.08, 7, 7, 3.5, 17.5§ F, 12, 3, 2, 52.75, 7, 4, 7, 18§ F, 14, 3, 2, 53.58, 4, 3, 3, 10§ M, 13, 3, 2, 55.92, 7, 8.5, 4, 19.5§ F, 12, 3, 2, 56.58, 11, 6.5, 8, 25.5§ F, 13, 3, 2, 57.5, 6, 7, 7, 20§ F, 14, 3, 2, 62.5, 15, 5.5, 3, 23.5§ F, 13, 3, 2, 65.33, 9, 10.5, 5, 24.5§ M, 12, 3, 2, 82.75, 15, 8, 7, 30§ M, 11, 3, 2, 83.67, 12, 9.5, 6, 27.5§ F, 11, 3, 2, 84.25, 11, 8, 10.5, 29.5§ F, 12, 3, 2, 85.5, 11, 6, 7, 24§

**Metacognitive Reflection: School-4**

§M, 12, 1, 1, 47.5, 8.5, 6.25, 7.25, 22§ F, 12, 1, 1, 49, 12.5, 8.75, 9.25, 30.5§ F, 11, 1, 1, 49.58, 10.5, 4, 9.5, 24§ M, 12, 1, 1, 49.67, 10, 2, 7, 19§ M, 14, 1, 1, 53.33, 10, 6, 6, 22§ F, 14, 1, 1, 54.5, 7, 7, 7, 21§ M, 12, 1, 1, 55, 8.5, 6, 11, 25.5§ F, 11, 1, 1, 56.67, 10, 9.5, 5.5, 25§ M, 14, 1, 1, 57.5, 11.5, 6.25, 6.25, 24§ F, 13, 1, 1, 58.83, 9.5, 4, 7, 20.5§ M, 12, 1, 1, 59.33, 14, 5.25, 6.25, 25.5§ M, 11, 1, 1, 59.5, 8, 8, 7.25, 23.25§ F, 12, 1, 1, 60.17, 12, 9.5, 7, 28.5§ M, 12, 1, 1, 60.83, 11.5, 7, 6, 24.5§ M, 13, 1, 1, 62, 12.5, 7, 7.25, 26.75§ F, 13, 1, 1, 63, 6.5, 9, 4.5, 20§ M, 13, 1, 1, 63.33, 13, 10.5, 7.5, 31§ M, 11, 1, 1, 66.67, 14.5, 8.5, 4.25, 27.25§ M, 11, 1, 1, 70.83, 17, 10.25, 12.75, 40§ M, 11, 1, 1, 74.67, 18, 9, 13.25, 40.25§ F, 12, 1, 1, 77.17, 15, 7, 8.5, 30.5§ M, 12, 1, 1, 78, 15, 8, 8.25, 31.25§ M, 12, 1, 1, 82.5, 17, 13.25, 10.5, 40.75§ M, 13, 1, 2, 45.33, 8, 4, 6, 18§ F, 10, 1, 2, 48.67, 7, 6, 5, 18§ F, 11, 1, 2, 49.17, 6, 3, 4, 13§ F, 14, 1, 2, 49.67, 4.5, 6, 3, 13.5§ F, 12, 1, 2, 51.33, 16, 8, 9.5, 33.5§ F, 12, 1, 2, 52.5, 12, 5, 4.5, 21.5§ M, 11, 1, 2, 53.17, 7, 4, 6, 17§ M, 13, 1, 2, 54.58, 5, 7, 4, 16§ F, 12, 1, 2, 57.17, 7, 5, 4, 16§ M, 12, 1, 2, 58.17, 8, 6, 2, 16§ M, 14, 1, 2, 59, 8.5, 4, 2, 14.5§ F, 11, 1, 2, 59.5, 9, 3, 6, 18§ F, 12, 1, 2, 60.08, 7.5, 3, 3, 13.5§ M, 13, 1, 2, 60.5, 10, 10, 4, 24§ F, 13, 1, 2, 61.33, 13, 7.5, 8, 28.5§ M, 11, 1, 2, 61.67, 12.5, 4, 6.5, 23§ M, 13, 1, 2, 62.5, 13, 9, 4, 26§ F, 11, 1, 2, 63.33, 12, 12, 9, 33§ F, 12, 1, 2, 63.92, 12, 5, 7, 24§ F, 14, 1, 2, 65.83, 11, 8, 5, 24§ F, 13, 1, 2, 68, 14, 8.5, 3, 25.5§ M, 13, 1, 2, 71.33, 14.5, 6, 10, 30.5§ M, 14, 1, 2, 76, 16.5, 12, 11.5, 40§ F, 11, 1, 2, 77.33, 12, 6, 6, 24§ M, 13, 1, 2, 78, 19, 10, 9, 38§ F, 11, 1, 2, 84.17, 16, 7, 10, 33§ M, 13, 2, 1, 41.58, 7, 9.5, 5, 21.5§ F, 12, 2, 1, 47.67, 11.5, 9, 3, 23.5§ M, 13, 2, 1, 49.33, 7, 5, 8.5, 20.5§ M, 12, 2, 1, 50.25, 5.5, 6, 7, 18.5§ M, 13, 2, 1, 51, 10, 7.5, 8.25, 25.75§ F, 12, 2, 1, 51.42, 12, 8.75, 6, 26.75§ M, 11, 2, 1, 54.33, 10.5, 9, 7.25, 26.75§ M, 12, 2, 1, 55.58, 15, 8, 3, 26§ M, 13, 2, 1, 56.33, 14, 13, 11.5, 38.5§ F, 11, 2, 1, 58.58, 13.5, 7.5, 6, 27§ M, 12, 2, 1, 59, 10, 6, 5, 21§ F, 12, 2, 1, 59.5, 15, 7, 7, 29§ F, 12, 2, 1, 60.75, 6, 6.5, 4.5, 17§ M, 11, 2, 1, 60.83, 10, 4.5, 6.5, 21§ M, 14, 2, 1, 61.42, 9, 9.5, 11, 29.5§ F, 12, 2, 1, 61.5, 13, 11, 7.25, 31.25§ F, 12, 2, 1, 61.83, 12, 9, 10, 31§ M, 12, 2, 1, 63.17, 18, 11, 5.5, 34.5§ M, 12, 2, 1, 63.83, 13, 5, 4, 22§ M, 11, 2, 1, 65, 8, 8, 8, 24§ F, 13, 2, 1, 65.5, 13.5, 13, 7.75, 34.25§ F, 12, 2, 1, 66.67, 13, 8.5, 9, 30.5§ M, 12, 2, 1, 67.67, 12, 11.5, 5, 28.5§ M, 12, 2, 1, 68.17, 10, 6, 10.25, 26.25§ F, 13, 2, 1, 70.25, 8, 12.5, 8.25, 28.75§ F, 11, 2, 1, 70.5, 15, 8.5, 10.75, 34.25§ M, 13, 2, 1, 72, 11, 5.5, 9.25, 25.75§ M, 14, 2, 1, 74.67, 10.5, 6, 6.5, 23§ M, 13, 2, 1, 81.67, 20.5, 13.5, 8, 42§ M, 12, 2, 1, 85.67, 10, 14, 8, 32§ M, 14, 2, 2, 46, 8.5, 3, 3, 14.5§ M, 11, 2, 2, 48.92, 7, 5, 4, 16§ M, 12, 2, 2, 50, 5, 4, 4, 13§ F, 14, 2, 2, 50.67, 7.5, 6, 9, 22.5§ M, 12, 2, 2, 51, 12, 5, 5, 22§ F, 13, 2, 2, 51.42, 12, 6, 4, 22§ M, 14, 2, 2, 54.75, 13, 7, 7, 27§ F, 13, 2, 2, 56.25, 7, 4, 5, 16§ M, 11, 2, 2, 58.5, 8.5, 8, 5, 21.5§ M, 11, 2, 2, 58.83, 7.5, 7, 4, 18.5§ M, 12, 2, 2, 59, 15, 9, 9, 33§ M, 14, 2, 2, 60.08, 7, 4, 2, 13§ F, 12, 2, 2, 60.75, 8, 9, 6, 23§ M, 13, 2, 2, 60.83, 12, 6.5, 7, 25.5§ F, 12, 2, 2, 61.5, 11, 10, 4, 25§ F, 12, 2, 2, 61.83, 14, 8, 10, 32§ M, 12, 2, 2, 62, 6, 6, 6, 18§ F, 14, 2, 2, 63.58, 9.5, 5, 6, 20.5§ M, 14, 2, 2, 64.75, 12, 6, 4, 22§ M, 11, 2, 2, 66.08, 5, 3, 1, 9§ M, 13, 2, 2, 67, 9.5, 7, 3.5, 20§ F, 13, 2, 2, 68.08, 10, 3, 7, 20§ F, 10, 2, 2, 69.5, 13, 11, 9.5, 33.5§ F, 12, 2, 2, 70.33, 13, 5, 9.5, 27.5§ F, 11, 2, 2, 71, 12, 5, 6.5, 23.5§ M, 13, 2, 2, 72.33, 10, 10, 11, 31§ M, 11, 2, 2, 84, 17, 9, 10, 36§ F, 12, 2, 2, 94.5, 15, 8, 14, 37§ M, 13, 3, 1, 47.83, 11, 6.25, 4, 21.25§ M, 13, 3, 1, 53.08, 3, 7, 5, 15§ M, 14, 3, 1, 53.33, 7, 4, 5, 16§ F, 12, 3, 1, 53.67, 8, 2, 6.25, 16.25§ M, 14, 3, 1, 54.33, 7, 5.5, 6.25, 18.75§ F, 13, 3, 1, 55.5, 8, 7, 6, 21§ F, 13, 3, 1, 55.58, 8, 7, 1, 16§ F, 14, 3, 1, 55.75, 9.5, 4, 5, 18.5§ M, 12, 3, 1, 55.83, 7, 7, 8, 22§ M, 13, 3, 1, 57.08, 14, 6, 5, 25§ M, 14, 3, 1, 57.75, 6.5, 3, 8, 17.5§ F, 13, 3, 1, 58.42, 11, 8, 1, 20§ F, 13, 3, 1, 59.5, 10.5, 3, 6, 19.5§ M, 12, 3, 1, 60.17, 7, 5.5, 4, 16.5§ F, 12, 3, 1, 60.58, 13.5, 2, 6.5, 22§ F, 11, 3, 1, 61.17, 12.5, 9, 5, 26.5§ M, 12, 3, 1, 63.08, 12.5, 9, 2.75, 24.25§ F, 12, 3, 1, 63.42, 13.5, 6.5, 5.5, 25.5§ M, 13, 3, 1, 65.33, 13, 6.5, 6.5, 26§ M, 13, 3, 1, 67.25, 11.5, 12.75, 5, 29.25§ F, 13, 3, 1, 67.67, 8, 12.75, 5, 25.75§ M, 12, 3, 1, 70, 11, 5, 7, 23§ M, 13, 3, 1, 71.58, 12, 9.25, 9, 30.25§ M, 12, 3, 1, 73.58, 18, 11.75, 10, 39.75§ M, 11, 3, 1, 75.33, 14, 8.5, 7, 29.5§ M, 11, 3, 1, 76.08, 16, 6, 6.5, 28.5§ F, 12, 3, 1, 77.33, 12.5, 6, 5, 23.5§ F, 14, 3, 1, 82.75, 15, 12, 11.5, 38.5§ F, 12, 3, 1, 85.08, 14, 9.25, 8.5, 31.75§ F, 12, 3, 2, 51.58, 8.5, 4, 5, 17.5§ F, 13, 3, 2, 53.5, 12, 6, 8.5, 26.5§ M, 12, 3, 2, 53.92, 6.5, 6, 2, 14.5§ M, 14, 3, 2, 54.42, 7, 9.5, 6, 22.5§ M, 12, 3, 2, 55, 6, 4.5, 5, 15.5§ F, 14, 3, 2, 55.5, 10.5, 8, 3, 21.5§ M, 12, 3, 2, 55.83, 5, 6, 6, 17§ F, 13, 3, 2, 56.25, 8, 8, 5.5, 21.5§ M, 13, 3, 2, 57, 11.5, 8, 4, 23.5§ M, 13, 3, 2, 58.08, 8.5, 4, 5, 17.5§ F, 12, 3, 2, 58.5, 7, 6, 8, 21§ F, 12, 3, 2, 59.5, 11, 6.5, 5, 22.5§ M, 12, 3, 2, 60.58, 10, 7, 11.5, 28.5§ F, 13, 3, 2, 60.75, 7, 7, 6.5, 20.5§ M, 11, 3, 2, 63.25, 8.5, 4, 4, 16.5§ M, 14, 3, 2, 63.58, 7, 5.5, 10, 22.5§ M, 14, 3, 2, 65.25, 5, 6, 4, 15§ F, 13, 3, 2, 67, 13, 5, 7, 25§ F, 11, 3, 2, 67.42, 10, 8, 3.5, 21.5§ M, 13, 3, 2, 68.83, 9.5, 6, 5, 20.5§ M, 14, 3, 2, 70.17, 13, 9, 4, 26§ F, 14, 3, 2, 72.42, 12, 9, 7, 28§ M, 12, 3, 2, 74.25, 14, 9, 4, 27§ F, 13, 3, 2, 75.5, 11, 8, 7.5, 26.5§ F, 12, 3, 2, 77.08, 10, 7, 5, 22§ F, 12, 3, 2, 78.5, 12, 9, 10, 31§

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§M, 14, 1, 1, 48.25, 8, 6, 3, 17§ M, 13, 1, 1, 49.42, 10, 5.5, 6, 21.5§ F, 11, 1, 1, 53.08, 9, 8.5, 3, 20.5§ F, 14, 1, 1, 55.42, 10, 3.5, 3, 16.5§ F, 13, 1, 1, 58.33, 8.5, 5.5, 5, 19§ F, 14, 1, 1, 58.92, 9.5, 2, 6, 17.5§ F, 11, 1, 1, 59.75, 11, 9, 5.5, 25.5§ M, 13, 1, 1, 60.5, 9.5, 4, 3, 16.5§ F, 14, 1, 1, 60.92, 9, 6, 4, 19§ M, 12, 1, 1, 61, 10, 3, 8, 21§ M, 14, 1, 1, 61.42, 7.5, 6, 2, 15.5§ F, 13, 1, 1, 63.67, 8, 7, 3, 18§ F, 14, 1, 1, 64.5, 10, 7, 3.5, 20.5§ M, 12, 1, 1, 65.08, 18, 14, 3.5, 35.5§ F, 11, 1, 1, 66.33, 12, 9, 8, 29§ F, 11, 1, 1, 66.5, 14, 7.5, 7, 28.5§ M, 13, 1, 1, 67.25, 13, 5, 4, 22§ M, 11, 1, 1, 68.58, 13.5, 11, 8, 32.5§ F, 12, 1, 1, 68.83, 16, 9.5, 7.5, 33§ F, 13, 1, 1, 70.5, 17.5, 6, 9.5, 33§ M, 12, 1, 1, 70.67, 10, 5, 7.25, 22.25§ F, 11, 1, 1, 71.25, 6, 6, 4.5, 16.5§ M, 12, 1, 1, 73.08, 12, 8.5, 6, 26.5§ M, 13, 1, 1, 75.33, 13, 8.5, 8, 29.5§ F, 13, 1, 1, 77.17, 19.5, 7, 9.5, 36§ F, 11, 1, 1, 79.67, 14.5, 6.5, 12, 33§ F, 11, 1, 1, 82.08, 16.5, 9.25, 6, 31.75§ M, 11, 1, 1, 84.92, 19, 9.5, 8, 36.5§ M, 12, 1, 1, 90, 20, 9.5, 8.25, 37.75§ M, 13, 1, 2, 49.25, 12, 7, 5, 24§ M, 12, 1, 2, 51.5, 13, 5.5, 4, 22.5§ M, 12, 1, 2, 55.42, 9.5, 1, 5, 15.5§ F, 13, 1, 2, 57.75, 9, 9.5, 5, 23.5§ M, 12, 1, 2, 58.42, 10, 7, 4, 21§ F, 13, 1, 2, 59.25, 10, 2, 2, 14§ M, 12, 1, 2, 60.5, 8, 5, 6, 19§ F, 14, 1, 2, 60.92, 12.5, 6, 6, 24.5§ F, 13, 1, 2, 61.25, 13, 6.5, 4, 23.5§ F, 12, 1, 2, 63.17, 9, 2, 4, 15§ M, 12, 1, 2, 64.33, 10, 4, 4, 18§ M, 12, 1, 2, 65.58, 8, 6, 5, 19§ F, 11, 1, 2, 66.42, 13, 7, 5.5, 25.5§ M, 11, 1, 2, 67, 8, 5, 5, 18§ F, 13, 1, 2, 68.42, 10, 4, 5, 19§ M, 13, 1, 2, 68.83, 7, 4, 6, 17§ F, 11, 1, 2, 70.42, 7.5, 3, 6, 16.5§ M, 12, 1, 2, 70.58, 12, 6, 7, 25§ M, 13, 1, 2, 70.75, 10.5, 7.5, 3, 21§ M, 10, 1, 2, 71.67, 13, 5, 6, 24§ M, 12, 1, 2, 73.67, 9.5, 5.5, 8, 23§ M, 12, 1, 2, 76.08, 11.5, 7, 5.5, 24§ M, 12, 1, 2, 78.08, 14, 7, 4.5, 25.5§ M, 11, 1, 2, 81.42, 16.5, 6, 7, 29.5§ M, 12, 1, 2, 82.17, 10.5, 2.5, 2, 15§ M, 12, 1, 2, 89.25, 15, 10.5, 7.5, 33§ F, 10, 1, 2, 90.17, 13, 7.5, 10.5, 31§ F, 14, 2, 1, 48.83, 6, 4, 2, 12§ M, 12, 2, 1, 49, 9.5, 7, 4, 20.5§ M, 13, 2, 1, 50.42, 4, 6, 7, 17§ M, 12, 2, 1, 52.17, 9, 2, 5, 16§ M, 12, 2, 1, 54.83, 5, 6, 3, 14§ F, 11, 2, 1, 58.17, 11.5, 8.5, 6, 26§ M, 13, 2, 1, 58.5, 16.5, 5.5, 6.5, 28.5§ M, 13, 2, 1, 59.92, 17, 4, 5.5, 26.5§ M, 12, 2, 1, 60.75, 12.5, 12.5, 5, 30§ M, 12, 2, 1, 61, 9, 5, 5, 19§ F, 10, 2, 1, 63, 9, 5, 7, 21§ M, 14, 2, 1, 63.25, 9.5, 5, 5, 19.5§ M, 13, 2, 1, 64, 5, 6, 2, 13§ M, 13, 2, 1, 64.33, 9, 8.5, 5, 22.5§ M, 13, 2, 1, 66.42, 11.5, 4.5, 8.5, 24.5§ M, 11, 2, 1, 67.25, 14.5, 6, 5, 25.5§ F, 12, 2, 1, 67.42, 11, 6, 7.5, 24.5§ M, 13, 2, 1, 68.58, 11, 6, 4, 21§ M, 13, 2, 1, 69.67, 14, 8, 7, 29§ F, 13, 2, 1, 70.75, 9, 5, 8, 22§ M, 12, 2, 1, 74.75, 19, 7.5, 6, 32.5§ F, 12, 2, 1, 77.58, 16, 9, 8, 33§ F, 13, 2, 1, 78.33, 13, 8, 6.5, 27.5§ F, 12, 2, 1, 82.42, 12, 5, 7, 24§ M, 12, 2, 1, 86.83, 20, 4, 12, 36§ F, 12, 2, 1, 87.58, 15.5, 6, 3, 24.5§ F, 14, 2, 2, 49, 5, 4, 6, 15§ M, 13, 2, 2, 49.65, 7.5, 6, 5, 18.5§ M, 14, 2, 2, 52.08, 9.5, 5, 5, 19.5§ M, 14, 2, 2, 53.58, 3, 3, 4, 10§ F, 12, 2, 2, 55.58, 6, 7, 7, 20§ M, 12, 2, 2, 58.67, 8, 7, 6, 21§ F, 11, 2, 2, 59.92, 17.5, 8.5, 7, 33§ F, 13, 2, 2, 60.25, 6, 5, 5, 16§ F, 11, 2, 2, 60.92, 14, 4.5, 4, 22.5§ F, 12, 2, 2, 61.58, 10, 4, 5, 19§ F, 12, 2, 2, 63.17, 6.5, 7, 3, 16.5§ F, 13, 2, 2, 63.58, 10.5, 7, 5, 22.5§ M, 14, 2, 2, 64.08, 10, 7.5, 3, 20.5§ M, 11, 2, 2, 64.58, 7, 7, 4, 18§ F, 14, 2, 2, 67.33, 12, 7.5, 5, 24.5§ M, 13, 2, 2, 70.58, 14, 2, 5, 21§ M, 12, 2, 2, 74.92, 12, 8, 6, 26§ M, 13, 2, 2, 78.25, 15, 3.5, 6, 24.5§ M, 13, 2, 2, 78.83, 13.5, 5, 5, 23.5§ M, 12, 2, 2, 84.17, 8, 5.5, 3, 16.5§ M, 12, 2, 2, 87.42, 9, 7, 5, 21§ F, 12, 2, 2, 92.92, 16.5, 8.5, 11, 36§ M, 14, 3, 1, 46.25, 14, 6.25, 7, 27.25§ M, 12, 3, 1, 48.92, 9, 6, 5, 20§ F, 12, 3, 1, 50, 13, 7, 4, 24§ F, 13, 3, 1, 51.58, 5, 8, 6, 19§ F, 13, 3, 1, 52.67, 7, 4, 2, 13§ F, 14, 3, 1, 53.25, 7, 6, 6, 19§ F, 12, 3, 1, 53.83, 9.5, 4, 3, 16.5§ F, 12, 3, 1, 56, 9, 7, 4, 20§ M, 12, 3, 1, 56.08, 11, 4.5, 8, 23.5§ F, 14, 3, 1, 56.83, 8, 6, 6, 20§ M, 12, 3, 1, 57.17, 12.5, 9, 6, 27.5§ F, 14, 3, 1, 57.58, 10.5, 8, 6, 24.5§ M, 12, 3, 1, 57.75, 7, 4, 0.5, 11.5§ F, 13, 3, 1, 58.25, 14.5, 5, 5, 24.5§ F, 13, 3, 1, 60.33, 6, 9, 5, 20§ F, 12, 3, 1, 60.83, 7, 6, 6, 19§ M, 12, 3, 1, 61.5, 13.5, 9, 1, 23.5§ M, 13, 3, 1, 63, 10, 3, 4, 17§ F, 12, 3, 1, 64.83, 14, 8, 6.5, 28.5§ F, 12, 3, 1, 68, 4, 3, 3, 10§ M, 12, 3, 1, 69.17, 15.5, 8, 7, 30.5§ M, 12, 3, 1, 71.92, 6.5, 5, 7, 18.5§ M, 12, 3, 1, 73.58, 15, 7.5, 3, 25.5§ F, 12, 3, 1, 74.25, 20.5, 9, 8, 37.5§ M, 11, 3, 1, 77.5, 17, 9, 7, 33§ M, 12, 3, 1, 78.25, 13.5, 10, 6, 29.5§ M, 11, 3, 1, 81.08, 12.5, 10, 4, 26.5§ M, 11, 3, 1, 83, 13.5, 8, 7.5, 29§ M, 12, 3, 1, 84.17, 11.5, 12.25, 9.75, 33.5§ M, 12, 3, 1, 90.58, 12.5, 6.5, 5, 24§ F, 14, 3, 2, 48.17, 11, 7.5, 6, 24.5§ F, 13, 3, 2, 50.92, 12, 8, 6, 26§ F, 11, 3, 2, 52.58, 9, 4, 5, 18§ F, 11, 3, 2, 53.17, 7, 4, 4, 15§ F, 14, 3, 2, 53.75, 10, 5, 3, 18§ F, 12, 3, 2, 55.92, 8, 7, 6, 21§ M, 11, 3, 2, 56.08, 6, 5.5, 2, 13.5§ F, 12, 3, 2, 56.75, 12.5, 9, 1, 22.5§ F, 14, 3, 2, 57, 11, 7, 4, 22§ M, 12, 3, 2, 57.5, 10, 6.5, 5.5, 22§ M, 12, 3, 2, 57.75, 8.5, 3.5, 4.5, 16.5§ M, 14, 3, 2, 57.83, 9.5, 4, 6, 19.5§ M, 11, 3, 2, 60.67, 8.5, 10, 5.5, 24§ F, 13, 3, 2, 61.33, 12.5, 2, 5, 19.5§ F, 13, 3, 2, 62.08, 6, 5, 7, 18§ M, 12, 3, 2, 63.5, 7.5, 5, 6, 18.5§ M, 12, 3, 2, 65.08, 14, 7, 5, 26§ M, 13, 3, 2, 71.92, 8, 8, 8, 24§ F, 11, 3, 2, 72, 6, 4, 6, 16§ F, 12, 3, 2, 75, 12.5, 6, 9.5, 28§ M, 13, 3, 2, 77.75, 10, 9, 6, 25§ F, 13, 3, 2, 80.07, 10, 10, 9, 29§ F, 10, 3, 2, 83.75, 15.5, 7, 6, 28.5§ F, 12, 3, 2, 85.67, 12, 9, 6, 27§