Enhancing Critical Thinking through Cooperative Learning in Biology

A Thesis Submitted in Partial Fulfillment of the Requirements of the Degree of Research Master of Teaching Life Sciences

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DEDICATION

To all who aim to learn from life

To all who make effort to help others

To all who think of improving the quality of our lives

To all who make plans to graduate good citizens

To all who love learning

To all who love teaching

To all who supported me

To my family

To my friends

To my advisors

To all whom I concern

I dedicate this hard work.....
ACKNOWLEDGEMENT

I have ever wondered as to when and how I shall write an acknowledgement in which I would thank all those who have stretched out the hand of help for this work to see the light, an acknowledgement that I would imprint in letters of gold.

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I would like to acknowledge the great support and cooperation shown sincerely to me by the administrator, biology coordinator, biology teachers, and students at the private school where this study took place.

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Finally, I would like to thank from my heart my family members; my father, mother, brothers, sisters, and spouse for their true love, support, patience, and care.
AN ABSTRACT OF THE THESIS OF

Fatima Ibrahim Al Husseiny for Research Master of Teaching Life Sciences

Title: Enhancing Critical Thinking through Cooperative Learning in Biology

Recent research findings such as Abrami et al (2008), White et al (2011), Jayapraba (2013), and Freman et al (2014) have shown that cooperative learning improves students’ thinking skills because it allows them to communicate actively with each other rather than listen passively. Therefore, cooperative learning has been proposed by many science educators to be implemented in the science classrooms to produce lifelong learners and critical thinkers (Lunenburg, Fred 2011).

The present study aims to investigate the effect of cooperative learning on enhancing critical thinking in biology and also the effect of self-assessment (being a part of a successful cooperative learning) on promoting critical thinking skills.

A sample of (120) students from two classes of different grades (seven and ten) in a private school in Beirut participated in this experimental study, whereby biology was taught to each class of the two different grades using two different teaching methods: cooperative learning (experimental group) and individualistic-direct learning (control group). Pre- and post- tests were administrated to both groups of each grade to compare students’ achievement particularly in critical thinking items before and after the intervention. In addition, self-assessment grids were administrated to students in the
experimental groups for two times during the study to investigate the correlation between student self-assessment practiced during cooperative learning and the development of critical thinking skills. Moreover, teams’ self-assessment grids and teacher’s assessment grids were administrated to assure the reliability of the results of team’s work.

Results of the study show that cooperative learning has significant effect on students’ critical thinking skills in grade ten only. However, in both grades there is correlation between self-assessment and critical thinking. The study also provides recommendations for future research and policy makers.
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CHAPTER I
INTRODUCTION

One quality that sets humans apart from all other species is the ability to think, reason, and communicate. The role of education is to enhance and develop these skills to the highest degree possible. Previously, educators used to consider students as passive listeners whose mind is an empty vessel that needed to be filled by the teacher with the appropriate knowledge. Presently, educators believe that students learn best when they take an active role in their learning (Freeman et al, 2014).

The advancement in developmental psychology and cognitive research has changed the way educators think about learning in general including teaching and learning science. Science educators realize that for students to understand science, they need to relate new information to what they already know and in order to gain depth of understanding, they need to personally construct their own knowledge by asking questions, designing and conducting investigations, and analyzing and communicating their findings; in other words, students need to develop into meaningful learners (Novak, 2002).

In addition to a meaningful learning orientation, students need to be scientifically literate to cope with the demands of the scientifically rich world in which we are living today; a world which requires that students possess a well connected store of knowledge, an adequate understanding of scientific inquiry skills, an appreciation that science is a distinctive way of knowing (including an
understanding of the nature of science), and a good grasp of the relationships among science, technology, and society (O’Rourke, Kenneth, 2008).

As a consequence, teaching science requires that teachers emphasize developing students’ skills in relating concepts within the discipline and across disciplines and not merely engaging them in rote learning, which may help students do well on standardized tests but will not provide them with the skills necessary to analyze and link concepts, solve complex problems, and develop critical thinking skills (Facione, Peter A. 2011).

In recent years, critical thinking has become something of a “buzz word” in educational circles. For many reasons, educators have become very interested in teaching skills and content. Of course, you can do both, but in the past, the emphasis in most people’s teaching has been on teaching content, and though many teachers would claim to teach their students how to think, most would say that they do this indirectly or implicitly in the course of teaching the content which belongs to the special subject.

Increasingly, educators have come to doubt the effectiveness of teaching “thinking skills” in this way because most students simply don’t pick up the thinking skills in question, the result is that many teachers have become interested in teaching these skills directly. (Abrami et al 2008).

Thinking critically, clearly, and effectively is not an easy process. Critical thinking is not a natural way to reason about the world. These skills, like any other, require considerable thought, effort and practice. It is both surprising and unfortunate that few academic
universities actually provide students with explicit courses directed at developing critical thinking skills and the tools of logic and reason. (Braithwaite J., 2006).

Science education research conducted in the past few decades has focused on understanding how students learn and how to help them construct personal understandings of scientific concepts. Science educators found that the use of student-centered teaching strategies in the science classroom within an overall inquiry-based pedagogy is an effective way to enhance students’ academic performance, critical thinking, and problem solving skills (Lunenburg, Fred, 2011).

Research findings have determined that teaching methods, among other factors, have an impact on elementary students’ science achievement. Educators have been striving to devise teaching methods to improve science outcomes. A variety of teaching strategies have been designed to be used in science classrooms, ranging from teacher-centered strategies to more student-centered ones. Based on the teaching methodology used by the teacher, students’ learning can take one of the three following forms: competitive, where students compete with each other; individual, where students work alone; or cooperative, where students work together to accomplish shared learning goals. Educators have become interested in cooperative learning because of two major reasons. First, they have recognized the potential benefits of cooperative groups as opposed to competitive learning. The second motive is that many studies indicate that when cooperative learning is applied properly, it has the potential to promote academic achievement, enhance social skills, and improve self-esteem (Pearson, 2010). Proponents of cooperative learning argue
that by working with others and sharing their experiences, one can see
different points of view and can thereby maximize learning as well as
developing interpersonal and communication skills. Many educators
believe that this is an effective method because this is the way that
scientists and engineers work (Paul, Richard & Elder, Linda, 2006).
Cooperative learning is one of the most efficient instructional methods
that enable students to work together in solving scientific problems
(Vijayratnam, Phawani, 2009).

Research has shown that cooperative learning improves
students’ thinking skills because it allows them to communicate
actively with each other rather than listen passively; therefore,
cooperative learning has been proposed by many science educators to
be implemented in the science classrooms to produce lifelong learners
(O’Rourke, Kenneth, 2008).

Since scientists, engineers, medical doctors, as well as
individuals in other walks of life work mostly in groups and less often
individually, science students would benefit from training on how to
collaborate and share responsibilities early on at school before joining
argue that small-group cooperative learning helps in improving
students’ achievement and in developing classroom community.
Therefore, employing cooperative learning—while studying concepts
explained by the teacher in the classroom—helps students make deeper
connections among facts, concepts, and ideas (Jayapraba, 2013).
Rationale for the Study

Several reasons were behind the selection of this research problem. First, many studies were carried out on the effect of cooperative learning on achievement of students, but very few were made on its effect on enhancing critical thinking, especially in biology. Second, critical thinking was studied on college students more than in schools. Third, research on the effectiveness of cooperative learning on students’ cognitive achievement is inconsistent. Some research established that it is effective, others found no differences between cooperative and traditional approach groups, and others even concluded that cooperative learning influences students’ achievement negatively. Fourth, relationship between critical thinking and metacognition (self-assessment) is studied in nursing education more than in schools.

Even in Lebanon, few studies have investigated cooperative learning in teaching and learning life sciences, such as (Itani, R 1996; Fakhreddine, L 2003; Kameh, L 2009; Hannoun, S 2010) and critical thinking such as (Karameh, J 2013). In addition, most studies made were applied on students of one grade; however this study is implemented on students of two different grades and cycles. However, there is shortage in research that addresses the relationship between cooperative learning and critical thinking.
Purpose of the Study

The present study aims to investigate the effect of cooperative learning on enhancing critical thinking in teaching and learning biology and also the effect of self-assessment (being a part of a successful cooperative learning) on promoting critical thinking skills.

Research Questions

This study attempts to answer the following general question:

Does cooperative learning increase students’ critical thinking more than individualistic learning?

For this aim, several sub-questions are posed:

1- Does cooperative learning have a better effect on students’ achievement in biology (domain B in the Lebanese taxonomy of evaluation) namely critical thinking items than individualistic learning?

2- Is there any correlation between student self-assessment practiced during cooperative learning and the development of critical thinking skills?

3- Is there a significant difference in the effect of cooperative learning on critical thinking on students of different grades (grade seven and grade ten)?

4- Is there a significant improvement in student self-assessment during the study in students of different grades (grades seven and ten)?
Hypotheses

The following hypotheses are to be tested:

Hypothesis 1: Cooperative learning has a better effect on students’ achievement in biology (domain B in the Lebanese taxonomy of evaluation) namely critical thinking items than individualistic learning.

Hypothesis 2: There is significant correlation between student self-assessment practiced during cooperative learning and the development of critical thinking skills.

Hypothesis 3: There is no significant difference in the effect of cooperative learning on critical thinking on students of different grades (grade seven and grade ten).

Hypothesis 4: There is significant improvement in student self-assessment during the study in both students of different grades (grade seven and grade ten).

Significance of the Study

Critical thinking skills are very important for introducing students to life and work domain. Therefore, it is important to investigate the importance of promoting and implementing these skills in classrooms.

Results of this study are expected to highlight the relationship between cooperative learning and critical thinking skills, and namely the role of self-assessment (practiced in cooperative learning) in
promoting those skills. Especially that it is the first time a study is conducted in Lebanon to elaborate this area of research concerning metacognition (expressed and measured in this study by self-assessment) through cooperative learning and its role in classrooms to enhance critical thinking.
CHAPTER II

LITERATURE REVIEW

1. CRITICAL THINKING

1.1. Importance

The concept of critical thinking may be one of the most significant trends in education relative to the dynamic relationship between how teachers teach and how students learn (Mason, 2010). Critical thinking shifts classroom design from a model that largely ignores thinking to one that renders it pervasive and necessary (Cohen, 2010; Tittle, 2010; Vaughn, 2009). Those who teach critically emphasize that only those who can “think” through content truly learn it (Numrich, 2010). Content “dies” when one tries to mechanically learn it. Content has to take root in the thinking of students and, when properly learned, transforms the way they think. As a result of being taught to think critically, students study biology and become biological thinkers. To achieve major improvements in student achievement will require fundamental changes in the way subject matter is taught. Critical teaching views content as something alive only in minds, as modes of thinking driven by questions, as existing in textbooks only to be regenerated in the minds of students (Lunenburg Fred C., 2011).

Classroom teachers at all levels should consider critical thinking and constructivism that offer real promise for improving the achievement of all students in the core subject areas. Current views hold that critical thinking includes a set of skills that are most
effectively taught within the context of a subject area. Since it is impossible to think critically about something of which one knows nothing, critical thinking is dependent on a sufficient base of knowledge. The critical thinker engages the material, the instructor, and other students in an active way in a “dynamic process of raising and pursuing questions about their own and others’ claims and conclusions, definitions and evidence, beliefs and reactions” (Maryland State Department of Education, 1990, pp. 17-18).

1.2. Definition

In fact, people have been thinking about critical thinking and have been researching how to teach it for about a hundred years. In a way, Socrates began his approach to learning over 2000 years ago, but John Dewey, the American philosopher, psychologist, and educator, is widely regarded as the father of modern critical thinking tradition. He called it reflective thinking and defined it as: “Active, persistent, and careful consideration of a belief or supposed form of knowledge in the light of the grounds which support it, and the further conclusions to which it tends (Dewey 1909, p.9).

Edward Glaser, co-author of what has become the world’s most widely used test of critical thinking, the “Watson-Glaser Critical Thinking Appraisal”, defined critical thinking as: (1) “An attitude of being disposed to consider in a thoughtful way the problems and subjects that come within the range one’s experience”; (2) “A knowledge of methods of logical inquiry and reasoning and some skill in applying those methods”. 
Glaser (1941) states that critical thinking calls for a persistent effort to examine any belief or supposed form of knowledge in the light of evidence that supports it and the further conclusions to which it tends (Glaser, 1941, p.5). This definition owes a lot to Dewey’s original definition. Glaser refers to “evidence” in place of “grounds”, but otherwise the second sentence is much the same. He speaks about an “attitude” or disposition to be thoughtful about problems and recognizes that you can apply what he calls “the methods of logical inquiry and reasoning” with more or less skill.

Facione (1990) proposed that critical thinking is “the process of purposeful, self-regulatory judgment. This process reasoned consideration to evidence, context, conceptualizations, methods, and criteria”. It can evaluate the validity of beliefs, but it is not a belief by itself – it is a process, and it is also important to understand that arguments based on critical thinking are not necessarily the most persuasive.

Elder and Paul (1994) interestingly define critical thinking as self-guided, self disciplined, and self-corrective thinking. They further add that to be a good thinker, one must be good at effective communication and problem-solving abilities and be ready to embrace new ideas and skills.

De Bono (2000) has repeatedly propounded that being a thinker does not involve being right or clever and solving all problems that come your way. Being an effective thinker, according to De Bono (2000), involves consciously wanting to be a thinker and going
through the motions of thinking i.e. role playing, deliberate use of thinking tools etc. He further adds that being a thinker involves deliberately practicing and focusing on your operating skill.

1.3. Measurement of Critical Thinking

1.3.1. Challenges in Assessing Critical Thinking

There are a number of challenges in assessing critical thinking skills and dispositions in students. Researchers have pointed out problems associated with both reliability and validity of existing measures. Furthermore, students’ abilities to use topic statements, evidence, explanations, conclusions, and logical organization did not generalize across tasks, suggesting that idiosyncratic and perhaps construct-irrelevant features of each passage or task were more salient aspects of student performance than any general ability to think critically. Silva (2008) has noted that performance-based assessments of creativity introduce, rather, subjectivity and error. Moreover, use of such performance tasks to assess the growth of critical thinking skills over time remains fraught with difficulties as long as individual tasks communicate more noise than signal (Moss & Koziol, 1991).

Norris (1989) argues that the fact that the degree of domain specificity in critical thinking remains unresolved makes assessment of critical thinking difficult. First, the type of inferences one is trying to make remains unclear to the extent that researchers cannot agree whether critical thinking is general or subject-specific. Second, it is difficult to assess critical thinking transfer, because transfer to other contexts is confounded with subject-specific knowledge that is
necessary for exercising critical thinking. Thus, a student who fails to transfer to another subject either requires additional instruction in critical thinking or additional instruction in the subject matter. Similarly, the disposition to think critically is confounded with the ability to do so. Thus, despite the fact that researchers have identified critical thinking skills and dispositions as distinct from one another, delineating their separate effects using an assessment is difficult in practice. Finally, Norris argues that traditional assessment formats are ill-suited for testing even limited aspects of the construct. Standardized instruments using multiple-choice formats to assess credibility judgment or deductive reasoning are as likely to reflect extraneous constructs—such as test-makers’ empirical, religious, or political beliefs and judgments—as they are to reflect critical thinking.

1.3.2. Instruments for Assessing Critical Thinking

Existing published assessments of critical thinking are numerous, and include:

- The Watson-Glaser Critical Thinking Appraisal (Watson & Glaser, 1980): It is a measure of critical thinking judgments and logical reasoning derived by testing skills of argument, drawing inferences, interpreting, deducting, recognizing assumptions, evaluating conclusions and assessing reasoning strengths (Kurfiss, 1988). Knowing if someone possesses these skills is helpful for planning educational strategies. However, reflective executive control or metacognition surrounding the use of these skills is also important to education and is not evaluated by this test alone.
The California Critical Thinking Skills Test (CCTST) and California Critical Thinking Dispositions Inventory (CCTDI) are measures of critical thinking achievement and evaluation (Saucier 1995, Colucciello 1997, Stone et al. 2001). These instruments were developed as a result of a Delphi study, in which 46 experts in research on thinking had to define critical thinking (APA, 1990). According to this group, critical thinking is: purposeful, self-regulatory judgment that results in interpretation, analysis, evaluation, and inference as well as the explanation of evidential, conceptual, methodological, criteriological or contextual considerations upon which that judgment is based (Facione 1990, p. 2). Based on this definition and in order to stimulate united research activities, several instruments for measuring different aspects of critical thinking were developed and validated:

1. The "California Critical Thinking Skills Test (CCTST)" for measuring general critical thinking skills (Facione & Facione, 1992). It is aimed at college students, but probably usable with advanced and gifted high school students. Multiple-choice, incorporating interpretation, argument analysis and appraisal, deduction, mind bender puzzles, and induction (including rudimentary statistical inference).

2. The "California Critical Thinking Dispositions Inventory (CCTDI)" (Facione, Facione, & Giancarlo, 1992) for measuring relevant dispositions and attitudes. It is a multiple-choice attempt to assess critical thinking dispositions. Probably useful for self-appraisal and, as anonymous information, for research and evaluation of groups.
3. The "Holistic Critical Thinking Scoring Rubric (HCTSR)" (Facione & Facione, 1994) for considering the subject matter or context in which critical thinking skills are applied.

Kennedy et al. (1991) note that none of these tests are intended for use with students below the fourth-grade level. As Ku (2009) points out, these instruments vary widely in both purpose and item format. Most of these assessments tend to be general critical thinking assessments rather than subject-specific.

Other recent general-content, multi-aspect, critical thinking tests include:

- **Cornell Critical Thinking Test, Level X (2005):** by Robert H. Ennis and Jason Millman. It is aimed at Grades 4-14. It includes multiple-choice; sections on induction, credibility, observation, deduction, and assumption identification.

- **Cornell Critical Thinking Test, Level Z (2005):** by Robert H. Ennis and Jason Millman. It is aimed at college students and adults, but usable with advanced or gifted high school students. It includes multiple-choice; sections on induction, credibility, prediction and experimental planning, fallacies (especially equivocation), deduction, definition, and assumption identification (An annotated list of critical thinking tests, Robert H. Ennis, Revised December, 2009).

Some authors advocate the use of cognitive scales and tests that can be used to demonstrate student learning of higher order and critical thinking, such as the Articulated Learning Strategy (Ash &
Clayton, 2004). Steinke and Fitch (2007) discuss several different approaches that include both indirect and direct measures of problem-solving skills, critical thinking and so on, that can be applied in service learning, and that can show evidence of linkages between academic, civic and personal categories of learning objectives (Asia-Pacific Journal of Cooperative Education, 2010, 11(3), 67-91).

On the other hand, Stiggins, Rubel, and Quellmalz (1990) suggest that the key to success in measuring and teaching thinking skills is to adopt taxonomy of skills and use it consistently. “This lends credence to viewing Bloom’s taxonomy as a way to model critical thinking in the classroom” (Garside C. 1996, Communication Education, Volume 45, July 1996).

1.4. Critical Thinking in Bloom’s Taxonomy

Beyer (1987) indicates that critical thinking has many definitions, and can also refer to skills drawn from Bloom’s taxonomy. Bloom (1974) taxonomy identifies higher order thinking skills that presuppose the use of basic critical thinking concepts. It gives helpful insights into cognitive processes and their interrelations. In this view, higher order skills include analysis, synthesis, and evaluation, all of which involve critical thinking skills such as analysis of elements, arguments, relevancy of issues, implications of information, and drawing logical conclusions.

In most of the education-oriented material, Bloom’s Taxonomy is often referenced, using the higher level thinking skills to connect to critical and creative thinking. “Critical thinking involves logical
thinking and reasoning…creative thinking involves creating something new or original…While critical thinking can be thought of as more left-brain and creative thinking more right brain, they both involve “thinking”. When we talk about HOTS “higher-order thinking skills” where concentrating on the top three levels of Bloom’s Taxonomy: analysis, synthesis and evaluation” (Lamb 2003).

Huitt (1998) equates evaluation with critical thinking and synthesis with creative thinking: “Synthesis and evaluation are two types of thinking that have much in common, but are quite different in purpose. Evaluation (which might be considered equivalent to critical thinking) focuses on making an assessment or judgment based on an analysis of a statement or proposition.

- **Analysis** “to identify the intended and actual inferential relationships among statements, questions, concepts, descriptions or other forms of representation intended to express belief, judgment, experiences, reasons, information or opinions”.

- **Synthesis** (which might be considered more equivalent to creative thinking) requires an individual to look at parts and relationships (analysis) and then to put these together in a new and original way.

- **Evaluation** “to assess the credibility of statements or other representations which are accounts or descriptions of a person’s perception, experience, situation, judgment, belief, or opinion; and to assess the logical strength of the actual or intended inferential relationships among statements, descriptions, questions or other forms of representation.”
Thus the fundamental **critical thinking skills** can be summarized as the ability to:

- Identify the elements in a reasoned case, especially reasons and conclusions.
- Identify and evaluate assumptions
- Clarify and interpret expressions and ideas
- Judge the acceptability, especially the credibility of claims
- Evaluate arguments of different kinds
- Analyze, evaluate, and make decisions
- Analyze, evaluate, and produce explanations
- Draw inferences
- Produce arguments \( (\text{Fisher, } 2001) \)

### 1.5. Critical thinking in the Lebanese Biology Curriculum

According to our Lebanese Science Curriculum developed by the Center for Educational Research and Development (CERD, 1998), the actual progress of biology and its fundamental knowledge, as well as, the technology of life, and their applications for man's service requires a new orientation of teaching at the intermediate level to cope with the contemporary world requirements. Some of the objectives are:

- Permit students to acquire scientific processes, specifically by developing an experimental approach and problem solving activities.
- Encourage students to appreciate the role of empirical proofs and models in science as well as to consider and accept
uncertainties of explanations and interpretations related to the observed phenomena.

- Permit students to conduct scientific messages; make scientific arguments; master the techniques of observation, experimentation, and analysis; and acquire scientific accuracy and critical thinking.

By examining these objectives, it is quite obvious that teaching critical thinking skills is a must, through which the Lebanese students analyze, interpret, synthesize, evaluate, and decide, modifying their current attitudes into more nationally efficient ones.

1.6. Critical Thinking in This Study

After extensive reading to the theoretical background, the following definition of critical thinking seems the most relevant to the present study: “Critical thinking is a higher-order thinking skill which mainly consists of evaluating arguments. It is a purposeful, self-regulatory judgment which results in interpretation, analysis, evaluation, and inference, as well as explanations of the evidential, conceptual, methodological, or contextual considerations upon which the judgment is based” (Astleitner, 2002).

Based on this definition, students’ critical thinking skills will be measured in this study by using the following action verbs that reflect also high order thinking skills presented in Bloom Taxonomy:

- Analyze
- Deduce
• Draw out a conclusion

These high order skills are presented in the Lebanese evaluation scheme in domain B questions which evaluate how students practice scientific reasoning. These questions include: pick up information from a text, relate information, pose a problem, formulate a hypothesis, interpret, deduce, draw out a conclusion, etc. (Refer to Appendix I)

2. Cultivating Critical thinking Skills in the Classroom

“Assuming that critical thinking can be enhanced through classroom activities, there are some features of classroom activities that enhance critical thinking. The key to developing critical thinking lies in creating conditions for participation rather than passivity, and in providing opportunities for the emotional engagement with the materials (Mayer, 1986). Students need to become active learners rather than passive recipients of information, taking responsibility for their own thinking and learning (Kruse, 1988; Maryland State Department of Education, 1990).

Active learning depends on a constructivist approach where children actively construct their knowledge, rather than simply absorbing ideas spoken to them by teachers (Fosnot, 2006; Phillips, 2000; Larochelle, 2010).

2.1. Constructivism

2.1.1. Definition of Constructivism
Constructivism is a trend in education that can play a dynamic role in the relationship between how teachers teach and how children learn. Borich and Tombari (1997) define constructivism as: “An approach to learning in which learners are provided the opportunity to construct their own sense of what is being learned by building internal connection or relationship among the ideas and facts being taught” (Borich and Tombari, 1997). So, the constructivist perspective emphasizes the learning occurs only when learners actively engage their cognitive structures in schema building experiences (Yager and Lutz, 1994; Fosnot, 1996).

2.2. Concept of Metacognition

Metacognition is a thinking activity that is closely related to constructivism because in building understanding on information, one has to think and monitor his own thinking.

2.2.1. Definition of Metacognition

Metacognition is an important concept in cognitive theory. It is about self-reflection, self-responsibility and initiative, as well as goal setting and time management. According to Winn and Snyder; “Metacognition consists of two basic processes occurring simultaneously which are monitoring your progress as you learn, and making changes and adapting your strategies if you perceive you are not doing so well ”(Winn, W. & Snyder, D., 1998). Metacognition refers to thinking about one’s own thinking which is examining one’s own information processing. It is thinking about your own thinking and about how you process information effectively.
According to Tan (2003): “Metacognition refers to our ability to understand and manipulate our own cognitive processes. It involves thinking about our thinking and purposely making changes in how we think.” (Tan, 2003)

Many students fail to think about their thinking. They do not think about how they think, which means they cannot control their information processing. They fail to engage in the “self-planning, self-monitoring, self-regulating, self-questioning, self-reflecting, self-reviewing” that is necessary to critical thinking and learning (Hyde and Bizar, 1989). It is also a learning skill. If you have good learning skill means you know how to monitor, regulate, and control your own thinking.

A key to grasping the concept of metacognition is the word purposeful. Metacognition is controlled. It is purposeful thoughtfulness. But how we engage our cognitive processes is not always clear and unambiguous. As teachers, we cannot sit back and watch. We have to use thinking techniques such as self-regulated learning to guide our instructional choices (Jayapraba, 2013).

To facilitate metacognition, teachers can teach students specific strategies and allow them time to practice the strategies. One of the strategies is teacher presenting to them divergent questions or teacher can encourage the students to generate their own questions. Ganz and Ganz(1990) suggest that: “Self-questioning encourages the students’ monitoring of their own cognition, along with the assessment of their feelings about the efficacy of their thinking. It also assists students in
the employment of self-correction and the development of newer understanding”. (Tan, 2003)

2.2.2. Reflection as an Educational Outcome

Reflective thinking can be first traced to Dewey (1933) and Habermas (1987), and can be defined as careful consideration and examination of issues of concern related to an experience. The research on reflection is strongly linked to the cognitive behavioral skills of self-monitoring, self-evaluating, and self-reinforcing goal-oriented behaviors that are essential aspects of metacognition.

Metacognitive self-regulation or self-assessment includes the sub-processes of goal setting, self-efficacy, knowledge use and thinking strategies. Self-assessment refers to the reflective thinking about experiences and situations to determine if knowledge is adequate, what goals are to be set, and if there is the self-efficacy required to reach them (Johnson, Klissa (2007)).

2.2.3. Self-Regulation of Learning

Self-regulation of learning (SRL) arises from the constructivist framework and integrates educational theories with teaching–learning strategies. Self-regulation occurs when students activate and sustain cognition, feelings and behavior toward attainment of academic goals (Gettinger, 1995). Students can be described as self-regulated to the degree they are metacognitively, motivationally, and behaviorally active participants in their own learning process (Zimmerman, 1989; Zimmerman, Bandura, & Martinez-Pons, 1992).
Zimmerman and Martinez-Pons (1986) found evidence of students’ use of ten types of self-regulated learning strategies. One of these strategies is self-assessing. Zimmerman (1989) self-regulated learning strategies of students was found to be highly correlated with their academic achievement indices, and with teacher’s ratings of their degree of self-regulation in class (Zimmerman, 1989).

Self-regulated learning strategies and motivational beliefs are the most important aspects of students’ learning to achieve excellence in the class context. Self-regulated learning strategies are the use of metacognitive strategies, cognitive strategies, and students’ management and control of their effort in the classroom academic tasks. Such strategies can be achieved through motivational beliefs components where these components include students; belief about their ability to perform, self-efficacy, goals, and interest, and emotional; reactions to the task (Kuiper, Ruth & Pesut, Daniel (2004)).

2.2.4. Self-Assessment

Critical thinking is thinking that assesses itself. To the extent that our students need us to tell them how well they are doing, they are not thinking critically.

Each step in the process of thinking critically is tied to a self-reflexive step of self-assessment. As a critical thinker, I do not simply state the problem; I state it and assess it for its clarity. I do not simply gather information; I gather it and check it for its relevance and significance. I do not simply form an interpretation; I check my
interpretation to see what it is based on and whether that basis is adequate (Johnson, Klissa (2007)).

Because of the importance of self-assessment to critical thinking, it is important to bring it into the structural design of the course and not just leave it to episodic tactics. Virtually every day, for example, students should be giving (to other students) and receiving (from other students) feedback on the quality of their work. They should be regularly using intellectual standards in an explicit way. This should be designed into instruction as a regular feature of it (Pearson, 2010).

One simple structure to use in attending to this dual need is to provide students a set of performance criteria that apply to all of their work, criteria that they will be using over and over. Then, make specific provision for encouraging students to think in a focused way about the particular demands of any given task or question before them.

One of the most powerful complex structures is that of requiring students to do a global analysis of the strengths and weaknesses of their performance in a class overall. In order for this tactic to work, the following have to be true:

- Students must be given, early on, performance profiles (correlated with grades).
- Students must be given multiple opportunities to assess their own work and that of their peers using the performance profiles.
• Students must be given a thorough orientation on what is and is not expected in the global self-assessment.
• Students should be required to support all claims that they make with relevant and representative evidence and reasoning.
• Students should understand that if they argue for a higher grade than they deserve, their grade will be lowered. (Richard Paul & Linda Elder, 2000).

Race (2001) summarized the advantages of self-assessment:

• Self-assessment deepens students' learning experiences.
• It helps students towards becoming autonomous learners.
• It helps students develop skills relating to life-long learning.
• It helps students to gain much more feedback than would otherwise be possible.
• Self-assessment gets students to reflect on their own work, and can open up productive student-tutor dialogues.
• Students' performance in traditional assessments is enhanced.

A number of appropriate self-assessment checklists are included in Jaques (2000). One of these lists concentrates on students' skills in organizing their learning:

• Contribution to group discussion.
• Carries out instructions and degree of supervision needed.
• Works easily with others.
• Response to criticism.
• Polite with colleagues.
• Ability to organize own work.
• Ability to supervise others' work.
• Speed of recognizing essentials.
• Adaptability to new situations.
• Efficiency at solving problems.

However, the argument for self assessment is not one-sided. There are dangers of student bias that need to be allowed for. Typically, bias may arise from:

• Reticence about providing negative information on fellow students;
• Reluctance to cover a full spectrum of marks, with realistic maxima and minima;
• Collusion that disadvantages some individuals;
• Reluctance to fail a student.

Design options to counter such bias include:

• Initial discussion, input and commitment by students to assessment program;
• Checking uniformity of student opinion (e.g. individual questionnaires);
• Observing anonymity in assessment (e.g. questionnaires completed in class);
• A clear procedure for arbitration on disputed assessments;
• A procedure for investigation of student participation (e.g. log books and exams).
In an experimental study, researchers Anat Zohar (1994) and colleagues tested 678 seventh graders’ analytical skills. Then they randomly assigned some students to receive critical thinking lessons as part of their biology curriculum. Students in the experimental group were explicitly trained to recognize logical fallacies, analyze arguments, test hypotheses, and distinguish between evidence and the interpretation of evidence. Students in a control group learned biology from the same textbook but got no special coaching in critical thinking. At the end of the program, students were tested again. The students with critical thinking training showed greater improvement in their analytical skills, and not just for biology problems. The kids trained in critical thinking also did a better job solving everyday problems (Zohar et al 1994).

Perhaps the most effective way to foster critical thinking skills is to teach those skills explicitly. Philip Abrami (2008) and colleagues analyzed 117 studies about teaching critical thinking. The teaching approach with the strongest empirical support was explicit instruction—i.e., teaching kids specific ways to reason and solve problems. In studies where teachers asked students to solve problems without giving them explicit instruction, students experienced little improvement (Abrami et al 2008).

Self evaluation- moderated mark, using predetermined criteria encourages sense of involvement and responsibility on part of students. Students individually evaluate their own contribution using predetermined criteria and award themselves a mark. However, self evaluations may be perceived as unreliable (Winchester-Seeto (2002).
Austin et al, (2008) made a study to examine whether self-assessment and reflection-in-action improves critical thinking among pharmacy students. A 24-item standardized test of critical thinking was developed utilizing previously-validated questions. Participants were divided into two groups (conditions). Those in condition 1 completed the test with no interference; those in condition 2 completed the test but were prompted at specific points during the test to reflect and self-assess. Significant differences (p=0.05) were observed between those who completed the test under condition 1 and condition 2, suggesting reflection and self-assessment may contribute positively to improvement in critical thinking. He concluded that structured opportunities to reflect-in-action and self-assess may be associated with improvements among pharmacy students in performance of tasks related to critical thinking.

In conclusion, self assessment also offers advantages to learning and may be captured via student reflections (McNamara, 2009).

2.3. Strategies for Developing Critical Thinking

McPeck (1990) suggests that teachers need to change their methods of presentation from a didactic mode to a more discursive or argumentative mode of teaching and assessment in order to emphasize critical thinking skills. Students need to elaborate, defend, and extend their positions, opinions, and beliefs. They think more deeply when they investigate the paths thinking takes on the way to a conclusion.
They also recognize the arguments underlying the positions others held (Maryland State Department of Education, 1990).

Teaching for critical thinking stresses meaningful, purposeful learning, not rote memorization. To the extent that associations can be made between ideas, the more meaningful the learning will be (Eggen and Kauchak, 1988).

Beyer (1987) likewise describes classroom that reinforce and support thinking: Students feel free to risk, challenge, and question; there is student-to-student interaction focused on information processing, where students consider the ideas, contributions, and arguments of peers; teachers don’t “tell”, rather, they help students critically analyze ideas; students are encouraged to become active learners rather than passive recipients of information; and students take responsibility for their own thinking and learning (Kruse, 1988; Halpern, 1987; Lindsey, 1988).

Verbal interaction has always been an important way by which people learn (Stanford and Roark, 1974; Palmerton, 1993). Adolescents are able to develop higher order thinking skills (formal operations) through internalizing the viewpoints of other people, which takes place during dialogues with others (Barnes, and Todd, 1977). Vygostky (1978) explains that the process of making sense of the world is profoundly influenced by ones’ interactions and perceptions of one’s environment. Speech functions as a means by which people construct and reconstruct their views of the world. He also explains that a central feature of the psychological study of instruction is the potential the students have to raise themselves to a
higher intellectual level of development through collaboration” (Garside, C. 1996).

Open discussion is sound practice for learning. Students elaborate, rehearse, and personalize information. “Teachers who move classes beyond a recitation-mode into discussion promote learning because they encourage students to use dialogue as a tool to enhance thinking and understanding” (Maryland State Department of Education, 1990, p.25). Further research indicates that complex skills and difficult material can be learned in shorter times if the learner verbalizes the information. Discussion helps develop critical thinking because students do the thinking and there is an opportunity for them to check their thinking against each other (Smith, 1990; Hill, 1990; Vermette, 1988).

In summary, features of classroom activities that enhance critical thinking include: active student participation, meaningful interaction with material, and student-to-student verbal interaction. In addition, Dixson (1991) explains that in order for critical thinking skills to be enhanced, teaching methods should allow for: (a) Differences in learning styles and abilities, (b) Interaction with the process, and (c) Human interaction to help clarify thoughts and ideas.

Matthew Lipman (1988) writes, "The improvement of student thinking-from ordinary thinking to good thinking-depends heavily upon students' ability to identify and cite good reasons for their opinions."

Training students to do critical thinking is not an easy task. Teaching which involves higher level cognitive processes, comprehension, inference, and decision making often proves
problematic for students. Despite the difficulties, many teachers are now promoting critical thinking in the classroom. They are nurturing this change from ordinary thinking to good thinking admirably. They are:

1) Promoting critical thinking by infusing instruction with opportunities for their students to read widely, to write, and to discuss.

2) Frequently using course tasks and assignments to focus on an issue, question, or problem.

3) Promoting metacognitive attention to thinking so that students develop a growing awareness of the relationship of thinking to reading, writing, speaking, and listening (Tama, 1989).

The last component of critical thinking instruction is metacognitive monitoring. Metacognition is usually defined as “what we know about what we know”, so metacognitive monitoring is determining how we can use this knowledge to direct and improve the thinking and learning process. While engaging in critical thinking, students need to monitor their thinking process, checking that progress is being made toward an appropriate goal, ensuring accuracy, and making decisions about the use of time and mental effort. In the jargon of cognitive psychology, metacognitive monitoring serves the executive function of directing the thinking process. It is made overt and conscious during instruction, often by having instructors model their own thinking process, so that the usually private activity of thinking is made visible and open to scrutiny (Halpern, 1998).
In the field of education and instruction, many approaches were used to develop programs for promoting thinking skills in students (e.g., Hager, 1995; Klauer, 1993; Mandl& Friedrich, 1992). But, only very few of these programs realized a comprehensive "critical thinking program" in a way that is actually suggested by educational researchers and instructional designers (Halpern, 1998; Maiorana, 1992). Such programs for promoting critical thinking should have the following features:

1) They should consider a disposition or an attitude against critical thinking.

2) They should regard critical thinking as a general skill that must be deepened within different subject matters or contexts.

3) They should offer a segmented and instructionally fully developed training in specific skills.

4) They should focus on all (or many) relevant sub skills of critical thinking and integrate them.

5) They should include parts for stimulating the transfer of knowledge.

6) They should support meta-cognitive skills for assisting self-regulation activities.

7) They should include formal everyday language problems.

8) They should train students for a several week's or month's period.
9) They should consider the organizational context of classroom instruction.

Overall, it seems very difficult to successfully implement critical thinking into traditional classroom instruction. When traditional classroom instruction do not work, then it is obvious to ask for alternative classroom scenarios. In such scenarios, the teacher should be assisted by some additional help or the students should be able to work for their own and therefore release the teacher from some duties.

Magno C. (2010) investigated the influence of metacognition on critical thinking skills. He hypothesized that critical thinking occurs when individuals use their underlying metacognitive skills and strategies that increase the probability of a desirable outcome. The Metacognitive Assessment Inventory (MAI) by Schraw and Dennison which measures regulation of cognition and knowledge of cognition, and the Watson-Glaser Critical Thinking Appraisal (WGCTA) with the factors inference, recognition of assumptions, deduction, interpretations, and evaluation of arguments were administered to 240 college students from different universities in the National Capital Region in the Philippines. Two models were tested: (1) In the first model, metacognition is composed of two factors while (2) in the second model, metacognition has eight factors as they affect critical thinking. The results indicated that in both models, metacognition has a significant path to critical thinking. The analysis also showed that for both metacognition and critical thinking, all underlying factors are significant.
3. COOPERATIVE LEARNING

3.1. Definition

Different educators have given various definitions of cooperative learning. All of them suppose that cooperative learning is created so that students work together in groups where social interaction starts taking place. The students depend on this social interaction to improve both their academic and social performance. Slavin believes that cooperative learning is an approach which enhances social communication (Slavin, 1988). Slavin (1988) describes cooperative learning as a group of teaching methods in which pupils are arranged in small mixed-ability learning teams.

According to Chang and Mao (1999), cooperative learning is a teaching strategy in which students work together in small teams and use a number of activities to achieve academic objectives and improve their understanding of subject matter to enhance the value of student-student interaction.

Along similar lines, Richards and Rodgers (2001) suggested that cooperative language learning is based on five major premises (Richards & Rogers, 2001). These five premises were also discussed by Johnson and Johnson (2001). They defined cooperative learning as “a relationship in a group of students that requires:

(1) Positive interdependence (a sense of sink or swim together), in which all team members work together to attain the group objective.

(2) Individual accountability (each of us has to contribute and learn), in which each group member is considered responsible for his
or her own understanding of the content, which in turn contributes to the objective of the team.

(3) Interpersonal skills (communication, trust, leadership, decision making and conflict resolution), in which learners argue, problem-solve, and work together.

(4) Face to face interaction.

(5) Processing (reflecting on how well the team is functioning and how to function even better), in which group members review and assess their capacity to work together successfully” (Johnson & Johnson, 2001).

Thus, cooperative learning is a teaching strategy that can result in meaningful learning. In cooperative learning, students work together in small, organized and managed groups to perform certain activities assigned by the teacher. These activities help students achieve academic objectives and enhance their understanding of subject matter (Lin, 2006).

3.2. Role of Cooperative Learning in Classrooms

Dewey (1966) long ago suggested that cooperative learning should be included in the classroom. He advocated cooperative learning as an approach that promotes social communication, and considered that rewards contribute to the effectiveness of the group as major components that constitute cooperative learning.

According to Vygotsky, the child’s new knowledge is learned through the interaction with others and then becomes mastered on the individual level. So, when students work together to construct their learning in a socio-cultural environment, all students will benefit (Vygotsky, 1978).
Reviewing the extensive literature on cooperative learning since 1897, Johnson and Johnson (1984) deduced that implementing the cooperative learning method in the classroom can lead to an increase in student achievement for all ability levels, the development of higher level thinking processes, positive peer relationships and improved social skills, as well as higher self esteem.

Researchers have tried to test the effects of cooperative instruction in different domains of education, including mathematics, languages, sciences, and social sciences. They have also tested cooperative instruction at different levels of education, from elementary to secondary and even college education. Many researchers have arrived at positive and promising results, finding out that cooperative learning enhanced academic achievement and even social skills. In addition to that, cooperative learning facilitated the personal growth of the individual, and enhanced the child's thinking abilities (Cowie, 1995).

3.3. Role of the Teacher in Cooperative Learning

The role of the teacher in cooperative learning is different from the role of teachers in traditional teacher-fronted lesson. The teacher has to create a highly structured and well-organized learning environment in the classroom in order to implement cooperative learning respecting its five components. This environment which the teacher needs to establish requires setting goals, planning and structuring tasks, establishing the physical arrangement of the classroom, assigning students to groups and roles, and selecting materials and time.
The teacher’s primary role is that of the facilitator of learning which requires monitoring tasks and clarifying skills whenever needs arise. In a cooperative learning environment, teacher speaks less. They raise broad questions to challenge thinking and prepare students for the assigned tasks. They also evaluate the students’ achievement and help students discuss how well they collaborated with each other.

3.4. Role of the Learner in Cooperative Learning

The primary role of the learner is that of a member of the team who should work cooperatively on assigned tasks with other team members. Thus learners have to learn teamwork skills. They are also responsible for their own learning to learn and required to learn how to plan, monitor, and evaluating their own learning.

3.5. Cooperative learning and Metacognition

The use of metacognitive strategies ignites one’s thinking and can lead to better learning and higher performance, especially among learners who strive. Developing metacognitive instructions or questions about the topic at hand would be more challenging for the teacher. The teacher would have to change his/her mind-set and pose questions that truly require the teacher to analyze the existing links to other common experiences and material, determine which processes the student may possibly use, and formulate questions accordingly. Some of the questions that are posed during the discussion can be meaningful and multifaceted. Hartman (2001) states that teaching with metacognitive strategies means that teacher will think about how their instruction will activate and develop students’ metacognition.
Bilgin, I.et.al. (2006) and Chang, C-Y., & Mao, S-L. (1999) in their contributions noted that cooperative learning activity engages the student in the learning process and seeks to improve the critical thinking, reasoning, and problem-solving skills of the learner. Stevens, R., & Slavin, R. (1995) stated that peer interaction is central to the success of cooperative learning as it relates to cognitive understanding. They further noted that comprehension is facilitated. They emphasized that as learners, some of who might normally "turn out" or refuse to speak out in a traditional setting, become actively involved in the learning process through group interaction. Chang.et.al (1999) noted that every cooperative-learning strategy, when used appropriately, can enable students to move beyond the text, memorization of basic facts, and learning lower level skills. This method which results in cognitive restructuring leads to an increase in understanding of all students in a cooperative group. Apart from academic benefits, cooperative learning has been found to promote self-esteem, interpersonal relationship and improved attitudes toward school and peers (Bilgin,I.et.al.(2006)).

In the cooperative learning strategy students have the opportunity to discuss their answers with fellow students. The students could jot down their answers to a question, turn to their neighbor and talk about their answers and sharing the same with the entire class. It forces student to discuss their thinking, analyze their position, and explain their point of view to their classmates. By their sharing information with the entire class, students would be able to evaluate themselves while gathering information from other
classmates. The teacher would also have the opportunity to evaluate the students’ understanding based on the content of the discussions.

The use of either the cooperative learning or metacognitive instructions would be easy to put into practice in the science classroom even with the pressure of syllabi and deadlines and the demand for marks from the parents. (International Journal on New Trends in Education and Their Implications p165-166).

Jayapraba (2014) made a study of quasi-experimental design in India involving 3 groups namely, two treatment groups-- cooperative learning(CL) group a metacognitive instructions(MI) group and a control group, was adopted. The study lasted for eleven weeks. A researcher-made achievement test was used to measure achievement in the 3 groups. Results revealed that the metacognitive instructions were most effective in enhancing academic achievement. Multiple regression analysis shows that there is significant relationship between metacognitive awareness and achievement. The researcher recommends that metacognitive instruction be adopted regularly in the classroom so as to help students learn material more efficiently and enhance academic achievement.

Madan L. Gupta, (2010) made a study where students in a physical sciences course were introduced to cooperative learning at the University of Queensland, Gatton Campus. A peer- and self-assessment system was successfully adapted to account for individual performance in cooperative learning group assignments. The results suggest that cooperative learning was very well received by students, and they expressed willingness to join cooperative learning groups in other courses. In addition, cooperative learning offered many benefits
to students in terms of graduate attributes such as teamwork, communication, lifelong learning and problem-solving.

3.6. Cooperative Learning and Academic Achievement

Many research studies have revealed the effectiveness of cooperative learning in promoting deep learning and higher achievement in the classroom especially science classroom (Jacobs, Lee & Ng, 1997; Johnson & Johnson, 1989; Johnson, Skon & Johnson, 1980; Slavin, 1995) in elementary schools (Johnson, Johnson & Taylor, 2001), middle schools (Okebukola, 1985), high schools (Acar & Tarhan, 2006; Chang & Mao, 1999; Humphreys, Johnson & Johnson, 1982; Lazarowitz, Hertz-Lazarowitz & Baird, 1994; Lin, 2006; Okebukola & Ogguniyi, 1984; Watson, 1991), and university level (Gupta, 2004).

Shroyer (1989) came up with 12 experimentally proven benefits of using cooperative learning in the teaching of the different secondary school subjects. Some of these benefits are:

1. Higher achievement and increased retention.
2. Greater use of higher level reasoning strategies, increased critical reasoning strategies and increased critical reasoning competencies.
3. Greater ability to view situations from others’ perspective.
5. Greater collaborative skills and attitudes necessary for working effectively with others (as cited in Lord, 1994, p.280).
Along the same lines, Slavin (1990) reviewed sixty studies that had addressed the effect of cooperative learning on students’ achievement. Seventy two percent of these studies favored cooperative learning in terms of achievement. Most of the research done on evaluating cooperative learning reveals that when cooperative learning takes group goals and individual accountability into consideration, students’ achievement on subject tests increases (Slavin, 1995).

Based on the results of several research studies, cooperative learning was shown to result in higher achievement more than competitive or individual learning (Johnson & Johnson, 1984; Joyce, Showers, & Rolheiser-Bennett, 1987). Since cooperative learning encourages student involvement and engagement in their own learning, it provides all students with opportunities to make their thoughts visible to others, allows them to talk about their own ideas, and permits them to consider the ideas of others, which enhances their higher order thinking skills (Chi, De Leeuw, Chiu, Lavancher, 1994; Chin & Brown, 2000; Jones & Carter, 1998; Wood, 1992). It is worth noting that higher achievement promoted by cooperative learning holds true for all ability levels, all age levels, all subject areas at all grade levels (2-12), and in urban, rural, and suburban schools (Johnson & Johnson, 1984; Slavin, 1995).

Although many studies show the positive effect of cooperative learning on students' science achievement, sometimes the cooperative learning method has negative or no significant effect. Chang and Lederman (2006) came up with similar findings when they applied cooperative learning to investigate students’ physical science
achievement. Six grade 7 classes were grouped into two groups: two classes (control group) were taught using the traditional approach, and the other four classes (experimental group) were taught using the cooperative learning approach. The researchers found out that cooperative learning had no significant differences on students’ achievement. Several other researchers reached the same finding in their studies (Chang and Lederman, 1994; Seymour, 1994; Tingle & Good, 1990).

In several experiments, the use of cooperative instruction actually resulted in poorer academic achievement than traditional methods. House (2000) designed a study in which secondary science students worked together in small groups while learning a new science topic. Those students earned lower test scores than the ones who were traditionally instructed, although in typical classroom situations (not introducing new topics) students working in small groups did achieve better than those learning traditionally. In 2005, House designed another study, which involved a large number of secondary science students (15,696). In his study, the researcher found out that cooperative learning was associated with significantly lower achievement results when used for introducing new science topics.

3.7. Cooperative Learning and Critical thinking

Cooperative learning is not only one strategy as one might think. It is regarded as a broad term for a number of instructional techniques and procedures that address social development in addition to conceptual learning.
According to Johnson and Johnson (1986), there is persuasive evidence that cooperative teams achieve at higher levels of thought and retain information longer than students who work quietly as individuals. The shared learning gives students an opportunity to engage in discussion, take responsibility for their own learning, and thus become critical thinkers (Totten, Sills, Digby, & Russ, 1991).

Garside C., (1996) in his study compared the effectiveness of traditional lecture methods of instruction to group discussion methods in developing critical thinking. The participants of this study were 118 students enrolled in introductory interpersonal communication classes. No significant difference was between the two instructional methods in developing critical thinking skills. However, significant gains were found from the pretest to the posttest for both instructional strategies. Specifically, the lecture method produced significant learning with regard to the total score, low level thinking items, and high level thinking items. Group discussion, however, produced significantly more learning with regard to high-level items. These findings indicate that face-to-face instructional methods make a significant difference in student learning.

A research entitled: “Cooperative Learning as a Means to Developing Students’ Critical and Creative Thinking Skills” by Vijayaratnam, P. (2009) focuses on how effective cooperative learning skills and the deliberate and conscious use of problem solving tools can aid students to develop their thinking skills which in turn can positively affect their personal, interactive and analytical skills – skills vital in the workforce. The sample population was 38 business degree students in a private university college in Malaysia.
For the purpose of this research, the researcher will focus on the three group tasks that students do in the course, in particular the problem solving tools that students are requested to deliberately and consciously use throughout their thinking and decision making process. The cooperative learning model used is a small group of four to five students who are grouped heterogeneously. In order to allow students to imbibe the virtues of cooperative learning, students are to remain in the same groups for the three group tasks throughout the semester. In this paper the researcher defines critical thinking as encompassing both logical and lateral thinking. It cannot be denied that both critical and creative thinking are interrelated and complementary aspects of thinking. Therefore, in order to develop effective thinking skills, one must pay attention to the development of both aspects of thinking.

4. Summary of Studies in Lebanon

A study titled “Motivational Beliefs and Self-Regulated Learning Strategies as Predictors of Academic Achievement in Secondary Schools in Beirut” conducted by Rayhana Itani (1996) checked if there is significant positive correlation between students’: overall motivational beliefs score and academic achievement score. GPA was taken as a measure for the academic achievement. The sample included 224 students in second secondary class in 10 schools in Beirut responded to an adapted Motivational Beliefs and Self-Regulated Learning Strategies Questionnaire. A series of correlation coefficients revealed a significant correlation coefficients exist
between students’ motivational beliefs and self-regulated learning strategies, and between students’ motivational beliefs and academic achievement, whereas non-significant correlation exists between students’ self-regulated learning strategies and academic achievement.

Two similar studies were conducted in Beirut: Bisat (1993) and Rubeiz (1995), relating four components of self-regulated learning strategies (self-consequating, goal setting, self-monitoring, and reviewing records) to academic achievement in elementary levels. Results of both studies revealed no significant relation between self-regulated learning strategies and academic achievement at the elementary levels.

Another research study entitled: “The Effect of the Learning Together Model of Cooperative Learning on Second Foreign Language Achievement and Academic Self-Esteem” conducted by Loubna Fakhreddine (2003) aimed at investigating the effect of using learning together model of cooperative learning method in improving foreign language achievement and enhancing academic self-esteem of 7th grade students learning English as a second foreign language. Data was collected through pretest and achievement posttest. The learners’ academic self-esteem was measured at the beginning and end of the study using a five-point Likert scale adopted from Johnson & Johnson (1996). Results showed that there was no statistically significant difference between the mean scores of the control and experimental groups. This suggests that the learning together model and whole-class-instruction were equally effective based on the data of this study. However, results showed that there was statistically significant differences between the posttest academic self-esteem mean scores of
the control and experimental groups. The learning together model was proved to be more effective on the academic self-esteem of the 7th grade students.

A thesis submitted in February 2010 by Susan V. Hannoun, for the major of Science Education, in the American University in Beirut under the title: “The Effect of Using Concept Maps as Learning Tools under Cooperative and Individualistic Structures on Middle School Students’ Achievement in Biology”. This study investigated the effect of using concept maps as learning tools under the cooperative and individualistic mode of learning on students’ performance on biology tests that require higher order thinking skills. Students in the cooperative group reviewed the day’s lesson by constructing a concept map cooperatively; students in the individualistic group completed concept maps individually; while students in the control group answered questions from their textbook. Results indicated that there were no significant differences between the control group and the experimental sections on test 1, post test and retention test. However, among the experimental groups, the experimental-individualistic group performed significantly better than the experimental-cooperative group on test 2.

Another thesis entitled: “The Effect of Cooperative Learning on Science Achievement and Achievement and Attitude toward science in the third grade” submitted by Layal M. Kameh, in September 2009. The purpose of this study was to investigate the effect of cooperative learning on elementary students’ science achievement, attitudes towards science, and attitudes towards cooperative learning. In addition to that, the study investigated the challenges that the teachers
face during cooperative learning. Results of the study showed that cooperative learning had no effect on students’ science achievement. However, it had a significant effect on students’ attitudes towards science and attitudes towards this teaching methodology. Results also showed that the science teacher who was involved in this study did no prefer using cooperative learning in her class.

By large, there’s general concurrence that cooperative learning has an effect on academic achievement and critical thinking.

The next chapter will discuss the research’s methodology.
CHAPTER III

METHODOLOGY

This chapter describes the methodology of data collection and analysis used in the present study. Specifically, the chapter includes sections that describe the participants, the study design, instruments, procedure, and data analysis.

Research Design

This study employed a quasi experimental design in which two intact sections of each grade were randomly assigned to control and experimental conditions, and an independent variable was manipulated.

The first part of the study was quantitative. The experimental design that the researcher used was the pre-test post-test control group design. This design greatly minimizes threats to internal validity of the experiment. In addition, the self-assessment of the student’s and team’s work in the experimental groups was measured using two self-assessment grids according to a five-point scale.

The second part of the study was a qualitative one where the teachers observe the teams in the experimental groups. That observation was done to assure the reliability of the results of team’s work.
The Variables

There were one dependent variable and one independent variable.

- The independent variable: was the teaching methodology used for each group (cooperative learning or individualistic-direct instruction) assuming that metacognitive skills are included within.

- The dependent variable was: students’ critical thinking skills measured through students’ academic achievement in Domain B questions.

- The control variables: All the other variables that might affect the dependent variables but are not manipulated are the constants. For instance, all students were girls, so the gender difference is eliminated in this study. In addition, all students were in the same school. Moreover, all the classes of the same grade were taught by the same teacher, and both sections of each grade took the same lessons using the same textbook, and were evaluated by the same tests. Had the teacher behaved differently with the two groups would be an independent variable. However, the teachers were trained equally on applying cooperative learning, and they assume that they didn’t behave differently in their classes except in terms of their learning style. So the lessons and the teachers’ behaviors are constants that didn’t affect the performance of the students in the study.

Participants

A total of 120 students (N=120) enrolled in two different grades (grade seven and grade ten) at a private high school in Beirut
participated in this study. These two different grades were selected on the basis that grade seven represents the first class in the third cycle while grade ten represents the first class in the fourth cycle. Table 1 shows the distribution of students among the groups.

Table 1

<table>
<thead>
<tr>
<th>Grade</th>
<th>Control Group</th>
<th>Experimental Group</th>
<th>Total Number of Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>30</td>
<td>30</td>
<td>60</td>
</tr>
<tr>
<td>10</td>
<td>30</td>
<td>30</td>
<td>60</td>
</tr>
<tr>
<td>Total</td>
<td>60</td>
<td>60</td>
<td>120</td>
</tr>
</tbody>
</table>

All participants were native speakers of Arabic and learning English as first foreign language. English Language is the medium of instruction in science classes since grade six.

The school was selected based on its convenience in terms of location and time especially that the researcher is a biology teacher at that school. In addition, the school is a high school, thus contains all the grades which are of the sample of this study. Also the school is well-equipped with tools that facilitate cooperative learning in terms of wide classes.

**Instruments and Measures**

The students’ achievement and critical thinking skills were measured by tests prepared by the researcher with the collaboration of their class teachers and the biology coordinator. All the tests included exercises including the three domains of evaluation in the Lebanese
curriculum: Domain A (knowledge), B (cognitive), D (communication). The students in the experimental and control groups were given the same tests at the same time and duration. In addition, the tests were corrected by the same teacher using the same correction key.

In addition, to assure alignment between the lesson objectives and the two measurement tests during the study and to ensure that the questions are at the appropriate cognitive levels, the researcher and the teachers in addition to the biology coordinator used as a reference the new Blooms’ taxonomy (Krathwohl, 2002) along with the lessons’ objectives. As a result, the cognitive questions that measure the students’ achievements include both low and high levels of Blooms’ Taxonomy. Then these tests were piloted in a different school, and based on the piloting results, minor modifications were made.

There were two different adopted measurement criteria in this study. The first was the critical thinking skills of students by scoring the questions that measure the high order thinking skills present in the pre- and post-tests. These skills are named “domain B” questions in the Lebanese curriculum. The second criterion was the students’ self-assessment of students’ learning skills by scoring the items present in a grid that was distributed among the students in the experimental groups.

The main instruments used in this study were:

1. **Pretest:**
The pretest was the midterm exam which was made one week prior to the study. It measured the achievement of students in low and high order questions regarding pre-study lessons. (Refer to appendixes (II) and (IV) for pretests of grades seven and ten respectively).

However, the domain B questions of each of the pretests of each grade were identified by the researcher and an educator to make sure that they involve no acquired knowledge and that they measure the high order skills of thinking. Then the mark of each question was added to obtain a sum which was converted into twenty to facilitate the comparison.

Tables 2 and 3 show the domain B questions in the pretest of grades seven and ten respectively.

Table 2
Grade Seven Pretest Domain B Questions

<table>
<thead>
<tr>
<th>Grade 7 Pretest Domain B Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>II-3    II-    II-  II-    II-  III-  III-  III-  III-  III-</td>
</tr>
<tr>
<td>4-a  4-b  4-c  5  6  A-5  A-6  A-7  A-9  A-10  B-1  B-2</td>
</tr>
</tbody>
</table>

Table 3
Grade Ten Pretest Domain B Questions

<table>
<thead>
<tr>
<th>Grade 10 Pretest Domain B Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-    I-  II-  II-  II-  III-  III-  III-  III-</td>
</tr>
<tr>
<td>B-2  B-3  1-a  1-b  2-a  2-b  3  1  2-a  2-b  3</td>
</tr>
</tbody>
</table>

Moreover, three critical thinking items that are repeated in each of the tests were selected specifically from the domain B questions in each pretest: “analyze”, “deduce”, “derive a conclusion”. Then the
sum of these questions was named: “critical thinking”. Also the marks were converted into twenty to facilitate comparison.

The tables 4 and 5 show the questions of critical thinking items in the pretest of each of grades seven and ten respectively.

Table 4

**Critical Thinking Selected Items of Grade seven Pretest**

<table>
<thead>
<tr>
<th>Grade 7 Pretest Domain B Questions</th>
<th>II-</th>
<th>III-</th>
<th>III-</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6</td>
<td>A-10</td>
<td>C-1</td>
</tr>
<tr>
<td>Critical Thinking Selected Items</td>
<td>Derive a Conclusion</td>
<td>Deduce</td>
<td>Analyze</td>
</tr>
</tbody>
</table>

Table 5

**Critical Thinking Selected Items of Grade Ten Pretest**

<table>
<thead>
<tr>
<th>Grade 10 Pretest Domain B Questions</th>
<th>I-</th>
<th>I-</th>
<th>II-</th>
<th>II-</th>
<th>III-</th>
<th>III-</th>
<th>III-</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B-2</td>
<td>B-3</td>
<td>1-a</td>
<td>1-b</td>
<td>2-b</td>
<td>2-a</td>
<td>2-b</td>
</tr>
<tr>
<td>Critical Thinking Selected Items</td>
<td>Analyze</td>
<td>Derive a Conclusion</td>
<td>Analyze</td>
<td>Deduce</td>
<td>Derive a Conclusion</td>
<td>Analyze</td>
<td>Deduce</td>
</tr>
</tbody>
</table>

2. **Posttest:**

This test was the final exam which was made in the last week of the study. The posttest measured the students’ achievement on all the material covered in this study. The posttest includes questions measuring the three domains A, B, and D. Refer to appendixes (III) and (V) for posttests of grades seven and ten respectively.

Also the domain B questions of each of the posttests of each grade were identified by the researcher. Then the mark of each question was added to obtain a sum which was converted into twenty to facilitate the comparison.
Tables 6 and 7 show the domain B questions in the posttest of grades seven and ten respectively.

**Table 6**

*Grade Seven Posttest Domain B Questions*

<table>
<thead>
<tr>
<th></th>
<th>II-A</th>
<th>II-B</th>
<th>II-C</th>
<th>II-D</th>
<th>III-A</th>
<th>III-B</th>
<th>III-C</th>
<th>III-D</th>
<th>III-E</th>
<th>III-F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 7 Posttest Domain B Questions</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>II-B-1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>II-B-2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>II-B-3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>II-B-4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 7**

*Grade Ten Posttest Domain B Questions*

<table>
<thead>
<tr>
<th></th>
<th>II-A</th>
<th>II-B</th>
<th>II-C</th>
<th>II-D</th>
<th>III-A</th>
<th>III-B</th>
<th>III-C</th>
<th>III-D</th>
<th>III-E</th>
<th>III-F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 10 Posttest Domain B Questions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>II-B-1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>II-B-2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>II-B-3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>II-B-4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In addition, the same three critical thinking items that were selected specifically from the domain B questions of the pretest were also selected from the domain B questions of the posttest of each grade. Also the marks were converted into twenty to facilitate comparison.

Tables 8 and 9 show the questions of critical thinking items in the posttest of each of grades 7 and 10 respectively.

**Table 8**

*The Questions of Critical Thinking Items in the Posttest of Grade Seven*

<table>
<thead>
<tr>
<th>Grade 7 Posttest Domain B Questions</th>
<th>II-B-4-a</th>
<th>II-B-4-b</th>
<th>II-C-1-b</th>
<th>III-B-2-c</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical Thinking Selected Items</td>
<td>Analyze</td>
<td>Derive a Conclusion</td>
<td>Derive a Conclusion</td>
<td>Deduce</td>
</tr>
</tbody>
</table>
Table 9

The Questions of Critical Thinking Items in the Posttest of Grade Seven

<table>
<thead>
<tr>
<th>Grade 10 Posttest Domain B Questions</th>
<th>II-1-a</th>
<th>II-1-b</th>
<th>III-3</th>
<th>IV-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical Thinking Selected Items</td>
<td>Analyze</td>
<td>Deduce</td>
<td>Derive a Conclusion</td>
<td>Analyze</td>
</tr>
</tbody>
</table>

3. **Assessment Grids:**

The grids were prepared by the researcher based on group interaction in the cooperative learning teams.

Three different grids were used:

a. **Student Self-assessment Grid** prepared by the researcher and piloted before administration: This grid included self-assessment of the student’s learning skills. It includes nine items in which each member of the team responds to a five-point scale. A mark of 1-5 is applied on a scale that goes from a very positive assessment of their ability to a very negative assessment. The grid also includes its objective and the instruction. At the top of the grid, the student writes his name, grade, section, date, and the title of the activity. This grid was distributed ten minutes before the end of two sessions of cooperative learning. (Refer to appendix VI).

The sum of the marks on each item were calculated for each student and named: “student self-assessment 1” referring to the first time which was at the first session of cooperative learning, and “student self-assessment 2” which refers to the last session of cooperative learning.
b. **Team’s Self-assessment Grid** prepared by the researcher and piloted before administration: This grid was distributed to each team in the experimental groups. Each team is responsible to fill the grid and submit it before the end of the cooperative learning session. This includes nine items assessing the team work and filled according to a five-point scale (Appendix VII). The aim of this grid is to ensure that students are practicing the cooperative skills and for the teacher to make team processing and give a feedback about the work.

The sum of the marks on each item were calculated for each team and named: “team’s self-assessment”. But since there was more than one time, the only one when the teacher observed the team was selected to compare the teams’ self-assessment with the teacher’s one.

c. **Teacher’s team-assessment grid** prepared by the researcher: This grid is filled by the teachers in the experimental groups in which they randomly chose two teams each session and observed them. The grid includes nine items which the teachers must observe and respond to a five-point scale (Appendix VIII). Along the whole study, the teachers have assessed the whole teams in each class. Then the marks of each item were calculated for each team and compared with the team’s self-assessment to assure the honesty of the team work.

**Procedure**

The research approval was first gained from the school principal and the school department of science. Before starting the research, students were informed about the purpose of the study. The researcher conducted an information session with the students to
explain the purpose of the study. Students’ participation was voluntary and students assumed that all information would be kept confidential.

A pilot study was made to establish clarity of the grids and tests in addition to the required duration if it is sufficient.

Prior to the study, the researcher prepared daily lesson plans for grades seven and ten taking into consideration one lesson plan for the experimental sections, and one for the control sections. The lesson plans in each grade cover the same objectives; however they differ in the learning strategy used (Appendix IX, X, XI, and XII). Afterwards, the lesson plans were discussed with the teacher and the science coordinator to check them.

In addition, before the study took place, the researcher trained for two weeks the teachers who taught these classes, how to make students work cooperatively. The researcher helped them in learning more about cooperative learning and in giving them extra details about her role in the class during cooperative learning. The researcher had to make sure that the teachers knew exactly the difference between the two classes and to be able to follow the directions that the researcher provided them with.

The study took about nine weeks. Students in grades seven and ten were taught biology two sessions per week. So each class had eighteen biology periods during the study; each period is fifty minutes long. The study was divided into two phases:

- **Phase 1:** It was a training period for both the teachers and the students. It extended for two weeks. During this period, students
practiced how to work cooperatively and distribute the roles among the team members. Moreover, the researcher used to follow up on the work of the teachers by making observations in both sections of each grade. The goal of the researcher’s observation is to check if the teachers are planning their teaching periods according to the assigned chart, and if the students are mastering how to work cooperatively. This part of the study aimed to help both students and the teachers to master the learning strategy used in this study so that the results of the second part can be reliable.

- **Phase 2**: It is the period of implementing the study. It lasted seven weeks. This phase used the same process as described in the first phase, except that the students’ achievement was considered as collected data. In addition, student-self assessment grids were given to each member of the teams in the experimental groups. Also, team-self-assessment grids were given to each team. Besides, teacher-assessment grids were filled by the teachers in the experimental groups. The students’ and teams’ grids were collected at the end of each session. Both sections were given an equal amount of time and worked on the same hands-on activities but in different contexts (individually or in groups). They had the same assignments and equal opportunities to practice their learning objectives.

   For the control groups, the lessons were explained using the traditional individual learning (teacher demonstration approach). This method includes asking open-ended questions, oral reading of textbook, classroom discussion, and oral reviews. The teachers asked students open-ended questions to get their attention. After students provided answers, the theoretical knowledge of science was explained
during the session. Students also worked on the same activities that the experimental group worked on, but the difference was that the students worked on these activities individually. The teachers used the textbook and other materials including worksheets to import concepts to the students. These sheets include hands-on activities that students must solve in both sections. They include questions based on blooms’ taxonomy so that students practice on critical thinking exercises along with the material taught.

The experimental groups were taught using Johnson and Johnson Model of cooperative learning, where the same hands-on activities were used, but students worked on them cooperatively rather than individually. Students in these sections discussed open-ended questions in groups, read the content knowledge in cooperative groups, in addition to doing the hands-on activities cooperatively. When the groups completed their work and reached a consensus, the teachers asked the readers of the groups to explain their answers and discuss them with other members of the class.

**Specifying Instructional Objectives**

The researcher and teachers introduced the students the cooperative skills that will be emphasized during the lesson. Then the academic objectives that the learners were expected to meet were stated.

**Deciding on the size of the group**

The researcher decided on the size of the learning groups. As cooperative learning groups tend to range in size from two to six, the researcher decided that groups of five would be an optimal choice.
Thus the experimental sections were divided into six groups each of five students. This selection was made taking into consideration the fact that as the size of group increases, the range of abilities, expertise, skills, and number of minds available for acquiring and processing information increase (Johnson and Johnson, 1987).

Assigning students to groups

The researcher chose the stratified random method in order to form heterogeneous groups. First, she ranked the order of students from highest to lowest in terms of their previous semester averages. Second, she selected the first group by choosing the highest student, the lowest student, and three middle achievers. Then she selected the remaining groups by repeating the same procedure with the reduced list.

Planning the instructional materials

The way teachers structure the materials to be used during a lesson can lead to effective academic learning and positive interdependence among group members (Johnson and Johnson, 1987). The teacher used the existing materials and structured them cooperatively. The same lessons, curriculum, and sources were used by the control groups. However, in the experimental groups, the teachers decided to distribute the materials in a carefully planned way to promote positive interdependence by communicating, so that the assignment is not an individual work but rather a joint effort and that students are in a sink or swim together learning situation.

Assigning the Roles in Each Group

Cooperative interdependence may also be arranged through the assignment of complementary and interconnected roles to group
members (Johnson and Johnson, 1987). The teachers assigned each group member a role that must be fulfilled for the group to function well. Each group had a card which contains the names of the group members and the role of each, so that the roles are rotated each section in order to give all the members equal chances to learn new roles and to ensure that positive interdependence is learned by all students (Refer to appendix XIII).

**Explaining the academic task:**

At the beginning of each session, the teachers set the task in a way that learners were clear about the assignment. Then they explained the objectives of the lesson and related the concepts and information to be studied to past experience and learning to ensure maximum transfer and retention. Moreover, they explained procedures students should follow and gave examples to help them understand what they are to study and to do in completing the assignment.

**Structuring positive interdependence:**

Positive interdependence creates peer encouragement and support learning (Johnson and Johnson, 1987). Thus the teachers asked the groups to hand a single answer sheet. Each group member signed the sheet to indicate that they agree with the answers and can explain them. As it was important also to emphasize individual accountability, the teachers called on one student at random from each group and asked her to answer a particular question and explain the rationale for the answer.

**Structuring Individual Accountability:**
To ensure that all members learn, the teachers assessed the level of performance of each group member by giving a practice test that was completed individually and then the group whose members reached a preset level of excellence was rewarded.

*Explaining the Criteria for Success*

At the beginning of each lesson, the teachers clearly explained the criteria by which learners’ work will be evaluated.

*Monitoring Students’ Behavior*

Much of the teacher’s time should be spent in observing group members in order to see what problems they are having in completing the assignment and in working cooperatively (Johnson and Johnson, 1987). Team assessment sheet was used by the teachers as they walked along the groups. Moreover, they provided task assistance when needed. In addition, they intervened to teach collaborative skills when problems aroused in a certain group and suggested more effective procedures for working together.

*Providing Content Closure to the Lesson*

At the end of the lesson, the teachers summarized the major points that were learned and asked learners to recall ideas or give examples. The teachers occasionally spent some time at the end of the session talking about how effectively each group functioned based on the team-evaluation grids and what things could have been improved. In addition, the appropriate and desirable behaviors within the learning groups were specified by the teachers before the learners started working such as keeping quiet and paying attention to the time and criticizing ideas and not members.
Data Analysis

Descriptive statistics (Means and standard deviations) for the domain B questions and critical thinking selected items of pretests and posttests were computed for each control and experimental group in each grade (seven and ten). Then t-tests were conducted to determine whether or not there were significant differences between means on domain B questions and critical thinking selected items on pretests and posttests of the control and experimental groups in each grade. Analysis of the results of pre and post-tests was conducted to determine whether the type of teaching method used was associated with a significant difference in the mean scores of each group. That is, to check whether the dependent variable (teaching method used) had an effect or not on student achievement on domain B questions and critical thinking in particular. In addition, correlation coefficients were obtained to study the relationship between each of the following: student self-assessment (2) and posttest critical thinking selected items; student self-assessment (1) and student self-assessment (2). Moreover, means and standard deviations of the items of student self-assessment grids in each experimental group of grades seven and ten were calculated.

Besides, means of the team’s and teacher’s assessment of the teams were calculated for each experimental group in each grade. Then they were compared to assure the reliability of the team’s work.

SPSS for windows was used to analyze the data collected.
CHAPTER IV

RESULTS

This chapter presents the results of this study in which data were collected using the instruments discussed earlier. The results of data analysis procedures are presented as they pertain to the research questions.

Cooperative Learning and Critical Thinking

Table 10 shows the mean scores and standard deviations for the domain B scores in pre- and post-tests of both experimental and control groups in grade seven. Students in the experimental and control groups have very close means in the pre-test (10.37/20 and 10.5/20 respectively). In the post-test, both groups show a significant increase in the domain B scores (15.5/20 and 14.12/20 respectively). However, the increase in the means of experimental group is greater than that of the control group.

Table 10

Mean and Standard Deviation of Domain B scores of pre-and post-test for grade seven groups

<table>
<thead>
<tr>
<th></th>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>G7 exp.</td>
<td>30</td>
<td>10.375</td>
<td>3.2250</td>
</tr>
<tr>
<td></td>
<td>G7 cont.</td>
<td>30</td>
<td>10.500</td>
<td>3.2088</td>
</tr>
<tr>
<td>Posttest</td>
<td>G7 exp.</td>
<td>30</td>
<td>15.504</td>
<td>2.8728</td>
</tr>
<tr>
<td></td>
<td>G7 cont.</td>
<td>30</td>
<td>14.118</td>
<td>3.4436</td>
</tr>
</tbody>
</table>

Table 11 shows the mean scores and standard deviations for the critical thinking selected items in the pre- and post-tests of both experimental and control groups in grade seven. Students in the
experimental and control groups have very close means in the pre-test (8.93/20 and 8.99/20 respectively). In the post-test, both groups show a significant increase in the critical thinking items scores (16.59/20 and 14.29/20 respectively). However, the increase in the means of experimental group is greater than that of the control group.

Table 11

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical Thinking (Pretest)</td>
<td>gr7, exp.</td>
<td>30</td>
<td>8.929</td>
</tr>
<tr>
<td></td>
<td>gr7, cont.</td>
<td>30</td>
<td>8.988</td>
</tr>
<tr>
<td>Critical Thinking (Posttest)</td>
<td>gr7, exp.</td>
<td>30</td>
<td>16.582</td>
</tr>
<tr>
<td></td>
<td>gr7, cont.</td>
<td>30</td>
<td>14.286</td>
</tr>
</tbody>
</table>

Similarly, concerning grade ten, table 12 shows the mean scores and standard deviations for the domain B scores in pre- and post-tests of both experimental and control groups in grade ten. Students in the experimental and control groups have very close means in the pre-test (9.67/20 and 8.69/20 respectively). In the post-test, both groups show a significant increase in the domain B scores (13.93/20 and 11.15/20 respectively). However, the increase in the means of experimental group is greater than that of the control group.

Table 12

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>G10 exp.</td>
<td>30</td>
<td>9.671</td>
</tr>
<tr>
<td>Domain B</td>
<td>G10 cont.</td>
<td>30</td>
<td>8.686</td>
</tr>
<tr>
<td>Posttest</td>
<td>G10 exp.</td>
<td>30</td>
<td>13.929</td>
</tr>
<tr>
<td>Domain B</td>
<td>G10 cont.</td>
<td>30</td>
<td>11.153</td>
</tr>
</tbody>
</table>
Table 13 shows the mean scores and standard deviations for the critical thinking selected items in the pre- and post-tests of both experimental and control groups in grade ten. Students in the experimental and control groups have very close means in the pre-test (9.37/20 and 8.37/20 respectively). Whereas in the post-test, both groups show a significant increase in the critical thinking items scores (14.7/20 and 11.46/20 respectively). However, the increase in the means of experimental group is greater than that of the control group.

Table 13

Mean scores and standard deviations for the critical thinking selected items in the pre- and post-tests for grade ten experimental and control groups

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical Thinking (Pretest)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>gr10, exp.</td>
<td>30</td>
<td>9.367</td>
<td>4.9630</td>
</tr>
<tr>
<td>gr10, cont.</td>
<td>30</td>
<td>8.367</td>
<td>3.9688</td>
</tr>
<tr>
<td>Critical Thinking (Posttest)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>gr10, exp.</td>
<td>30</td>
<td>14.698</td>
<td>4.2872</td>
</tr>
<tr>
<td>gr10, cont.</td>
<td>30</td>
<td>11.456</td>
<td>6.3271</td>
</tr>
</tbody>
</table>

Figures 1 and 2 represent the histograms showing the means of the scores of domain B questions of each group of grades seven and ten in pretest and posttest respectively.
Figures 3 and 4 represent the histograms showing the means of the scores of critical thinking items of each group of grades seven and ten in the pretest and posttest respectively.
A two-tailed t-test at the level 0.05 of significance shows no significant difference between cooperative learning and individualistic learning in grade seven on domain B of pre- or post-tests (t-value of 0.89 and 0.1 respectively).

In addition, no significant difference is shown between cooperative learning and individualistic learning on critical thinking items of pre- or post-tests (t-value of 0.96 and 0.07 respectively). However, the t-value was 0.07 on critical thinking post-test which is close to 0.05. (Table 14)

Table 14

| t-test for pretest and posttest domain B and critical thinking items of grade seven |
|-------------------------------------------|-----------------|-------------|--------|--------|
|                                           | Group           | N     | Mean  | SD    | Sig (2-tailed) | Mean difference |
| Pretest Domain B                          | gr7, exp.       | 30    | 10.375| 3.2250| 0.885          | - 0.1250       |
|                                           | gr7, cont.      | 30    | 10.500| 3.2088|               |                |
| Posttest Domain B                         | gr7, exp.       | 30    | 15.504| 2.8728| 0.108          | 1.3866         |
|                                           | gr7, cont.      | 30    | 14.118| 3.4436|               |                |
| Critical Thinking (Pretest)               | gr7, exp.       | 30    | 8.929 | 4.7405| 0.962          | -0.0595        |
|                                           | gr7, cont.      | 30    | 8.988 | 4.6335|               |                |
| Critical Thinking (Posttest)              | gr7, exp.       | 30    | 16.582| 3.9905| 0.074          | 2.2959         |
|                                           | gr7, cont.      | 30    | 14.286| 5.3169|               |                |

On the other hand, a two-tailed t-test at the level 0.05 of significance shows no significant difference between cooperative learning and individualistic learning in grade ten on domain B of pretest (t-value of 0.399 > 0.05). However, there is a significant
difference on domain B of post-test (t-value of 0.042 < 0.05). (Table 15)

In addition, no significant difference is shown between cooperative learning and individualistic learning on critical thinking items of pre (t-value of 0.409 > 0.05). However, there is a significant difference on critical thinking items of post-test (t-value of 0.03 < 0.05). (Table 15)

Table 15
T-test for pretest and posttest domain B and critical thinking items of grade ten

<table>
<thead>
<tr>
<th></th>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>Sig (2-tailed)</th>
<th>Mean difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domain B (Pretest)</td>
<td>gr10, exp.</td>
<td>30</td>
<td>9.671</td>
<td>4.4861</td>
<td>0.399</td>
<td>0.9857</td>
</tr>
<tr>
<td></td>
<td>gr10, cont.</td>
<td>30</td>
<td>8.686</td>
<td>4.1851</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Domain B (Posttest)</td>
<td>gr10, exp.</td>
<td>30</td>
<td>13.929</td>
<td>3.8909</td>
<td>0.042</td>
<td>2.7760</td>
</tr>
<tr>
<td></td>
<td>gr10, cont.</td>
<td>30</td>
<td>11.153</td>
<td>5.8610</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Critical Thinking (Pretest)</td>
<td>gr10, exp.</td>
<td>30</td>
<td>9.367</td>
<td>4.9630</td>
<td>0.409</td>
<td>1.0000</td>
</tr>
<tr>
<td></td>
<td>gr10, cont.</td>
<td>30</td>
<td>8.367</td>
<td>3.9688</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Critical Thinking (Posttest)</td>
<td>gr10, exp.</td>
<td>30</td>
<td>14.698</td>
<td>4.2872</td>
<td>0.030</td>
<td>3.2418</td>
</tr>
<tr>
<td></td>
<td>gr10, cont.</td>
<td>30</td>
<td>11.456</td>
<td>6.3271</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Therefore, hypothesis 1 “Cooperative learning has a better effect on students’ achievement in biology (domain B in the Lebanese taxonomy of evaluation) namely critical thinking items than individualistic learning” is validated for grade ten students but not validated for grade seven students.
However, hypothesis 3 “There is no significant difference in the effect of cooperative learning on critical thinking on students of different grades (grade seven and grade ten)” is not validated.

**Students’ Self-assessment and Critical Thinking**

The averages of the items of student-self assessment (1) and (2) in both grades show that student self-assessment (2) mean scores are greater than student self-assessment (1) mean scores. Also, the means of grades seven and ten are the same in student self-assessment (1) and (2). (Figure 5)

The correlation gives a measure of the linear association between two variables.

Table 16 shows a significance of 0.01, so there is relation between self-assessment (2) and critical thinking in grade seven.
Table 16

Correlations between students-self evaluation 2 and critical thinking items of posttest of grade 7 experimental group

<table>
<thead>
<tr>
<th></th>
<th>Correlations of Grade 7</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Student Self-assessment (2)</td>
<td>Critical Thinking (Posttest)</td>
</tr>
<tr>
<td>Student Self-assessment (2)</td>
<td>Pearson Correlation 1 .614**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed) .001</td>
<td></td>
</tr>
<tr>
<td></td>
<td>N 30 30</td>
<td></td>
</tr>
<tr>
<td>Critical Thinking (Posttest)</td>
<td>Pearson Correlation .614**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed) .001</td>
<td></td>
</tr>
<tr>
<td></td>
<td>N 30 60</td>
<td></td>
</tr>
</tbody>
</table>

**Correlation is significant at the 0.01 level (2-tailed).**

Table 17 shows a t-value of 0.019< 0.05, so there is relation between self-assessment (2) and critical thinking in grade 10.

Table 17

Correlations between students-self assessment2 and critical thinking items of posttest of grade 10 experimental group

<table>
<thead>
<tr>
<th></th>
<th>Correlations of Grade 10</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Student Self-assessment (2)</td>
<td>Critical Thinking (Posttest)</td>
</tr>
<tr>
<td>Student Self-assessment (2)</td>
<td>Pearson Correlation 1 .439*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed) .019</td>
<td></td>
</tr>
<tr>
<td></td>
<td>N 30 30</td>
<td></td>
</tr>
<tr>
<td>Critical Thinking (Posttest)</td>
<td>Pearson Correlation .439*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed) .019</td>
<td></td>
</tr>
<tr>
<td></td>
<td>N 30 60</td>
<td></td>
</tr>
</tbody>
</table>

**Correlation is significant at the 0.05 level (2-tailed).**

Figure 6 represents a scatter diagram which shows the correlation between student self- assessment (2) and critical thinking.
posttest. The x-coordinate corresponds to the student self-assessment (2) and the y-coordinate to the critical thinking (posttest). This corresponds to a positive association. In this example, the student self-assessment (2) is considered as an independent variable and critical thinking (posttest) as a dependent variable. We observe that the points are close to the line. This corresponds to a positive association. Then there is correlation between student self-assessment (2) and critical thinking.

A Scatter Diagram showing the correlation between self-assessment (2) and critical thinking of posttest.

Therefore according to the results shown in tables 16 & 17, and figure 6, hypothesis 2 “There is significant correlation between student self-assessment practiced during cooperative learning and the
development of critical thinking skills” is validated for both grades seven and ten.

Also hypothesis 4 “There a significant improvement in student self-assessment during the study in both students of different grades (grade seven and grade ten)” is validated (Tables 16 & 17, and figure 6).

**Team’s Self-assessment and Teachers’ Assessment**

Table 18 shows the average of team’s self-assessment and teachers’ assessment of all the teams of both grades seven and ten experimental groups. The results show high values of self-assessment among the teams. Hopefully, the teachers’ assessment is close in values to those of the teams. The average of team’s self-assessment and teachers’ assessment in grade seven is 18.2 and 17 respectively. While the average of team’s self-assessment and teachers’ assessment in grade ten is 18.8 and 18.2 respectively.

**Table 18**

*Average of Team’s self-assessment and teachers’ assessment of all teams in both grades seven and ten*

<table>
<thead>
<tr>
<th>Grade</th>
<th>Team’s Number</th>
<th>Average of Team’s self Assessment</th>
<th>Average of Teachers’ Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Team 1</td>
<td>20.0</td>
<td>16.0</td>
</tr>
<tr>
<td></td>
<td>Team 2</td>
<td>20.0</td>
<td>19.6</td>
</tr>
<tr>
<td></td>
<td>Team 3</td>
<td>15.1</td>
<td>15.1</td>
</tr>
<tr>
<td></td>
<td>Team 4</td>
<td>18.7</td>
<td>17.8</td>
</tr>
<tr>
<td></td>
<td>Team 5</td>
<td>17.3</td>
<td>16.9</td>
</tr>
<tr>
<td></td>
<td>Team 6</td>
<td>18.2</td>
<td>16.4</td>
</tr>
<tr>
<td></td>
<td>Total average</td>
<td>18.2</td>
<td>17.0</td>
</tr>
<tr>
<td>10</td>
<td>Team 1</td>
<td>18.2</td>
<td>17.8</td>
</tr>
<tr>
<td></td>
<td>Team 2</td>
<td>19.6</td>
<td>18.2</td>
</tr>
<tr>
<td></td>
<td>Team 3</td>
<td>18.2</td>
<td>17.3</td>
</tr>
<tr>
<td></td>
<td>Team 4</td>
<td>17.3</td>
<td>17.3</td>
</tr>
<tr>
<td></td>
<td>Team 5</td>
<td>19.6</td>
<td>19.1</td>
</tr>
<tr>
<td></td>
<td>Team 6</td>
<td>20.0</td>
<td>19.6</td>
</tr>
<tr>
<td></td>
<td>Total average</td>
<td>18.8</td>
<td>18.2</td>
</tr>
</tbody>
</table>
Figure 7 represents a histogram showing the team’s self-assessment and teachers’ assessment of each team in the experimental groups of each of grades seven and ten classes.

![Figure 7](image)

*Figure 7. A histogram showing the average of team’s self-assessment and teacher’s assessment of teams in both grades.*

Figure 8 represents a histogram showing the average of team’s self-assessment and teachers’ assessment of grades seven and ten.

![Figure 8](image)

*Figure 8. The average of team’s self-assessment and teacher’s assessment of grades seven and ten.*
CHAPTER V

DISCUSSION

The purpose of this study is to investigate the effect of cooperative learning and self-assessment on enhancing critical thinking in biology and the effect of self-assessment on promoting critical thinking skills. Studies in Lebanon on the effect of cooperative learning on enhancing critical thinking are scarce. In this study, the teachers were trained on cooperative work for two weeks before the study. Then the students in the experimental groups were trained for two weeks on practicing cooperative learning in the classroom, and then the study was implemented for seven weeks.

The Application of Cooperative Learning in this Study

This study adopted the Johnson and Johnson model which stipulates five components (positive interdependence, individual accountability, interpersonal skills, face-to-face interaction, and group processing), all of which were addressed in this study. As is clear from the lesson plans, the teachers made sure to reinforce each of the above mentioned aspects. They motivated students to work cooperatively and help each other learn the material, work on the activity, and answer the questions. Each group was expected to present only one response that includes the answers of the questions which all of the group members agree upon (positive interdependence). In addition to that, the teachers made students responsible of helping all the group members to have the ability to
answer any question individually. That is, the answers on the paper that they already agreed on must be individually explained by each member of the group (individual accountability). Moreover, the teachers asked students to communicate, discuss different points of view, argue, take turns and make sure that all the group members participate in the work (interpersonal skills and face-to-face interactions). Finally, after students finished their group work and presented it to the other groups, the teachers provided each student with a self-assessment grid that assessed how well she helped her group. After that, the teachers provided each group with another grid to assess how well each group did and let members of the group discuss it. Then, the teachers did a class discussion about the performance of the each group and each individual, reinforcing positive behavior (group processing).

**Consistency between Team’s Self-assessment and Teacher’s Team Assessment**

The comparison between team’s self-assessment and teachers’ assessment of the teams shows close scores (table 18 and figures 7 & 8); this ensures that cooperative learning was working properly and reflects the honesty of students in assessing their work. Since the teachers were objective in their assessment, their values were less than those given by students; however, they didn’t vary a lot. In addition, it was good that students were comfortable in assessing themselves especially that these scores aren’t included in their marks. So these scores reflect the progress of their learning and critical thinking skills.
This assures reliability to student-self-assessment since the teachers weren’t able to assess each student in each session.

**Cooperative Learning and Critical Thinking**

Results show that there is non-significant correlation between cooperative learning and critical thinking for grade seven students (table 14); however, the correlation is significant for grade ten students (table 15).

For grade seven, both groups (control and experimental) started with very similar mean scores in the pre-test, and both groups improved significantly on the post-test (tables 10, 11, 12, & 13). As mentioned earlier in the results, the results show that cooperative learning has no effect on students’ domain B scores or critical thinking scores in the experimental group. Those results show that cooperative learning has neither a positive nor a negative effect on students’ critical thinking. The results of this study are parallel to the results of other studies carried out about the effect of cooperative learning on students’ academic achievement in science. Sherman (1989), Sadler (2002), and Burron, James, and Ambroisio (1993) applied different types of cooperative learning models on middle school students and came up with the same results: cooperative learning had no effect on students’ academic achievement in science, but had an effect on other aspects like confidence and attitudes.

In addition, Chang and Lederman (2006) came up with similar findings when they applied cooperative learning to investigate students’ physical science achievement. Six grade seven classes were
grouped into two groups: two classes (control group) were taught using the traditional approach, and the other four classes (experimental group) were taught using the cooperative learning approach. The researchers found out that cooperative learning had no significant differences on students’ achievement. Several other researchers reached the same finding in their studies (Chang and Lederman, 1994; Seymour, 1994; Tingle & Good, 1990).

The lack of significant differences between the control and the experimental groups in grade seven in this study may be due to the fact that the grade seven students were trained on using cooperative learning for a relatively short period of time and thus might not have mastered the skills for using these strategies efficiently since it was the first time they practice team work rather than group work. Although Lebanese students are used to group work, they are not used to the more structured cooperative learning groups.

However, students of grade ten were more trained and expert in cooperative learning (team work) than grade seven. Probably time limitation of the study has also affected the result. More research is needed to investigate this finding. If this study was extended, significant differences might have been observed.

Moreover, the critical thinking items measured in the tests are based on action verbs that are new for students of grade seven since it is the first year in which students learn biology as a separate material, and in this grade they are introduced to action verbs such as analyze, formulate a hypothesis, etc.
It is important to note that students of grade seven are low achievers in the pretest; however they have improved in the posttest (tables 10 &11).

As for grade ten (table 15), the findings are in parallel with the literature review, namely the reported studies that confirm a significant correlation between cooperative learning and critical thinking.

Totten, Sills, Digby, & Russ, 1991) concluded that the shared learning gives students an opportunity to engage in discussion, take responsibility for their own learning, and thus become critical thinkers. In addition, Bilgin, I.et.al.(2006), and Chang, C-Y., & Mao, S-L. (1999) in their contributions noted that cooperative learning activity engages the student in the learning process and seeks to improve the critical thinking, reasoning, and problem-solving skills of the learner.

Based on the results of several research studies, cooperative learning is shown to result in higher achievement more than individual learning (Johnson & Johnson, 1984; Joyce, Showers, & Rolheiser-Bennett, 1987). Since cooperative learning encourages student involvement and engagement in their own learning, it provides all students with opportunities to make their thoughts visible to others, allows them to talk about their own ideas, and permits them to consider the ideas of others, which enhances their higher order thinking skills (Chi, De Leeuw, Chiu, Lavancher, 1994; Chin & Brown, 2000; Jones & Carter, 1998; Wood, 1992). It is worth noting
that higher achievement promoted by cooperative learning holds true for all ability levels, all age levels, all subject areas at all grade levels (2-12), and in urban, rural, and suburban schools (Johnson & Johnson, 1984; Slavin, 1995).

Most of the research carried out on cooperative learning show that it had a positive influence on students’ science academic achievement (Al-Sadaawi, 2008; Anderson, Mitchell & Osgood, 2006; Bianchini, 1998; Brush, 1998; Carter and Jones, 1994; Chang & Mao, 1999b; Chen, 1999; Correa, 1995; Gerus, 2002; Humphreys, Johnson & Johnson, 1982; Johnson, 1990; Johnson, Brooker, Stutzman, Hultman, & Johnson, 2006; Johnson, Johnson, Scott & Ramolae, 2006; Johnson, Johnson & Taylor, 1993; Jones and Carter, 2006; Kahl and Woloshyn, 2006; Lazarowitz, Hertz-Lazarowitz & Baird, 1994; Lewis & Lewis, 2008; Lonning, 1993; Okebukola & Ogunniyi, 1984; Shachar & Fischer, 2004; Tien, Roth & Kampmeier, 2002; Watson, 1991; Yamarik, 2007).

In addition, Garside C. (1996) concluded that group discussion produced significantly more learning with regard to high-level items. Besides, Vijayaratnam P. (2009) concludes that it cannot be denied that both critical and creative thinking are interrelated and complementary aspects of thinking. Therefore, in order to develop effective thinking skills, one must pay attention to the development of both aspects of thinking.
Self-assessment and Critical Thinking

The comparison between students’ self-assessment (1) and (2) (figure 5) show that students have improved in self-assessment during the study since self-assessment (1) was made at the beginning of the study whereas student self-assessment (2) was made at the end of the study where students have practiced the skills of cooperative learning and critical thinking. These results assure the role of self-assessment and are in parallel with studies in literature, namely Halpern (1998) who assumes that both reflection and self-assessment prompt a cognitive orientation, and Jayapraba (2014) who concluded that the metacognitive instructions were most effective in enhancing academic achievement.

Moreover, results show significant correlation between student self-assessment (2) and posttest critical thinking items (tables 16 & 17 and figure 6). Then when student self-assessment increase, this indicates that metacognition is increasing, and thus critical thinking is enhanced.

These findings are in parallel with the literature review, namely the reported studies that confirm a significant correlation between self-assessment and critical thinking. For instance, Magno, Carlo (2010) concluded that metacognition has a significant path to critical thinking. Austin et al, (2008) also concluded that structured opportunities to reflect-in-action and self-assess may be associated with improvements among pharmacy students in performance of tasks.
related to critical thinking. Moreover, metacognition plays a critical role in successful learning; it is important to study metacognitive activity and development to determine how students can be taught to better apply their cognitive resources through metacognitive control (Livingston, Jennifer A., 1997).
CHAPTER VI

CONCLUSION

As a summary of this study, hypothesis 1 “Cooperative learning has a better effect on students’ achievement in biology (Domain B in the Lebanese taxonomy of evaluation) namely critical thinking items than individualistic learning” is validated for grade ten students but not validated for grade seven students. Also hypothesis 2 “There is significant correlation between student self-assessment practiced during cooperative learning and the development of critical thinking skills” is validated for both grades seven and ten. However, hypothesis 3 “There is no significant difference in the effect of cooperative learning on critical thinking on students of different grades (grade seven and grade ten)” is not validated. Whereas hypothesis 4 “There is no significant difference in the effect of cooperative learning on self-assessment on students of different grades (grade seven and grade ten)” is validated.

In brief, educators have long seen critical thinking as a desirable educational outcome. More recently, the Partnership for 21st Century Skills has identified critical thinking as one of several skills necessary to prepare students for post-secondary education and the workforce. Although a concrete definition of critical thinking on which most researchers can agree remains elusive, common areas of overlap exist among the various approaches. Typically, critical thinking is believed to include the component skills of analyzing
arguments, making inferences by using inductive or deductive reasoning, judging or evaluating, and making decisions or solving problems. Background knowledge is believed to be a necessary, though not sufficient, condition for enabling critical thought within a given subject. Critical thinking entails cognitive skills, or abilities, and dispositions. These dispositions, which can be seen as attitudes, or habits of mind, include open- and fair-mindedness, inquisitiveness, flexibility, a propensity to seek reason, a desire to be well-informed, and a respect for and willingness to entertain diverse viewpoints.

Although learning progressions of critical thinking skills and dispositions do not yet (and may never) exist, at least one researcher has tied the progression of critical thinking skills to cognitive development in general and metacognition in particular. Empirical research in the area of metacognition suggests that people begin developing critical thinking competencies at a very young age and continue to improve them (or not) over the course of a lifetime. Many adults exhibit deficient reasoning and fail to think critically. However, in theory, all people—from all intellectual ability levels and from the very young to the very old—can be taught to think critically.

If teachers are to be successful in encouraging the development of critical thinking skills, explicit instruction in critical thinking needs to be included in the curriculum, whether that instruction occurs as a stand-alone course, is infused into subject-matter content, or both. Cooperative or collaborative learning methods hold promise as a way of stimulating cognitive development, along with constructivist approaches that place students at the center of the learning process.
“The more students know about effective learning strategies, the greater their metacognitive awareness and the higher their classroom achievement is likely to be” (Mango 2010). Besides, this students’ academic achievement can be increased if teaching strategies are planned in a metacognitive way. Students must be taught how to develop and be aware of the strategies. Teachers must improve their students’ metacognitive awareness in order to improve their learning abilities. At last, as long as critical thinking is a desired outcome of education, we will need to find ways to help students improve their abilities to think critically and their disposition to use these skills.

Limitations of the Study

This study had several limitations. First, there are many models of cooperative learning. Although this study is about cooperative learning in general, yet the researcher only used one model. Not all cooperative learning approaches might give the same results. Second, the students in this study were familiar with group work throughout their academic years; however, they were never introduced to cooperative learning except in this study. Third, since this study was done in one school and two classes of different grades and cycles and on girls only, then it might not be generalized to other schools and to other classes and cycles, since there is a speculation of how to apply the findings to other regions. In addition, the sample that was chosen was small. The fourth limitation was time, since the study was done in the second semester of the year, thus there wasn’t enough time to make student-self-assessment more than two times. At last, the
teachers weren’t able to assess all the teams in each session due to time limitation of the session.

**Recommendations for Future Research and Training**

The findings of the present study have implications for the improvement of present system of school education on both theoretical and practical context.

For future research, it is recommended that this same study to be carried for a longer period of time and on a larger sample, including many schools, many classes, and many teachers, and on both girls and boys. Moreover, teachers need to be introduced to a variety of cooperative learning methods that can be applied in the classroom and have the opportunity to implement these methods. Teachers also need to be aware of the difference between group work and cooperative learning; thus there is a need for extensive training for both teachers and students for cooperative learning and extending theses strategies across all subject areas.

Above all, there is a need for more research on how best to improve the quality of biology learning at the middle and secondary school level, and more specifically on how best to use cooperative learning in the Lebanese setting.

Also, further research is required to more fully elucidate the nature and magnitude of the associations between self-assessment and critical thinking skills.

Finally, teaching students how to think critically is a necessity for a better education and better citizens.
On the other hand, concerning training, there is a need for longer training periods for students and teachers on cooperative learning skills especially self-assessment. Teachers should remember that it takes students a considerable amount of time to learn how to use an effective strategy. Therefore, they should be patient and give students continued support during this learning experience. Also it is required to keep encouraging students to use the metacognitive activities over and over again until can use it automatically. Teachers should encourage students to monitor the effectiveness of their new strategies in comparison to the effectiveness of old strategies. These help students to see the utility of using the new strategy.

Moreover, it is recommended that the schools provide the teachers with all the physical amenities for cooperative learning activities. This includes rooms with furniture arrangements enabling students to sit down and start work in cooperative learning situations without having to move their desks and enabling the teacher to observe them easily.

**Recommendation for Policy Makers**

The results of the present study can significantly influence the field of science education.

First, a major purpose of science education should be to develop instructional practices for developing scientific reasoning skills, critical thinking and decision-making capacity. Since metacognition is an inherent component in developing cognitive
skills, students and teachers must be taught how to apply cooperative learning in the classrooms and how develop metacognition by using metacognitive skill enrichment activities.

Second, it is recommended that the Ministry of Education and Higher Education (MEHE) in Lebanon give teachers the opportunity to participate in workshops regarding cultivating cooperative learning skills, critical thinking skills, and metacognition in their classes depending on the class level.

Third, the MEHE should help teachers by providing guidelines for planning and ready-made activities that are ready to be implemented in class. There may be association between different teachers from different schools to have benefit of their work and experience.

At last, the science text books should be designed by raising meaningful and interesting questions and emphasizing applications and problem solving rather than been dominated by declarative knowledge (facts, definitions and descriptions) whereas procedural (knowing how, knowing why) and situational knowledge should be provided for deep study processes.
REFERENCES


48. Roland Case and LeRoi Daniels. Introduction to the TC2 Conception of Critical Thinking. The Critical Thinking Consortium. Professional Readings from tc2

49. Rothsten, Ran and Santana, Luz. Make Just One Chance: Teach Students to Ask their own Questions. Foreword by Wendy D. Puriefoy.


APPENDIX
The following table includes the science skills which should be attained by students throughout the teaching-learning process who will be evaluated accordingly. In the context of a contractual agreement, teachers are required to communicate to their students the contents of this table at the beginning of the academic year.

<table>
<thead>
<tr>
<th>Objectives</th>
<th>Skills</th>
</tr>
</thead>
</table>
| A- Acquiring knowledge | A1- Recall knowledge  
  - Recall the acquired knowledge related to specific facts, terminology, principles, laws, theories, models…  
A2- Apply knowledge  
  1- Select the knowledge and use it in a new situation.  
  2- Apply knowledge in a new context. |
| B- Practicing scientific processes | B1- Collect Information  
  - Select information related to a real situation or to its representation in a table, text, graph, media…  
B2- Interrelate information to define a problem and/or formulate a hypothesis.  
  - Organize data in order to prove a relation.  
  - Compare new data to previous data.  
  - Identify a cause and effect relation.  
  - Define a problem.  
  - Formulate a hypothesis.  
B3- Test a hypothesis  
  - Identify the consequences implied by a hypothesis that could be verified.  
  - Design an experiment.  
  - Use data to test a hypothesis  
B4- Synthesize  
B5- Demonstrate critical thinking  
  - Criticize experimental results, an argument, design an experiment… |
| C- Mastering of techniques | C1- Use laboratory or field materials and apply laboratory techniques.  
C2- Perform an experiment following a given design.  
C3- Carry out measurements, construct a model or make drawing based on observation… |
| D- Communicating | D1- Utilize proper scientific terminology.  
  - Use appropriate scientific terminology to express information, observation, tabulated data, drawing, graph, or a flow chart, in verbal or written form.  
D2- Use various modes of scientific representation.  
  - Represent data by a table, a graph, a drawing, a chart, a symbol, or a formula. |
First exercise (5 pts)

Answer briefly the following questions:

1- Specify how are the respiratory movement identified in grasshopper, fish and Man.
   a- Grasshopper: ........................................................................................................
   b- Fish: ......................................................................................................................
   c- Man: .....................................................................................................................

2- Define the respiratory frequency.
   ......................................................................................................................................

3- Indicate the constituents of the elaborated sap?
   ......................................................................................................................................

4- Specify how we can identify carbon dioxide gas.
   ......................................................................................................................................

5- When the diaphragm in Man is lowered:
   a- Does that mean that it is contracted or relaxed? ......................................................
   b- What is the direction followed by air in this case? ....................................................

6- The following document shows the composition of inhaled air in Man:

<table>
<thead>
<tr>
<th>Name of the Gas</th>
<th>Amount in inhaled air (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen gas</td>
<td>79</td>
</tr>
<tr>
<td>Oxygen gas</td>
<td>21</td>
</tr>
<tr>
<td>Carbon dioxide gas</td>
<td>0.03</td>
</tr>
</tbody>
</table>

**Document 1**

Referring to document 1, and to the acquired knowledge, indicate the true statement(s) and correct the false one(s).

In the exhaled air the amount of:
   a- \( N_2 \) is less than 79 % .....................................................................................
   b- \( O_2 \) is less than 21 % ......................................................................................
   c- \( CO_2 \) is less than 0.03 % ..................................................................................
A- The adjacent figure shows the different structures present in a green leaf:

![Leaf diagram]

Document 2

1- What is the structure responsible for photosynthesis in this figure? Justify the answer.

………………………………………………………………………………………………………..
………………………………………………………………………………………………………..

2- Referring to your acquired knowledge, indicate the role of conducting vessels.

………………………………………………………………………………………………………..
………………………………………………………………………………………………………..

B- The role of stomata is unknown for a G7 student. So he proposed the following hypothesis: “stomata are the openings responsible for the entrance of carbon dioxide.” In order to test this hypothesis the following document represents the experiment performed.

![Stomata diagram]

Legend: Carbon dioxide=☆

The results: photosynthesis takes place in leaf A and doesn’t in leaf B.

Document 3

3- Pose the problem of the above experiment.

………………………………………………………………………………………………………..

4- Indicate:

a - One controlled variable: .................................................................

b- The manipulated variable: .................................................................

c- The affected (responding) variable: .............................................................

5- Referring to the results, indicate the leaf (A or B) that is able to absorb carbon dioxide from the external environment. Justify the answer.
6- Derive a conclusion concerning the role of the stomata.

Third Exercise (9 pts)  Photosynthesis and Light

A- According to the acquired knowledge:
1- Define organic matter.
2- Indicate the products of photosynthesis.
3- Give the name of the structure in the plant responsible for the absorption of water.
4- List the raw materials needed by the plant to make photosynthesis.

B- Referring to document 4 and knowledge:
The process of photosynthesis in plants needs energy in the form of light. Sun light, which appears white, is in fact made of the colors of the rainbow including red, orange, yellow, green, blue, and violet. When light strikes a leaf, it is absorbed by the chlorophyll. Chlorophyll absorbs 85% of the blue light and 55% of red light. On the other hand, green light is reflected (turned back) rather than being absorbed by chlorophyll. This explains why chlorophyll appears green in color.

Document 4

5- Explain why photosynthesis can’t take place at night.
6- Pick out the statement that explains the green color of chlorophyll.
7- If chlorophyll reflects (turns back) the red light and absorbs the green and blue lights, then predict what would be the color of chlorophyll?

Consider two green leaves A and B. One of them is exposed to a blue light while the other is exposed to a red light. After 3 days, both leaves are treated with hot alcohol, and then dipped in iodine water. The following results are obtained.

-Leaf A shows light blue color.  -Leaf B shows dark blue color
8- What does the blue color (obtained after treating a leaf with hot alcohol then with iodine water) indicate?

9- Compare the intensity of the blue color in leaves A and B. What does this indicate?

10- Deduce whether leaf A is exposed to blue or red light. Justify the answer.

C- The following graph shows the variations of $O_2$ gas (in arbitrary unit) produced during photosynthesis in algae (green plants) as function of the light intensity (in lux).

![Graph](image)

Document 5

1- Analyze the results of document 5.

2- "Light is important for photosynthesis". This statement is not accurate (not completely true), change it to be accurate based on the analysis of the above graph.

Wishing You All the Best
APPENDIX III
POSTTEST OF GRADE 7

<table>
<thead>
<tr>
<th>Science Department</th>
<th>Final Exam</th>
<th>Duration: 60 min</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>In Life &amp; Earth Sciences</td>
<td>Date: / /</td>
</tr>
<tr>
<td>Name: .........................</td>
<td>Grade 7; section (...)</td>
<td>Score: /20</td>
</tr>
</tbody>
</table>

First Exercise (3.75 pts)

**Indicate the true statements and correct the false ones:**

1- Food plays an essential role in the production of energy.

2- Germinating seeds absorb carbon dioxide and release oxygen gas.

3- The blood leaving the lungs is rich with carbon dioxide and poor in oxygen gas.

4- The earthworm leaves in aerial medium and has tracheal respiration.

5- During a physical activity, the need of the body in oxygen increases.

Second Exercise (9.5 pts)  
Respiration in Salamander

A-

The salamander is a terrestrial animal that looks like a lizard. There is a variety of salamander that differs from each other by the medium of life and the type of respiration when adult.

All salamanders start their life by being a larva before becoming adult. At the first period of life, the larva of salamander has an aquatic life where it respires using highly vascularized gills. These gills disappear when the salamander becomes adult to be totally replaced by other organs.

**Document 1**

1- Refering to document 1, identify the type of respiration in the larva of salamander.

2- Pick up from the text the characteristic of gills that facilitates the exchange of respiratory gases.
B- To determine the medium of life of a given salamander, we perform the following experiment where an oxymeter measures with time, the quantity of oxygen gas in water in the presence of salamander (B). In (A) where there is no salamander the quantity of oxygen gas remains constant.

Document 2

The following table shows the variation of the quantity of oxygen gas in the container containing the salamander:

<table>
<thead>
<tr>
<th>Time (min)</th>
<th>0</th>
<th>5</th>
<th>10</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantity of Oxygen Gas in the Presence of Salamander (mL)</td>
<td>9</td>
<td>8.4</td>
<td>7.9</td>
<td>7.4</td>
</tr>
</tbody>
</table>

1- Indicate:
   a- The manipulated variable: .................................................................
   b- The affected variable: ...........................................................................

2- Formulate the hypothesis tested in this experiment.
..........................................................................................................................

3- Give the name of setup (A) then indicate its role.
..........................................................................................................................

4-a- Analyze the results presented in the above table.
..........................................................................................................................

   b- Draw out a conclusion
..........................................................................................................................

C- To identify the gas released by the salamander, we use the cresol red that becomes yellow in the presence of carbon dioxide. The obtained results in container (B) are shown in the following table:
1- a- Compare the color of the cresol red at the beginning of the experiment to that after 15 minutes.
……………………………………………………………………………………………………………………
……………………………………………………………………………………………………………………
b- Draw out a conclusion.
……………………………………………………………………………………………………………………
……………………………………………………………………………………………………………………
2- The salamander can survive in an aquatic medium. Justify why referring to parts B and C.
……………………………………………………………………………………………………………………
3- We cover the skin of this salamander by modeling clay then we replace it in water. After few minutes the salamander dies.

Indicate the organ of respiration that this salamander uses in water……………………………………

Third Exercise (6.75 pts) Food and Health

A- To have a good health, it is necessary follow a balanced food diet that contains convenient quantities of proteins, lipids, carbohydrates, minerals, and vitamins. Any lack of one of these food constituents leads to serious diseases such as Rickets which results from the lack of vitamin D, Kwashiorkor that results from the lack of proteins, Infarctions that result from eating high amounts of lipid, and obesity (increase of body mass) that results from eating high quantities of sugar and lipids.

1- Fill in the following table using the information in the above text.

<table>
<thead>
<tr>
<th>Diseases</th>
<th>Causes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rickets</td>
<td></td>
</tr>
<tr>
<td>Kwashiorkor</td>
<td></td>
</tr>
<tr>
<td>Infarction</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Color of Cresol Red in Container (B) where the Salamander is.</th>
<th>At the Beginning of the Experiment</th>
<th>After 15 Minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Red</td>
<td>Yellow</td>
</tr>
</tbody>
</table>
B- The following histograms show the percentages of the constituents of two food diets 1 and 2 and that of the balanced one.

\[\begin{array}{|c|c|c|c|c|}
\hline
& Starch & Lipids & Proteins & Sugar \\
\hline
Food Diet 1 & & & & \\
\hline
Food Diet 2 & & & & \\
\hline
Balanced Food & & & & \\
\hline
\end{array}\]

2- a- Compare the percentages of proteins in the food diet 1 to that in the balanced one.
…………………………………………………………………………………………………………………………
…………………………………………………………………………………………………………………………

b- Compare the percentages of proteins in the food diets 2 to that in the balanced one.
…………………………………………………………………………………………………………………………
…………………………………………………………………………………………………………………………

c- Deduce (with justification) which food diet (1 or 2) leads to Kwashiorkor.
…………………………………………………………………………………………………………………………
…………………………………………………………………………………………………………………………

3 – The food diet 2 is responsible for Infarction. Justify why
…………………………………………………………………………………………………………………………
…………………………………………………………………………………………………………………………

4- In order to avoid obesity, the fat person must make a lot of physical exercises, during which cellular respiration occurs at high rate.

a - Complete the equation of the chemical reaction of cellular respiration:
Energetic food + ………………. → ………………. + ………………. + …………….

b – List the uses of the energy produced during the cellular respiration.
…………………………………………………………………………………………………………………………
…………………………………………………………………………………………………………………………

Wishing You All the Best
First Exercise

Nerve and Nerve Fiber

A- The following documents show the recording of the amplitudes of the responses to a nerve and a nerve fiber after stimulation with increasing intensities.

![Diagram of nerve and nerve fiber responses](image)

**Document 1**

1- Indicate the document that corresponds to the response of a nerve and the one that corresponds to a nerve fiber. Justify your answer.

……………………………………………………………………………………………………………
……………………………………………………………………………………………………………
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2- Indicate the law which is applied in each case.

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3- a- Explain the reason for the presence of a plateau in the curve of document 1.

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……………………………………………………………………………………………………………
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b- What does the intensity 10 a.u in document 1 represent?

……………………………………………………………………………………………………………
……………………………………………………………………………………………………………
……………………………………………………………………………………………………………
……………………………………………………………………………………………………………
……………………………………………………………………………………………………………
……………………………………………………………………………………………………………
B- The following table presents the variation of the speed of propagation of the nervous message as a function of the diameter and the nature of the nerve fiber.

<table>
<thead>
<tr>
<th>Diameter of the Nerve Fiber (µ m)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed of Propagation of the Nervous Message</td>
<td>Myelinated Nerve Fiber</td>
<td>1</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Non Myelinated Nerve fiber</td>
<td>0.1</td>
<td>0.5</td>
<td>1</td>
</tr>
</tbody>
</table>

1- Transform the above table into a graph.

2- Analyze the above table.

3- Derive the 2 conclusions concerning the above table.

4- Explain how the myelin sheath affects the speed of propagation of the nervous message.

5- Specify another factor that affects the propagation of the nervous message.
Second Exercise

Types of Nerve Fibers

We perform an experiment on two types of nerve fibres of an individual. Fiber 1 issued from a skin thermoreceptor and involved in thermal sensation. Fiber 2 issued from a nociceptor and involved in the painful sensation.

The individual puts his hand in front of a lit lamp. The adjacent document is a schematic representation of the experimental set up. We increase progressively the power (intensity) of the lamp, leading to an increase in its heating temperature. We record the nervous messages propagating at the level of these two fibres using fine receptor electrodes.

The experimental results are shown in document 2.

<table>
<thead>
<tr>
<th>Temperature of the lamp</th>
<th>Recording messages at the level of fiber 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>30°C</td>
<td></td>
</tr>
<tr>
<td>35°C</td>
<td></td>
</tr>
<tr>
<td>40°C</td>
<td></td>
</tr>
<tr>
<td>45°C</td>
<td></td>
</tr>
<tr>
<td>50°C</td>
<td></td>
</tr>
<tr>
<td>55°C</td>
<td></td>
</tr>
</tbody>
</table>

Document 2
N.B. Each vertical line corresponds to an action potential

1- a. Analyze document 2 (considering only the results of fiber 1 upon the increase in temperature).

b. What can be deduced?

2- Compare the temperature at which the first AP(s) appear (s) in each of fiber 1 and 2. Draw out a conclusion.

3- Indicate for each receptor the probable threshold intensity. Justify your answer.
Third Exercise

Salivation

The medulla oblongata is the nerve center that controls the secretion of saliva by salivary glands (salivation). 2 nerves: the tympanic and the lingual connect this center to the salivary glands and tongue respectively. For the aim of studying the mechanism of salivary secretion, we performed on four dogs the following experiments:

For the first dog: pouring vinegar on the tongue leads to salivary secretion.

For the second dog: the excitation of the peripheral end of the lingual nerve sectioned at (A) does not cause secretion. The excitation of the central end leads to secretion of saliva.

For the third dog: the excitation of the central end of the tympanic nerve sectioned at (B) does not cause secretion. The excitation of the peripheral end leads to salivary secretion.

For the fourth dog: the electric excitation of a specific region in the medulla oblongata provokes the secretion of saliva.

1- Salivation is an involuntary action. Justify why.

2- a. Analyze experiments 2 and 3.
   b. Deduce the role of the lingual nerve and that of the tympanic nerve.

3- Trace, using arrows, the pathway of nervous message in this involuntary action.

4- a- Give the scientific name of the connection between the tympanic nerve and the salivary gland. Justify.
   b- What is the nature of the nervous message at this level? Explain why?
First Exercise  
Neuro-neuronic Synapses

The following document shows two neuro-neuronic synapses, one is excitatory and the other is inhibitory.

![Diagram of two neuro-neuronic synapses](image)

Document 1

Refering to document 1 and to your knowledge:

1- Specify the nature of each of the two synapses A and B. justify your answer.

……………………………………………………………………………………………………………
……………………………………………………………………………………………………………
……………………………………………………………………………………………………………
……………………………………………………………………………………………………………

2- Explain how the transmission of the nervous message is done at the level of a synapse in A.

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3- Specify the fate of the neurotransmitters after this transmission.

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……………………………………………………………………………………………………………
……………………………………………………………………………………………………………
……………………………………………………………………………………………………………
Second Exercise

Green Algae

The following documents show a microscopic observation of spirogyra (green algae) with aerobic bacteria which need oxygen. A is not illuminated (exposed to light) and B is illuminated only in zone X.

Document 2

1- a. Analyze the above results.
   b. What can you deduce?

   ...........................................................................................................................
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   c. What would happen if we replace the green algae by mushroom filament? Justify.

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Third Exercise  

Transpiration in Green Leaves

The stomata are located in the green leaves and they are made of 2 cells that open and close to exchange gases.

1- Define transpiration.

The following document represents the number of the stomata and the transpiration in two different plants.

<table>
<thead>
<tr>
<th>Plant</th>
<th>Layers of the leaf</th>
<th>Number of stomata per mm$^2$</th>
<th>Transpiration (mg.dm$^{-2}$.h$^{-1}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dahlia</td>
<td>Upper</td>
<td>22</td>
<td>500</td>
</tr>
<tr>
<td></td>
<td>Lower</td>
<td>30</td>
<td>600</td>
</tr>
<tr>
<td>Line</td>
<td>Upper</td>
<td>0</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td>Lower</td>
<td>60</td>
<td>490</td>
</tr>
</tbody>
</table>

Document 3

Referring to document 3:

1- Compare the number of stomata and the transpiration in the upper layer and lower layer of the leaf in the two plants.

2- Draw out 2 conclusions concerning the above table.

Fourth Exercise  

Hormonal Communication

1- Based on your acquired knowledge, define:

   a- Glycemia

   b- Glycogen
After the ablation of the pancreas of a fasting dog we measure glycemia, glucosurie (glucose in urine) and hepatic glycogen (glycogen in the liver). The results are shown in the adjacent graph.

**Document 4**

2- Analyze the 2 curves a and c in document 4.

3- Explain the reason that stands for the variation in the glycemia and in the hepatic glycogen in the above graph.

4- Formulate a hypothesis explaining the variation of glycosurie (curve b).
APPENDIX VI

STUDENT SELF-ASSESSMENT GRID

Name: ........................................... Date...........................................

Grade........ / Section: ......

The Title of the activity: ..............................................................................................................

- The objective of this grid is to self-assess the student’s learning skills during team work.

Using "5" as the highest point and "1" as the lowest, decide to what degree you were successful in each of the following areas. Circle one number.

<table>
<thead>
<tr>
<th>Student’s Self-assessment of Learning Skills</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-I accomplished my tasks.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-I shared ideas and opinions.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3-I organized my thoughts before and while speaking.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4-I used appropriate terms when stating ideas.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5-I asked for facts and reasoning.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6-I offered to explain and clarify statements.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7-I clarified statements using examples.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8-I can summarize what have been said without referring to notes.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9-I can relate the material to previous information or experience.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX VII
TEAM'S SELF-ASSESSMENT GRID

Grade........ / Section: .....  Date........................................

The Title of the activity: ..........................................................................................................

- The objective of this grid is to self-assess our team’s work.

A. Using "5" as the highest point and "1" as the lowest, decide to what degree your team was successful in each of the following areas. Circle one number.

<table>
<thead>
<tr>
<th>Team Work Assessment</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1- All of the team’s members contributed ideas.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2- All of the team’s members listened carefully to the ideas of other team members.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3- All of the team’s members encouraged other members to contribute their thoughts and opinions.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4- Everyone in the team shared ideas/information.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5- Everyone in the team helped others.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6-Everyone in the team accepted help.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7-Everyone in the team responded kindly to disagreements.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8- Everyone in the team understood the activity.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9- We finished the task on time.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Team Members’ Names

..........................................................................................................................
..........................................................................................................................
..........................................................................................................................
..........................................................................................................................
..........................................................................................................................
APPENDIX VIII

TEACHER’S TEAM-ASSESSMENT GRID

Grade........ / Section: ...... Date......................................................

The Title of the activity: .................................................................................................

- The objective of this grid is to assess the team’s work by the teacher during her observation.

**Team Members’ Names**

........................................................................................................................................

........................................................................................................................................

........................................................................................................................................

........................................................................................................................................

........................................................................................................................................

Team Work Assessment

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-</td>
<td>All of the team’s members contributed ideas.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-</td>
<td>All of the team’s members listened carefully to the ideas of other team members.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3-</td>
<td>All of the team’s members encouraged other members to contribute their thoughts and opinions.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4-</td>
<td>Everyone in the team shared ideas/information.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5-</td>
<td>Everyone in the team helped others.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6-</td>
<td>Everyone in the team accepted help.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7-</td>
<td>Everyone in the team responded kindly to disagreements.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8-</td>
<td>Everyone in the team understood the activity.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9-</td>
<td>The team finished the task on time.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX IX

LESSN PLAN FOR CONTROL GROUP OF GRADE SEVEN

Title: Chapter 3/Act 4: Respiration in Aerial Medium

Instructional Objectives:
At the end of this session, students should be able to:

1- Identify the type of respiration in human
2- Explain how gaseous exchange occurs with pulmonary respiration.
3- Deduce the role of blood in pulmonary respiration.

Materials: textbook, white board, colored pens, sheets,

Procedure:

➢ Start the session by asking students: Indicate the type of respiration in human. (Pulmonary respiration)
- Justify why it is called pulmonary? (Because the lungs are the organs of respiration)
- Name the gases involved in respiration. (Oxygen gas and carbon dioxide)

➢ Ask students: Refer to your textbook page 56 to answer the following questions individually:
  - Compare the quantity of oxygen in blood that enters the lungs and that that leaves the lungs.
  - Calculate the difference between the amount of oxygen in blood that enters the lungs and that that leaves the lungs.
  - Draw out a conclusion.
  - Discuss the answers.
  - Compare the quantity of carbon dioxide in blood that enters the lungs and that that leaves the lungs.
  - Calculate the difference between the amount of carbon dioxide in blood that enters the lungs and that that leaves the lungs.
  - Draw out a conclusion.
  - Discuss the answers.
  - Deduce the role of blood in pulmonary respiration.
  - Discuss the answers.

Evaluation:
- Write a short text describing the composition of blood entering the lungs and blood leaving the lungs.

Assignment:

Study the notes + homework probing the activity number 3 page 56.
APPENDIX X

LESSN PLAN FOR EXPERIMENTAL GROUP OF GRADE SEVEN

Title: Chapter 3/Act 4: Respiration in Aerial Medium

Instructional Objectives:
At the end of this session, students should be able to:

4- Identify the type of respiration in human
5- Explain how gaseous exchange occurs with pulmonary respiration.
6- Deduce the role of blood in pulmonary respiration.

Materials: textbook, white board, colored pens, answer sheets, student self-assessment grids, team self-assessment grids, teacher’s team assessment grids, and team cards

Procedure:

➢ Start the session by asking students: Indicate the type of respiration in human. (Pulmonary respiration)
- Justify why it is called pulmonary? (Because the lungs are the organs of respiration)

- Name the gases involved in respiration. (Oxygen gas and carbon dioxide)

➢ Ask students to arrange themselves in teams and each member is assigned her role according to the team cards.

➢ Discuss the following questions cooperatively (Each team submits one answer sheet)
Refer to your textbook page 56 to answer the following questions:

A- 1- Compare the quantity of oxygen in blood that enters the lungs and that that leaves the lungs.
2- Calculate the difference between the amount of oxygen in blood that enters the lungs and that that leaves the lungs.
3- Draw out a conclusion.

B- 1- Compare the quantity of carbon dioxide in blood that enters the lungs and that that leaves the lungs.
2- Calculate the difference between the amount of carbon dioxide in blood that enters the lungs and that that leaves the lungs.
3- Draw out a conclusion.

➢ The speaker of each team presents their answer.
➢ Discuss the answers of all the teams.

Evaluation:

Individual’s Accountability:

Ask students to individually write a short text describing the composition of blood entering the lungs and blood leaving the lungs.

Distribute student’s self-assessment grid and team’s self-assessment grid.

Assignment:

Study the notes + homework probing the activity number 3 page 56.
Title: Chapter 2/ Activity 4: The Stomata

Instructional Objectives:

At the end of this session, students should be able to:

1. Infer that stomata are the site of gaseous exchange in a leaf.
2. Compare the upper surface of a leaf to the lower surface.
3. Deduce the part of leaf where stomata are present more.

Materials: textbook, white board, colored pens, sheets.

Procedure:

- Start the session by asking students: Indicate the site of a chlorophylllic plant where photosynthesis takes place.
  - Have you watched a leaf at the morning? What do you observe on it?
  - Indicate the name of the openings in the leaf? (Stomata)
  - Specify the role of stomata. (Site of gaseous exchange)
- Ask students to individually observe document (a) page 40 to answer the following questions.
  - Pick up the role of cobalt chloride.
  - Pose a problem.
  - Formulate a hypothesis.
  - Analyze the results of the experiment.
  - Derive a conclusion.
- Discuss the answers with the whole class.

Evaluation:

- Define stomata.
- Indicate the role of stomata.
- Indicate the part of the leaf where there stomata are more present.

Assignment:

Study the notes + homework probing the activity number 2 page 41.
APPENDIX XII

LESSN PLAN FOR EXPERIMENTAL GROUP OF GRADE TEN

Title: Chapter 2/Act 4: The Stomata

Instructional Objectives:

At the end of this session, students should be able to:

1. Infer that stomata are the site of gaseous exchange in a leaf.
2. Compare the upper surface of a leaf to the lower surface.
3. Deduce the part of leaf where stomata are present more.

Materials: textbook, white board, colored pens, answer sheets, student self-assessment grids, team self-assessment grids, teacher’s team assessment grids, team cards.

Procedure:

- Start the session by asking students: Indicate the site of a chlorophyllic plant where photosynthesis takes place.
  - Have you watched a leaf at the morning? What do you observe on it?
  - Indicate the name of the openings in the leaf? (Stomata)
  - Specify the role of stomata. (Site of gaseous exchange)

- Ask students to arrange themselves in teams.

- Discuss the following questions cooperatively (Each team submits one answer sheet)
  - Observe document (a) page 40 to answer the following questions.
  - Pick up the role of cobalt chloride.
  - Pose a problem.
  - Formulate a hypothesis.
  - Analyze the results of the experiment.
  - Derive a conclusion.

- The speaker of each team presents their answer. Discuss the answers of all the teams.

Evaluation:

**Individual’s Accountability:**

Ask students to answer individually the following questions:

- Define stomata.
- Indicate the role of stomata.
- Indicate the part of the leaf where stomata are more present.

- Distribute student’s self-assessment grid and team’s self-assessment grid.

Assignment:

Study the notes + homework probing the activity number 2 page 41.
## APPENDIX XIII
### TEAM CARDS

<table>
<thead>
<tr>
<th>Team ..........</th>
<th>Session</th>
</tr>
</thead>
<tbody>
<tr>
<td>Team Members Names</td>
<td>1</td>
</tr>
<tr>
<td>Leader</td>
<td>Writer</td>
</tr>
<tr>
<td>Writer</td>
<td>Leader</td>
</tr>
<tr>
<td>Speaker</td>
<td>Worker</td>
</tr>
<tr>
<td>Worker</td>
<td>Timer</td>
</tr>
<tr>
<td>Timer</td>
<td>Speaker</td>
</tr>
</tbody>
</table>