Investigating Metacognitive Awareness and Self-Efficacy of High School Students through Prompted Reflections in Mathematics and Science

استقصاء الوعي بما وراء المعرفة و بالفعالية الشخصية لدى طلاب المدارس الثانوية من خلال
حث الأفكار في مادتي الرياضيات والعلوم

By

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A Dissertation Submitted to the Faculty of Education of the British University in Dubai for the Degree of Master of Education in Science Education

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April, 2014

DISSERTATION RELEASE FORM

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ABSTRACT

Metacognition has been identified as a crucial component of effective learning of mathematics and science education. It entails students recognizing their learning processes, styles, preferences and self-efficacy. The present study aims to determine the effects of metacognitive prompted reflection for enhancing students' metacognitive awareness and self-efficacy in Physics and Mathematics classes. A quantitative research approach by employing a pretest-posttest quasi-experimental design was adopted to fulfill the study purposes. The participants were 184 high school students in a K-12 private school in Dubai, the United Arab Emirates. The experimental group participated in metacognitive treatment by responding to prompted reflection questions for six weeks. Data were collected using the Self-Efficacy and Metacognition Learning Inventory (SEMLI-Math & SEMLI-Physics) as a pretest and posttest, and subjected to descriptive and inferential statistics of both metacognitive awareness and self-efficacy. Data analysis revealed that prompted reflections have affected the students' metacognitive awareness and self-efficacy positively. There was significant improvement in metacognitive awareness and self-efficacy of students in the experimental groups except the physics groups which showed little improvement in self-efficacy. These findings are important as they can guide educators in understanding different metacognitive factors and selecting strategies that improve students' metacognitive awareness and self-efficacy within the realm of curriculum innovation and change.

Keywords: Metacognition, Prompted Metacognitive Reflections, Self-efficacy, Metacognitive Awareness, Metacognitive Knowledge, Metacognitive Regulation, Metacognitive Intervention.

ملخـــــص

لقد تم تحديد أن ما وراء المعرفة يعتبر مكون حاسم لفعالية التعلم في دراسة مادتي الرياضيات والعلوم . كما أن ما وراء المعرفة يقتضي إلمام الطلاب بعملية تعلمهم وعلى الأساليب المتبعة في التعلم، والتفضيلات، وعلى الفعالية الشخصية. وتهدف هذه الدراسة إلى تحديد تأثير حث الأفكار بما وراء المعرفة في تعزيز الوعي بهذا النوع من المعرفة وبالفعالية الشخصية في دروس الرياضيات و العلوم. ولكي يتم إستيفاء أغراض هذه الدراسة، فقد تم اتباع منهج كمي في البحث باستخدام تصميم شبه تجريبي لمراحل ما قبل و ما بعد الاختبار. وشارك في الدراسة 184 طالب من طلاب الصف الثاني عشر بمدرسة ثانوية في دبي بالامارات العربية المتحدة. وقد شاركت مجموعة التجريب في المعالجة المعنية بما وراء المعرفة من خلال الاستجابة للأسئلة التي تعتمد على حث الأفكار و لمدة ستة أسابيع . كما تم تجميع البيانات عبر استخدام قائمة من الصفات والخصائص المتعلقة بالفعالية الشخصية وبما وراء المعرفة في التعلم لمادتي الرياضيات والعلوم (SEMLI-Math & SEMLI-Physics) على مرحلتين ، مرحلة ما قبل الاختبار ومرحلة ما بعد الاختبار، ومن ثم اخضاع هذه المراحل لعملية احصائية تنطوي على الوصف وعلى الاستدلال لكل من الوعي بما وراء المعرفة و بالفعالية الشخصية .

وتبين من تحليل البيانات بأن حث الأفكار كان له تأثير إيجابي على وعي الطلاب بما وراء المعرفة و بالفعالية الشخصية. كما أنه كان هناك تحسن كبير في الوعي بما وراء المعرفة و بالفعالية الشخصية في مجموعات التجريب باستثناء مجموعة مادة الفيزياء التي أظهرت قدرا قليلا من التحسن في الفعالية الشخصية. و هذه النتائج تعتبر مهمة نسبة لأنها يمكن أن تكون بمثابة دليل للمعلمين في فهم العوامل المختلفة لما وراء المعرفة وفي اختيار الاستراتيجيات التي يمكن من خلالها الارتقاء بمستوى وعي الطلاب بما وراء المعرفة وبالفعالية الشخصية وذلك في سياق التجديد والتغيير للمناهج الدراسية.

الكلمات والعبارات الرئيسية: ما وراء المعرفة ، حث الأفكار في ما وراء المعرفة، الفعالية الشخصية، الوعي بما وراء المعرفة، تنظيم ما وراء المعرفة، تدخل ما وراء المعرفة.

DEDICATION

This dissertation is lovingly dedicated to my parents. Their support, encouragement and believe in me have sustained me throughout my life. A special feeling of gratitude to my husband and my lovely children, Rayan, Faris, Adam and Jana, whose existence in my life and their love are a constant source of inspiration.

AKNOWLEDGEMENT

First of all, I am grateful to The Almighty Allah for galvanising me to complete this work.

I would like to express my sincere thanks to Dr. Sufian Forawi, my dissertation supervisor. I am extremely grateful and indebted to him for his valuable guidance, care, patience and encouragement extended to me. His continuous support and guidance helped me throughout the research and writing of this dissertation.

I would like to thank Mrs. Radhika Iyer for her help in proofreading my work and supporting me throughout my academic journey.

I place on record, my sincere thanks to all my friends and colleague, directly or indirectly, who have lent their helping hand and their support in this venture.

Last but not least, I would like to thank my family: my parents, my husband and my children. Their support and patience encouraged me throughout this academic quest.

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Chapter One: Introduction

One of the main objectives of mathematics and science education is to help students to become independent, autonomous, efficient and lifelong learners (Donnelly 2010; Kozma 2013; Kuo et al. 2013). Promoting learning is to make learning explicit and to bring learning itself to consciousness (Watkins 2001). Accordingly, many educators and psychologists have long promoted the effective role of cognitive and metacognitive strategies in teaching and learning as a way to achieve this end. Mathematics and science learning reaps various cognitive processes involved in problem solving, inquiry learning, reading and writing (More & Hill 2002; Veenman 2012). Consequently, the mathematics and science education reform demands development of teaching and learning to develop learners' metacognitive awareness by guiding them to be responsible for their own learning by being able to plan, monitor and evaluate their learning (Chiu 2007; Sandi-Urena, Cooper & Stevens 2011; Zohar & Barzilai 2013). Problem solving, critical thinking and self-directed learning are highlighted in education for preparing students for higher education and career (Donnelly 2010; Fisher 2011; Lai 2011). Several studies (Collins 2011; Lai 2011; Ozsoy & Ataman 2009; Schraw & Dennison 1994) have indicated that meaningfulness of learning can be empowered by metacognition. Concurrently, the literature review on metacognition indicates a plethora of studies (Balcikanli 2011; Flavell 1979; Schraw 1998; Schraw & Dennison 1994; Thomas, Anderson & Nashon 2007; Veenman 2012) which have conceptualized the construction of metacognition over the last decades. The theoretical review of metacognition highlights the interrelationships of metacognitive knowledge and skills (Kaplan 2008; Veenman et al. 2006). Metacognition includes the metacognitive skills which are denoted to as "executive or self-regulatory processes" (Veenman 2012, p.21).

Hence, Experimental research is one of the most powerful research approaches to find the "cause-and-effect relationships among variables" (Fraenkel, Wallen & Hyun 2012, p.265) as educational reform is inclined to give more weight to experimental research that investigates the effect of certain intervention (Slavin 2011; Thomas, Anderson & Nashon 2007). Those types of studies are recommended by the researchers in both science and mathematics fields (Bransford, Brown & Cocking 2000; Magnusson et al. 2004). Therefore, the focus of the current study is to contribute to the large body of work that has been done in relation to metacognition in science and mathematics education (Thomas, Anderson & Nashon 2008; Veenman, Van Hout-Wolters & Afflerbach 2006; Zohar & Dori 2012) through the attempt to explain the effect of using prompted reflections as a metacognitive intervention on high school students' metacognitive awareness and self-efficacy. The current study was built on previous considerations to study metacognition in a specific task or domain and to consider the executive processes of metacognition as the self-regulatory process during learning activities (Lai 2011; Veenman 2013; Zohar & Dori 2012).

Empirical studies (Bransford, Brown & Cocking 2000; Pintrich 2002; Schraw 2000; Veenman 2012; Veenman, Hout-Wolters & Afflerbach 2006) indicate that students' metacognitive knowledge and skills start at the elementary school age while the steep growth of metacognitive skills happens during high school age (Veenman, Wilhelm & Beishuizen 2004). Since the early work of Flavell (1976, 1979) and Brown (1978) on metacognition, a considerable number of evidences have concluded that students' awareness of their metacognitive functioning plays a main role in improving metacognitive skills and to enhance learning in mathematics and science education (Collins 2011; Desoete 2007; Fouché & Lamport 2011; Lai 2011; Nashon & Nielsen 2011; Wiezbicki-Stevens 2009).

1.1 Statement of the Problem

The improvement of students' learning in mathematics and science classes relies on the understanding of students' learning difficulties, teaching approaches and curriculum design that might contribute to learning issues (Bransford, Brown & Cocking 2000; Du Toit 2013; Fouché & Lamport 2011; Lai 2011; Matouk et al. 2013; Mercer, Jordan & Miller 1996). Teaching of mathematical and scientific concepts for understanding and reasoning empowers students' learning and problem-solving skills as envisioned by the National Council of Teachers of Mathematics (NCTM 2014) and the National Research Council (NRC 1996). Several studies on learning processes in mathematics and physics indicate that students take a lot of time in studying computation procedures and due to concentration problems and metacognitive deficits, these students struggle to accurately complete multistep computations (Kaplan et al. 2013). The NCTM and NRC indicate that among the processes that support effective learning in mathematics and physics are problem solving, proof and reasoning, reflection, modeling, representing and communicating (Kuo et al. 2013). The urgency to actively engage learners in these processes is highlighted in mathematics and science educational reforms. Therefore, the recommendation is to foster students' understanding of content knowledge along with the scientific and mathematics processes that can be achieved by enhancing students' metacognitive development (eds. Mullis et al. 2012).

Recent reports from the Organization for Economic Co-operation and Development (OECD 2013), the Program for International Student Assessments-PISA 2012 (KHDA 2013) and the Trends in Mathematics and Science Study-TIMSS 2011 (KHDA 2012) indicate that students with low scores are the students who find difficulties in mathematics and science questions that involve reasoning skills to solve unfamiliar problems and situations as multi-step problems and complex contexts. The students' content knowledge is assessed as well as the effective use of their knowledge and learning experience in real world situation where they need to use reasoning and thinking skills. The United Arab Emirates (UAE) students achieved below the OECD's average score in mathematics and scientific skills in PISA 2012 (KHDA 2013) and TIMSS 2011 (KHDA 2012). The analysis of the students' performance in the UAE emphasises the need to focus on certain factors affecting the students' achievement, such as, student engagement in learning, self-efficacy and reasoning skills (KHDA 2013). Another finding highlights the teachers' role to implement teaching strategies and learning activities that engage the students in their learning processes through practical applications and encourage them to be reflective learners by enhancing their metacognitive skills.

1.2 Rationale and Significance of the Study

The Ministry of Education in the UAE (Ministry of Education Strategy 2010-2020) is calling for educational development in schools to meet higher education and workforce requirements and to foster learning outcomes. The call for development aligns with the paradigm shift in teaching and learning from instructivism to constructivism approach, and has resulted in a high need for study as indicated by many UAE universities where they started to use different metacognitive strategies and activities for learning and assessment (Forawi, Almekhlafi & Al-Mekhlafy 2011; Tubaishat, Lansari & Al-Rawi 2009) to help students become more aware of their learning processes. The UAE vision 2021 (UAE Government 2011) for education aligned with the recommendations from the reports about the UAE students' performance in internationally standardized tests (KHDA 2013) prioritize the development of science and mathematics teaching and learning procedures to improve students' skills to be critical thinkers, innovative, knowledgable, self-regulated and life-long learners which demands more focus on teaching and learning methods. The KHDA (2013) school inspection handbook 2013-2014 states that the 'Outstanding' schools are the ones that are more inclined to create opportunities for learners to enhance their critical thinking skills and consequently, obtain better attainment. A review of studies (Aurah 2013; Chantharanuwong, Thathong & Yuenyong 2012a; Chantharanuwong et al. 2012b; Sweeney 2010; Zohar & Barzilai 2013) on metacognition in mathematics and science education points to a lack of studies, especially at school level, that employ controlled study designs to provide evidence of the effectiveness of metacognitive intervention to enhance students' learning, self-efficacy and metacognitive awareness. Therefore, students' attainment and progress demand investigation of the effect of certain metacognitive treatment on students' metacognitive awareness and self-efficacy growth in mathematics and science education.

Metacognition plays a vital role in student learning (Bransford, Brown & Cocking 2000; Pintrich 2002; Schraw 2000). Although, several empirical studies (Collins 2011; Desoete 2007; Kramarski, Mevarceh & Arami 2002; Nashon & Nielsen 2011; Schraw 1998) have showed that metacognition is 'teachable' and can enhance academic performance, self-regulation and problem solving skills, these studies have revealed limited research that has been conducted to discover the effect of implementing certain metacognitive strategy within mathematics and physics classes and its impact on learning. While there are numerous metacognitive instruction methods, the most effective one is the one that empowers learners' knowledge and practice of employing metacognitive skills such as monitoring and evaluating task performance (Balcikanli 2011; Dymoke 2013; Schraw & Dennison 1994).

In order to successfully engage students in metacognitive activities in mathematics and science learning to improve their metacognitive skills and to enhance their learning, students must develop metacognitive awareness to control and regulate their knowledge and skills. These metacognitive knowledge and skills are developed as students engage in developing new conceptual understandings, build on prior knowledge and reflect on their own learning as they move through the phases of learning. The literature about metacognition provides the field with empirical evidence that students can be taught to be reflective learners (Lai 2011; Schraw 2000;

Zohar & Dori 2012). Reflection as a type of metacognitive activity starts in the learning processes when learners question themselves about their personal knowledge (Bransford, Brown & Cocking 2000; Entwistle & Peterson 2004; Flavell 1979; Pintrich 2002), subsequently, they can better regulate their knowledge and monitor their performance to facilitate learning and enhance understanding (Schraw, Crippen & Hartley 2006). Endorsing “prompted metacognitive reflections” (Collins 2011, p.39) or metacognitive prompting by asking students to answer reflective questions as the students work their way through mathematics and physics learning, can help students connect their learning experience and apply content knowledge to unfamiliar contexts (Davis 2003; Collins 2011; Wiezbicki-Stevens 2009). The theoretical review of metacognition points to the challenge for educators to promote metacognitive reflection by providing students with explicit opportunities to reflect on their learning experience to improve awareness of their own learning and to be self-regulated learners (Balcikanli 2011; Collins 2011; Orlich et al. 2013; Schraw 2000; Slavin 2011; Wiezbicki-Stevens 2009). However, many learners cannot engage in metacognitive thinking without teacher’s guidance through well-designed metacognitive activities that demand the teachers’ metacognitive awareness in the first place (Ku & Ho 2010; Rahman 2011).

Reflection is found to be effective for developing the learners’ ‘Metacognitive Awareness’ (Hennessey 1999; Nelson 1992; Schraw & Dennison 1994) of how they think, how they learn, self-regulation and monitoring own cognitive processes related to further learning. This means engaging learners in prompted reflections in the form of open-ended questions, where the learners are asked to write about specific concepts that are taken in the subject and to self-reflect about their learning experience, improve learners’ metacognitive awareness and self-efficacy (Collins 2011; Davis 2003; Wiezbicki-Stevens 2009). By taking into account the methods employed in previous studies on instruction in developing metacognitive strategy, the current study is based on the use of prompted metacognitive reflection questions (Collins 2011; Davis 2003). This study adds to the field of research by examining effects directly related to the gap indicated in the literature review for implementing metacognitive intervention in high school mathematics and physics curricula (Veennman 2012; Zohar & Barzilai 2013). Therefore, the current study's findings can help researchers and educators understand better how metacognitive strategies can be implemented as a tool to improve students' metacognitive awareness and therefore to enhance learning outcomes. It is hoped that the current research will add to the body of knowledge about metacognition and will aid in bridging the gap that currently exists between metacognitive theories and its applications in mathematics and physics classes.

1.3 Study Objectives

The purpose of the current study is to provide empirical evidence by finding the effects of prompted reflections as metacognitive intervention on high school students' metacognitive awareness and self-efficacy growth in mathematics and physics. This study was guided by the assumption that to better understand the potential impact of reflection on supporting a reflective, metacognitive approach of learning, it is critical to investigate the students' experience by administering a self-reported questionnaire adapted from Thomas, Anderson & Nashon (2008) inventory. A quantitative approach best suited the study purpose to find the cause and effect relationship between variables. The researcher's background as a high school mathematics teacher extensively contributed to designing the metacognitive reflective questions that are subject related and guided the participants to deeper responses.

1.3.1 Research Question and Hypotheses

Thus, the present study was undertaken to address the following main question:
To what extent does prompted reflection affect physics and mathematics students' metacognitive awareness and self-efficacy?

To address the above question comprehensively, the following hypotheses were formulated to guide the study:

Ho 1: There would be a significant difference in the metacognitive awareness scores of the students who participated in the prompted reflections activities and those who did not.

Ho 2: There would be a significant difference in the self-efficacy scores of the students who participated in the prompted reflections activities and those who did not.

The context of the study is K-12 American curriculum private school in Dubai, the UAE. The participants are hundred eighty-four grade twelve male and female students from the same cultural and socio-economic background with ages ranging from 16 to 17. The study was conducted for eight weeks in mathematics and physics classes where one mathematics teacher and one physics teacher taught the participating students in 8 classes.

1.4 Structure of Dissertation

This chapter has presented the topic, objectives, key question and components of the research itself. The literature review presented in chapter two highlights the following major topics: the theoretical review of metacognition, the recent literature and studies on metacognitive strategies and inventories to assess metacognition, reflection and self-regulation in mathematics and physics. This is followed by how this research was translated into educational practice. Chapter three outlines the research methodology that describes the current study's context, sampling, approach, design, instrumentation and ethical considerations. Chapter four outlines the data analysis and results. Finally, chapter five presents the discussion, conclusion, implications and recommendations.

Chapter Two: Literature Review

2.1 Introduction

Metacognition has been identified as a fuzzy concept due to its various definitions and dimensions (Flavell 1981, p.37; Veenman, Van Hout-Wolters & Afflerbach 2006) and has been investigated from various perspectives and for several purposes. Metacognition is defined as a multidimensional set of skills that includes thinking about own thinking and involves different types of knowledge that make metacognition an inspiring area for research (Lai 2011). The literature review on metacognition points to the numerous studies (Lai 2011; Rahman 2011; Veenman 2012; Zohar & Barzilai 2013; Zohar & Dori 2012) that highlight the effect of metacognitive strategies on students' learning processes and metacognitive skills and consequently, learning outcomes. The following major parts are emphasized in the literature: definition of metacognition, trends and theoretical review, recent research on metacognitive treatments and inventories to enhance and measure metacognitive awareness, the relationship between metacognition, and reflection and self-regulation in mathematics and physics education. This chapter looks at the current state of research as it relates reflection as metacognitive strategy to metacognitive awareness and self-efficacy in mathematics and physics education.

2.2 Definitions and Components of Metacognition

Cognitive psychology can be understood as the attempt to understand how people think and how they employ their basic mental abilities to recall information, analyze, prove and reason (Hunt & Ellis 2004, p.2). Cognition includes various skills that can help the learners to achieve particular goals and can be identified and measured (Schraw, crippen & Hartley 2006, p.112). Metacognition has been related to cognition by defining metacognition as the individuals' awareness to monitor and regulate their own cognitive processes (Hennessey 1993). However, not all cognitive processes require metacognition (Lai 2011). Within cognitive psychology, metacognition is mainly defined as the executive control of cognitive processes (Kuhn & Dean 2004). Schraw and Moshman (1995, p.350) describe metacognitive theory as "a relatively systematic structure of knowledge that can be used to explain and predict a broad range of cognitive and metacognitive phenomena". Metacognitive theory focuses on cognitive characteristics of the mind, ways of thinking and levels of control and understanding of the cognitive processes (King 1999 cited in Rahman 2011). The cognitive system consists of "metacognitive self-instructions and the cognitive processes that are involved in the execution of those instructions" (Veenman 2012, p.27). Moreover, within the cognitive system, both cognitive and metacognitive actions feed different goals and functions (Brown 1987; Butler 2006; Veenman et al. 1992 in Veenman 2012 p.27). The attempts to conceptualize metacognition indicate the complex relationship between cognition and metacognition where metacognition is part of the cognitive system and the higher order factor that controls the cognitive system (Veenman, Van Hout-Wolters & Afflerbach 2006).

Metacognition as a concept originally indicates the individual's knowledge and regulation of one's cognitive activities in learning processes (Schraw, Crippen & Hartley 2006). Flavell (1976, p. 232) was the first to refer to metacognition as "one's knowledge concerning one's own cognitive processes and products or anything related to them". This definition is applied in several ways to point to the process of thinking about our own thinking (Flavell 1979, p.906). Later, Schraw and Dennison (1994) clarified that metacognition is linked to the ability to understand, reflect and control one's learning, while King (1999 cited in Rahman 2011) described the attributes of metacognition as a person's ability to think about his or her own learning processes and to identify suitable strategies to analyze and to implement what has been learned.

There are several terms that are commonly associated with metacognition such as metacognitive awareness, metacognitive activities, theory of mind, meta-memory, metacognitive skills, judgement of learning, executive skills, learning strategies, self-efficacy and self-regulation (Veenman, Van Hout-Wolters & Afflerbach 2006) when grouped, these terms refer to specific metacognitive skills and knowledge that are related to certain age or type of task while others are related to cognitive and metacognitive processes at the same time (Veenman, Van Hout-Wolters & Afflerbach 2006). However, "Metacognitive Awareness" (Hennessey 1999; Nelson 1992; Schraw & Dennison 1994) as a term has been adapted in several studies and means the individuals' awareness of how they learn, how they think and engage in self-reflection. Metacognitive awareness also includes the awareness of monitoring and assessing one's cognitive processes related to further learning (Balcikanli 2011; Schraw, Crippen & Hartley 2006). Generally, definitions of metacognition point to the importance of learners' awareness of their own thinking to have the knowledge about and regulation of cognitive strategies used in learning and to be able to reflect on one's performance and learning experiences (Bransford, Brown & Cocking 2000; Flavell 1979; Pintrich 2002).

Researchers like Brown & DeLoache (1978) and Kluwe (1987) believe that self-regulation is a secondary component of metacognition while other researchers like Winne (1996) and Zimmerman (1995) consider self-regulation as a higher order concept of metacognition because it also includes motivational and emotional processes (Veenman, Van Hout-Wolters & Afflerbach 2006). Another distinction is made between metacognitive knowledge and skills by referring to metacognitive knowledge as the individual's declarative knowledge about the relations between learner, task and strategy feature (Flavel 1979), while metacognitive skills refer to the individual's procedural knowledge for regulating one's problem solving and learning processes (Brown & DeLoache 1978; Veenman 2005).

Flavell (1979), Schraw and Dennison (1994), and Schraw, Crippen and Hartley (2006) classify the metacognition components into two main components: metacognitive knowledge and metacognitive regulation. Metacognitive knowledge as defined by Flavell (1979, p.906) is the knowledge about an individual's cognition as a learner and how, when and why to apply certain strategy to improve performance and involves three factors: (1) declarative knowledge which refers to the individual's knowledge about own beliefs and perception of task structure and self-efficacy, (2) procedural knowledge which means the "knowledge about the execution of procedural skills" (Schraw & Moshman 1995, p.353), while (3) conditional knowledge means "knowing when and why to apply various cognitive actions" (Schraw & Moshman 1995, p.353). Metacognitive regulation contains three regulatory skills comprising planning, monitoring and evaluating (Balcikanli 2011; Schraw 2001). (1) Planning indicates choosing appropriate strategies and resources. (2) Monitoring indicates individual's awareness of comprehension and task performance. (3) Evaluating indicates the evaluation and judgment of outcomes and effectiveness of the regulation process if it matched the task goals. The components and factors of metacognition are shown in Figure 1 below.

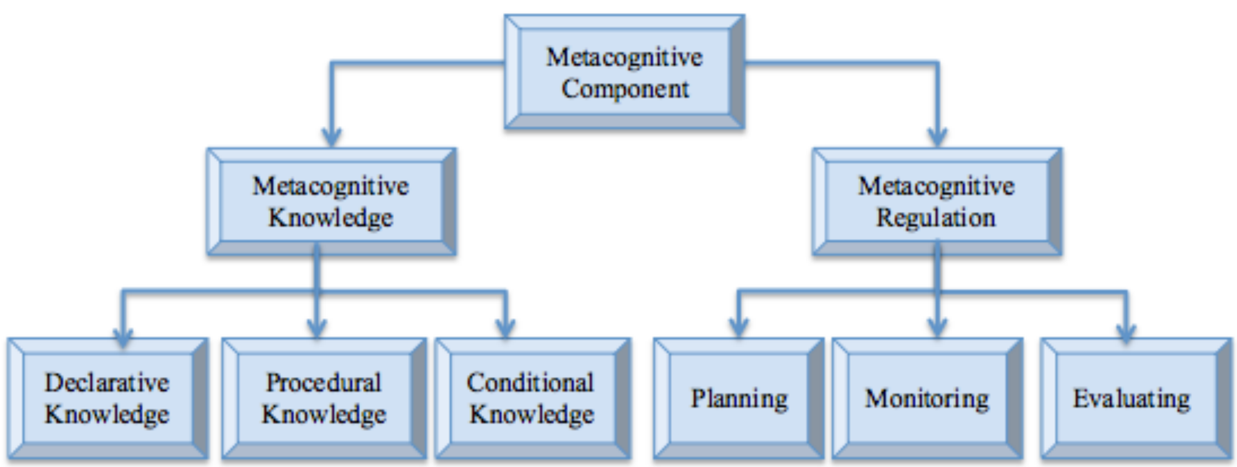

Figure 1: Metacognitive Components

Metacognitive components are generally correlated, which indicate that the sources for all the main metacognitive schemas are in a loop (Balcikanli 2011). One of the main questions about metacognition in research is whether it is domain specific or general. Flavell (1979, p.906) clarifies that the factors of metacognition are defined as “four classes of phenomena”: metacognitive knowledge and experience, tasks and strategies. The possibility that the learners can transfer their cognitive and metacognitive knowledge to be employed in new contexts remains one of the important open questions in literature (Lai 2011). One group of researchers (Schraw 1998, p.116; Veenman, Van Hout-Wolters & Afflerbach 2006) is involved in the debate that an individual’s cognitive skill is subject or domain related while an individual’s metacognitive skills can be employed similarly in any domain. Other researchers (Davis 2003; Thomas, Anderson & Nashon 2008) contradict this position by debating that the employed metacognitive skills differ according to the different cognitive tasks. Therefore, metacognitive skills should be researched in different contexts and subjects.

Metacognition has been considered a fuzzy concept due to several reasons. One of them is the interrelationship between the concept and its components and another reason is the inconsistency in the meaning of metacognition as a concept in the field of research (Lai 2011; Zohar & Dori 2012; Veenman 2012; Veenman, Van Hout-Wolters & Afflerbach 2006, p.4). Several frameworks were developed to categorize metacognitive components; the typology of these components is shown in Table 1 below (Lai, 2011). Researchers like Flavell (1979) and Brown (1978) distinguish between metacognitive knowledge and skills (Veenmanet al. 2006) where metacognitive skills represent the self-regulatory processes of metacognition (Zimmerman 1995). This difference is also supported by several studies (Brown 1987; Flavell 1979; Schraw, Crippen & Hartley 2006) which contend that metacognitive knowledge is linked to the set of knowledge that specifies how actions develop while metacognitive regulation is more related to the tasks and actions to accelerate learning.

<table>
<tr><th>Metacognitive Component</th><th>Type</th><th>Terminology</th><th>Citation</th></tr>
<tr><td rowspan="7">Cognitive knowledge</td><td rowspan="4">Knowledge about oneself as a learner and factors affecting cognition</td><td>Person and task knowledge</td><td>Flavell, 1979</td></tr>
<tr><td>Self-appraisal</td><td>Paris & Winograd, 1990</td></tr>
<tr><td>Epistemological understanding</td><td>Kuhn & Dean, 2004</td></tr>
<tr><td>Declarative knowledge</td><td>Cross & Paris, 1988
Schraw et al., 2006
Schraw & Moshman, 1995</td></tr>
<tr><td rowspan="2">Awareness and management of cognition, including knowledge about strategies</td><td>Procedural knowledge</td><td>Cross & Paris, 1988
Kuhn & Dean, 2004
Schraw et al., 2006</td></tr>
<tr><td>Strategy knowledge</td><td>Flavell, 1979</td></tr>
<tr><td>Knowledge about why and when to use a given strategy</td><td>Conditional knowledge</td><td>Schraw et al., 2006</td></tr>
<tr><td rowspan="4">Cognitive regulation</td><td>Identification and selection of appropriate strategies and allocation of resources</td><td>Planning</td><td>Cross & Paris, 1988
Paris & Winograd, 1990
Schraw et al., 2006
Schraw & Moshman, 1995
Whitebread et al., 2009</td></tr>
<tr><td rowspan="2">Attending to and being aware of comprehension and task performance</td><td>Monitoring or regulating</td><td>Cross & Paris, 1988
Paris & Winograd, 1990
Schraw et al., 2006
Schraw & Moshman, 1995
Whitebread et al., 2009</td></tr>
<tr><td>Cognitive experiences</td><td>Flavell, 1979</td></tr>
<tr><td>Assessing the processes and products of one's learning, and revisiting and revising learning goals</td><td>Evaluating</td><td>Cross & Paris, 1988
Paris & Winograd, 1990
Schraw et al., 2006
Schraw & Moshman, 1995
Whitebread et al., 2009</td></tr>
</table>

Table 1: Typology of Metacognitive Components (Lai 2011, p.7)

Basic development of metacognitive knowledge and skills starts at an early age during early-school years and can be observed (Whitebread et al. 2009) while metacognitive skills become academically oriented in formal education when the learners need to regulate their knowledge (Veenman, Van Hout-Wolters & Afflerbach 2006). Veenman (2012) states that during high school age the steep linear development of metacognitive skills happens. Learner's metacognitive knowledge alone is not enough to be an indicator of success in performing a task because it is affected by the students' self-efficacy, capability and motivation (Veenman 2005). From this point of view, the recommendation is to study and teach specific metacognition for specific task or domain (Veenman, Ven Hout-Wolters & Afflerbach 2006) and to consider the executive process of metacognition which is the self-regulatory processes during learning activities (Lai 2011; Zohar & Dori 2012). Moreover, learners may not use their metacognitive skills constructively because of the lack of knowledge of how to employ these skills (Veenman, Van Hout-Wolters & Afflerbach 2006).

2.2.1 Assessment of Metacognitive Awareness

Although much effort is being channeled into creating an inventory to assess learners' metacognitive awareness, several studies discuss the reliability and validity of these inventories due to the multivariate nature of metacognition (Balcikanli 2011; Lai 2011; Magno 2010; Rahman 2011; Veenman 2012). Another debate about metacognition arises from the difficulty to assess the metacognitive skills and knowledge because they cannot be observed directly and the available measures of metacognitive awareness is narrow in focus and decontextualized from the school context (Lai 2011, p.2). The distinction of metacognition components demands development of a variety of assessment tools and measures (Zohar & Dori 2012). Veenman (2005) distinguishes between two methods of assessing metacognitive skills: on-line methods where the metacognitive skills are assessed during the task like observation, computerized logs and thinking aloud while off-line methods refer to assessing metacognitive skills either before or after the task performance such as questionnaires and interviews; this latter method mainly depends on the learners' self-reports (Veenman 2012).

Many approaches were adopted to assess metacognitive awareness like observations (Veenman & Spaans 2005), questionnaires (Pintrich & De Groot 1990; Schraw & Dennison 1994; Thomas 2003; Thomas, Anderson & Nashon 2008), interviews (Zimmerman & Martinez-Pons 1990), analysis of metacognitive activity such as thinking-aloud protocols (Afflerbach 2000; Veenman, Elshout & Groen 1994), metacognitive prompting (Fiorella, Vogel-Walcutt & Fiore 2012), reflection (Entwistle & Peterson 2004; Wiezbicki-Stevens 2009), stimulated recall (Van Hout-Wolters 2000) and online computer log (Stephens & Winterbottom 2010; Veenman et al. 2004). Each assessment approach has its advantages and disadvantages. For example, questionnaires are easy to administer with a large number of participants and do not affect instruction time, whereas interviews and thinking-aloud protocols entail individual assessments. The most popular method to assess metacognitive skills or strategies is questionnaires, however, students' answers on questionnaires hardly reflect actual behavioral measures during task performance (Lai 2011; Veenman 2005; Veenman, Prins & Verheij 2003). It was also found that as students' age increase, the accurate assessment of metacognition requires more domain-specific focus when metacognitive awareness is studied (Lai 201; Sperling et al. 2002).

2.2.2 Metacognitive Inventories

It is important for learners in mathematics and physics education to be aware of the strategies that develop their metacognitive awareness which are found to be important for improving reasoning skills and learning outcomes in mathematics (Du Toit 2013; Mevatech & Fridkin 2006; Parsons 2011) and physics (Davis 2003; Nashon & Nielson 2011; Zohar & Dori 2012). Consequently, the need to assess learners' metacognitive awareness has led to several attempts to create a valid and reliable inventory (Lai 2011; Schraw & Dennison 1994). The following will cover some of the most used inventories in mathematics and science education.

One of the most well-known and frequently used inventories to measure metacognitive aspects using self-report items is the Metacognitive Awareness Inventory (MAI) by Schraw and Dennison (1994). The MAI was created for adults and involves fifty-two self-report items to measure the eight factors of metacognition under two broader components: metacognitive knowledge and metacognitive regulation. Another inventory is the Metacognitive Skills and Knowledge Assessment (MSA) by Desoete, Roeyers and Buysee (2001). MSA involves 160 items that assess the learners' metacognitive knowledge and skills through seven components of metacognition. Three factors of metacognitive knowledge: declarative, procedural and conditional alongside four factors of metacognitive skills: monitoring, planning, evaluation and prediction. MSA is a multi-method inventory where students' performance is compared with predictions (Ozsoy & Ataman 2009).

The Self-Efficacy and Metacognition Learning Inventory-Science (SEMLI-S) was created by Thomas, Anderson and Nashon (2008). The inventory was created based on: first, the theoretical framework that relates students learning processes in science with metacognitive science learning "orientation" (Thomas, Anderson & Nashon 2008, p.1702) which means that the assessment and evaluation of students' metacognitive knowledge, skills and learning processes are task and context related and varies between subject domain and overtime (Veenman, Van Hout-Wolters & Afflerbach 2006). Second, is the methodological consideration to create empirical inventory to measure nature and level of students' metacognitive awareness in science classrooms as a result of the effect of certain treatment to enhance students' metacognitive awareness (Thomas, Anderson & Nashon 2008; Schraw & Impara 2000). Although Thomas, Anderson and Nashon (2008) agree with Veenman, Van Hout-Wolters and Afflerbach (2006, p.7) that "general metacognition may be instructed concurrently in different learning situations and may be expected to transfer to new ones", they included items in their inventory that were related to the context to emphasize the importance of the setting where teachers and students assume their roles. Their effort was to create an empirical self-report inventory to be used in science education for measuring students' metacognitive awareness, self-efficacy and constructivist connectivity in science learning processes with science learning materials. The domain of learning environments research in science education is full of inventories that support the researchers' perspective, for example, the Metacognitive Orientation Learning Environment Scale-Science inventory (Thomas 2003) and prior to that, the Constructivist Learning Environment Scale inventory (Taylor, Fraser & White 1994). All these tools include items or an introductory sentence that ask the learners to focus and to relate their reflection or self-report to domain-specific learning processes and metacognition. SEMLI-S inventory is used in several studies in the domain of biology (Aurah 2013; Mavrikaki & Athanasiou 2011), chemistry (Sandi-Urena, Cooper & Stevens 2011) and physics (Nashon & Nielson 2011; Thomas 2011; Chantharanu-wong, Thathong & Yuenyong 2012), and is also cited in several studies (Butterfield 2012; Schellings 2011; Schererl & Tiemann 2014). The inventory was modified where the initial SEMLI-S consisting of 72-items was then reduced to 30-items related to five factors. The inventory was piloted with 505 students (13-18 years old), and then tested for validity and reliability purposes. The Rasch analysis shows that SEMLI-S fits the Rasch model well. The reliability of SEMLI-S is tested by Cronbach's-Alpha and the results have reliable alpha scores (0.68 to 0.85). There is also significant correlation (at the 0.01 level) between the five subscales (Thomas, Anderson and Nashon 2008, pp.1709-1716). The SEMLI-S factor analysis indicates that it can be used for all its factors simultaneously or for each factor separately to assess individual metacognitive science learning orientations.

The majority of the inventories that assess metacognitive skills are students' self-report tools (Rowe 1991; Royer, Cisero & Carlo 1993; Schraw & Dennison 1994; Thomas, Anderson & Nashon 2008). 'Self-report' assesses the students' perceptions of their metacognitive awareness by asking the students to focus on the nature and the level of their metacognitive knowledge and skills along with evaluating their use of cognitive and metacognitive processes. There are several empirical self-report inventories that explore students' learning and metacognition like the Learning Processes Questionnaire (LPQ) (Biggs 1987), the Learning and Study Strategies Inventory (LASSI) (Weinstein, Schulte & Palmer 1987), the Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich et al. 1993) and the Assessment of Cognitive Monitoring Effectiveness (ACME) (Osborne 1998). The above inventories are not related to the class context or to certain subject but they are based on general cognitive and metacognitive constructs (Schraw 2000).

2.3 Metacognition in Mathematics and Physics Education

Mathematics and science learning reaps various cognitive processes involved in problem solving, inquiry learning, reading and writing (Kuo et al. 2013; More & Hill 2002; Veenman 2012). Learning mathematics and physics requires reading textbooks to gain conceptual knowledge, solving problems using reasoning and applying formula besides planning and carrying out laboratory experiments. Certain issues, supported with evidence of learning difficulties, are addressed in mathematics and physics education such as undeveloped problem solving skills, poor conceptualization and difficulty in applying knowledge across disciplines (Du Toit 2013; Kroll & Miller 1993; Kuo et al. 2013; More & Hill 2002, pp.1-2; Phang 2010). The literature regarding metacognition in science and mathematics education supports several definitions of metacognition as the awareness of learning processes and the learner ability to think about own thinking (Du Toit 2013; Gilbert 2005; Mevarech and Fridkin 2006; Nashon & Nielsen 2011; Parson 2011; Thomas & McRobbie 2001). Blank (2000) states that the learners' perceptions of the status of their scientific ideas represent an aspect of metacognition.

Relatively little is done about metacognitive processes in reading and problem solving in mathematics and science education (Azevedo et al. 2007; Parsons 2011; Lai 2011). Learning by doing in mathematics and science domain means learning to acquire content knowledge and to apply this knowledge to solve problems (Desoete, Roeyers & De Clercq 2003; Kramarski & Mevarech 2003; Mevarech & Fridkin 2006; Nashon & Nielsen 2011; Veenman 2012). Studies on the effect of metacognition in science are mainly focused on problem solving in physics, specifically to compare experts versus learners (Anderson & Nashon 2007; Elshout, Veenman & Van Hell 1993; Glaser & Chi 1988; Nashon & Nielson 2011). The issue of learners in physics and mathematics is the superficial problem analysis and the lack of other orientation activities that lead to losing track of problem solving steps and strategies and therefore, being unsystematic with memory traces (Veenman 2012, p.29).

Metacognitive awareness empowers the students' self-efficacy and motivation to overcome any anxiety in math and physics learning (Lai 2011; Ramirez & Beilock 2011). Teachers find difficulties in engaging students in guided-inquiry process so to overcome this issue, students must develop metacognitive skills of "thinking about their own thinking" that are necessary to facilitate this kind of exploration (Veenman 2012; Zohar & Dori 2012). These metacognitive skills are developed as students engage in developing new conceptual understandings, build on prior knowledge and reflect on their own learning as they move through the phases of this guided-inquiry process. The evidence on the effect of metacognition to empower inquiry and discovery learning in science is strongly proved in physics domain (Anderson & Nashon 2007; Manlove, Lazonder & De Jong 2007) and correlated to problem solving skills in physics (Nashon & Nielsen 2011; Phang 2010) and mathematics (Du Toit 2013; Mevarech & Fridkin 2006).

The following part will highlight several studies on metacognitive strategies. Numerous studies (Hacker, Dunlosky & Graesser 2009; Veenman 2012; Wang, Haertel & Walberg 1990;

Zohar & Dori 2012) have highlighted the importance of guiding students to develop their metacognitive skills and to make their thinking processes explicit to teachers and their common recommendation is to conduct further studies with focus on the effect of metacognition on learning variables to empower learning outcomes.

Teaching of metacognitive strategies has shown evidence of improvement in teachers' and students' engagement with subject's concepts and writing tasks (LaVaque-Manty & Evans 2013). Other concepts are positively connected to reflection and metacognition like motivation, engagement and self-efficacy (Silver 2013; Wu & Looi 2013). Bransford, Brown & Cocking (2000, p.21) affirm the need to explicitly implement metacognitive strategies in teaching and learning procedures and to conduct action research in science classroom environment. The engagement in planning activities happens through cognitive activities like problem solving steps and strategies, revising calculations and checking answers that are all reliant on the learner's metacognitive skills (Veenman, Van Hout-Wolters & Afflerbach 2006). There is much evidence that metacognitive skills are considered the most crucial of intellectual abilities that support learning performance (Veenman, Wilhelm & Beishuizen, 2004; Veenman & Spaans 2005; Zohar & Dori 2012).

General metacognition can be taught alongside any subjects, however, task or domain related metacognition should be taught for each task or domain distinctly (Zohar & Dori 2012). A considerable number of studies support studying metacognition related to specific domain or task like problem solving in math (Desoete, Roeyers & De Clercq 2003; Kramarski & Mevarech 2003), science (Thomas 2003) and physics (Phang 2010; Nashon & Nielsen 2011). These studies recommend comparison on metacognition across domains and tasks (Sperling et al. 2002), linking instruction and teachers' feedback to metacognition (Balcikanli 2011; Ku & Ho 2010; Lai 2011; Rahman 2011) and developing the students' metacognitive awareness in formal educational settings and in other settings (Veenman, Van Hout-Wolters & Afflerbach 2006).

Although the growing body of literature on metacognition underlines its importance in learning, the effects of metacognitive strategies on learning outcomes are merely reported and measured (Lai 2011; Zohar & Dori 2012). To ascertain the cause and effect relationship between metacognitive strategies and learning outcomes, metacognitive knowledge and skills need to be measured using a pretest-posttest design (Veenman, Van Hout-Wolters & Afflerbach 2006; Zohar & Barzilai 2013). Ozsoy and Ataman (2009) adopted a quasi-experimental design to find the effect of implementing structured metacognitive strategy in problem solving activities to enhance forty-seven fifth grade students' problem solving achievement and metacognitive skills. The study lasted nine weeks and the Metacognitive Skills and Knowledge Assessment (MSA-TR) (Desoete, Roeyers & Buysee 2001) was used. MSA-TR comprised 160 items that assessed the learners' metacognitive knowledge and skills. The findings indicated that the students in the experimental group significantly improved in metacognitive skills and mathematical problem solving achievement (Ozsoy & Ataman 2009, pp.76-78). The same findings were corroborated by other studies in the field which had also adopted the quasi-experimental design (DuToit 2013; Mevarech & Fridkin 2006). Mevarech and Fridkin (2006) studied the impact of implementing metacognitive intervention on learners' metacognitive regulation and mathematics achievement while Nashon and Nielsen (2011) investigated the relationship between high school students' analogical thinking in physics problem solving and their self-regulation and metacognition. Both studies concluded that metacognitive awareness can improve students' learning processes and accordingly, learning outcomes. The importance of metacognitive awareness lies in its influential role to develop students' thinking and learning processes (Thomas, Anderson & Nashon 2008; Thomas & McRobbie 2001; White 1988).

2.4 Metacognition and Reflection

Reflection as one of the metacognitive strategies has been highlighted in the past decade for its influential role to empower learners' metacognitive awareness and learning processes (Entwistle & Peterson, 2004; Hacker, Dunlosky & Graesser 2009; Lai 2011). Metacognition and reflection have been traced back to educational psychologists and early thinkers of metacognition such as James, Dewey, Vygotosky and Piaget (Slavin 2011). Hence, 'Reflection' is defined as the individual awareness of own experience (Boud, Keogh & Walker 1985). Dewey (1909, in Fisher 2011, p.2) defines "reflective thinking" as "Active, persistent, and careful consideration of any belief or supposed form of knowledge in light of the grounds that support it and the further conclusions to which it tends". Later on in the 1980s, reflection started getting scholarly attention with more focus on development of a reflective pedagogy framework that points to reflection as the learners' response to their learning experience. Definitions of metacognition and reflection are usually used interchangeably in the literature. The definition of reflection is aligned with the components of metacognitive self-knowledge of an individual's awareness of his or her own strengths and weaknesses besides motivational beliefs related to learning (Pintrich 2002).

In class practice, reflection may be in the form of "metacognitive reflection" activity (Tarricone 2011, p.6), to reflect on certain learning experience or one's cognitive processes. Reflection sometimes represents a stage in a metacognitive schema. When learners are given the opportunities to reflect on their learning process, they can better organize and manage new information and they can recognize what learning strategies accelerate understanding (Rando 2001; Schraw 2000; Weinstein 2006). Bransford, Brown and Cocking (2000) assert that this ability to reflect differentiates expert from novice learners. Moreover, reflection transfers experience into learning and enables learners to employ their experiences in new situations (Boud, Keogh & Walker 1985). Thus, the main source for constructing learning objectives, Bloom's Taxonomy, has been modified to include metacognition, with the addition of metacognitive self-knowledge, as a new category of knowledge and an influential aspect of learning (Krathwohl 2002; Pintrich 2002). Several studies (Bransford, Brown & Cocking 2000; Flavell 1979; Murray 1999; Pintrich 2002; Schraw 2000; Weinstein 2006) have suggested that more opportunities should be provided to learners to reflect on their learning processes to improve their metacognitive awareness and to enhance their learning by being better in regulating their knowledge.

Reflection as a learning activity requires time and focus on cognitive processing to engage in continuous internal mental dialogue of one's thinking about own thinking, to regulate one's knowledge towards applying it in unfamiliar situations or contexts and to judge assumptions or understandings when interfered with one's learning (Donelly 2010; Stefani et al. 2007; Zubizaretta 2004). Empirical studies (Boud, Keogh & Walker 1985; Hoffman & Spatariu 2008; Morrison 1996; Murray 1999; Pintrich 2002; Zohar & Dori 2012) have demonstrated the efficiency of different types of reflection such as journals, self-reflection, metacognitive prompting and guided-reflection especially when used in specific subjects and related to certain concepts and tasks.

2.4.1 Reflection Methods

Mathematics and physics share a lot of characteristics in subject's nature and both require similar skills in learning such as problem solving and reasoning skills. Students should be proficient in mathematical skills to be successful on a science inquiry where many topics in physics are applications of math concepts (Collins 2011, p.28). Problem solving skills require from the learners reflection, conscious and regular monitoring of their own thinking processes to recognize the effective technique and strategy to solve a problem and to regulate the required knowledge to help in solving. Reflection on problem solving strategies and the rationale behind choosing certain techniques or reaching certain answers, enhance the learners' problem solving skills to perform a task and to make sense of the problem. The whole process helps students to clarify their understanding and empower their self-efficacy. Students with poor metacognitive skills have difficulty in applying mathematical and physics concepts in problem solving and subsequently, in learning. Teaching metacognitive strategies explicitly such as reflection, thinking aloud, and modeling help students with metacognitive deficits to be metacognitively aware (Kaplan et al. 2013).

The literature about metacognition in mathematics and science education indicates that writing has become a recent prerequisite in enhancing a learner's metacognition and investigation skills (Collins 2011, p.15-16). Scaffolding approach, in math and science writing tasks, has been identified as an effective technique to empower students' understanding in content knowledge (Yore & Treagust 2006; Hohenshell & Hand 2006). According to these findings, the different methods of reflection such as guided reflection, self-reflection and metacognitive prompting helps in empowering the students' learning, achievement and metacognitive awareness level (Bransford, Brown & Cocking 2000; Collins 2011; Davis 2003; Flick & Tomlinson 2006; Lai 2011; White & Frederiksen 1998; Wiezbicki-Stevens 2009). Metacognitive prompting was developed to help in progressing the reflection from dialogic to critical (Collins 2011; Surgenor 2011). Guided reflection is a method of reflection that involves engagement in a series of questions that help the individual to think and explore his/her actions (Surgenor 2011). A study (Parsons 2011) in higher education aimed to explore and to investigate the effect of 'writing to learn' as metacognitive intervention in mathematics classes on the students overall achievement and self-reflection with respect to learning mathematics concluded that writing in mathematics enhanced the students' meaningful connections about content and themselves as learners and encouraged them to reflect on their learning.

The demand to stimulate students' thinking processes about mathematical matters has been addressed in the last two decades in mathematics education literature, therefore, the call for reform in mathematics education refers to reflection as a high level of cognitive thinking process and a central part of mathematics education (Kaune 2006; Kilpatrick 1986). Reflection has been proved as a useful metacognitive activity to enhance high school students' mathematical understanding (Parson 2011; Tok 2013), learners' thinking and learning processes (De Corte 1995; Schoenfeld 1992). White and Frederiksen (1998) conducted a study to explore how reflection, as a metacognitive intervention implemented in physics classes, can be used to improve student understanding of the connection between scientific inquiry and real world. The researchers hypothesized that the difficulties in physics learning are due to the learners' low level of metacognitive awareness rather than the lack of intellectual ability. The results confirm previous findings that reflection is not an end but a means towards a helpful metacognitive approach that facilitates student learning and understanding of the inquiry process. Davis (2003) studied the role of generic and directed reflection of 180 middle school students at the end of a unit in physics about heat flow and energy conversion. The students were asked to reflect eleven times after analyzing and critiquing a news article about the topic. The study found that students who did not reflect or whose reflections were poor in quality obtained less successful results in the final project. The findings also indicated that the general type of responses endorsed quality of reflection that is more productive.

'Metacognitive prompting' is defined as "an externally generated stimulus that either tacitly or explicitly activates reflective cognition or evokes strategy use with the objective of enhancing a learning or problem solving objective" (Hoffman & Spatariu 2008, p.878). Metacognitive prompting has been proved as effective in enhancing students' self-efficacy and problem solving efficiency in mathematics and physics (Collins 2011; Hoffman & Spatariu 2008). Endorsing "prompted metacognitive reflections" (Collins 2011, p.39) by asking students reflective questions as they work their way through mathematics and physics learning, triggers their reflective cognition and helps to connect their learning experience and content knowledge to unfamiliar contexts (Collins 2011; Davis 2003; Hoffman & Spatariu 2008; Wiezbicki-Stevens 2009). A quasi-experimental study (Berthold, Nückles & Renkl 2007) on the effect of cognitive and metacognitive prompting on learning concluded that cognitive and metacognitive prompts empower students' learning especially when metacognitive and cognitive prompts are combined. Distinctive methods of metacognitive prompting have been effective in many disciplines and contexts such as mathematics (Kramarski & Gutman 2006) and physics (Davis 2003). Prompting has been used to get students to think, review and reflect before, in or after the lesson to deepen understanding and comprehension (Fogarty 2006, p.8). Self-reflection questions and comments by naming and describing while learning help the students to better understand when there is any difficulty.

2.5 Metacognitive Awareness and Self-Efficacy

The relationship between metacognitive awareness, self-efficacy, self-regulation and learning processes is highlighted in the literature (Lai 2011; Veenman, Van Hout-Wolters & Afflerbach 2006). Hence, metacognition does not influence learning outcomes when it is isolated but rather is related to other elements of learning theory (Veenman 2012). The literature related to this matter (Lai 2011; Schraw, Crippen & Hartley 2006), indicates that students' metacognitive awareness and the metacognitive strategies that they use in learning processes are subsets of self-regulation such as self-efficacy, where the learner's self-confidence about performance and goal attainment influence the learning outcomes. A self-directed or self-regulated learner is the learner who can monitor his own progress and make modifications when needed. By reviewing self-regulated literature, a connection is highlighted between engagement and metacognition. The key element to enhance students' metacognitive awareness and skills is teaching students explicitly how to develop these skills.

Many researchers (Boekaerts 1997; Efklides 2011; Mason & Scrivani 2004; Pintrich & De Groot 1990; Pintrich & Schunk 2002; Thomas, Anderson & Nashon 2008; Zimmerman & Martinez-Pons 1990) are interested in the complex relations between metacognitive knowledge, skills, epistemological beliefs, self-regulation and learning processes on one side and self-efficacy, motivational processes and study interests on the other side. Simultaneously, other researchers studied the relationship between affective variables such as subject and test anxiety and metacognition (Tobias & Everson 1997; Zohar & Dori 2012) or learning difficulties (Borkowski 1992; Harris, Reed, & Graham 2004; Swanson, Christie & Rubadeau 1993). Neuropsychological studies on metacognition have been narrowed to very specific metacognitive processes like feeling of knowing and judgement of learning phenomena (Metcalfe & Shimamura 1994; Pinon et al. 2005). Those studies recommended more investigation from other perspectives such as instructional, developmental or diagnostic perspectives and the learners' monitoring, planning and reflection skills as part of metacognitive components.

However, the role of student's self-efficacy in empowering academic outcomes has been proven where students with high level of self-efficacy often persevere longer with tasks, and are more likely to set and monitor their goals (Bandura 2006; Collins 2011; Britner & Pajares 2006; Zimmerman & Cleary 2006). Although gender differences seem to play a role in the level of the student's self-efficacy, the research about gender differences in self-efficacy shows inconsistent results (Zimmerman & Martinez-Pons 1990; Jacobs et al. 2002). A study by Pajares (2003) concludes that although grade nine female students obtained better writing scores, the male students showed a higher level of self-efficacy than the female students. Another study (Zimmerman & Martinez-Pons 1990) indicates that there is no significant difference in self-efficacy in mathematics between male and female students while Jacobs et al. (2002) concludes that female students have higher self-efficacy than males from kindergarten through grade twelve in mathematics. While metacognitive awareness plays significant role in self-regulated learning, self-efficacy is important to help the learners to have the belief that they can perform tasks and achieve goals (Zimmerman & Cleary 2006). The learners with less successful strategies are the individuals that have low level of self-efficacy (Brown et al. 1983 cited in Collins 2011, p.34). Self-reflection on performance is the last stage of self-regulation where the learner evaluates the extent of their satisfaction about performance outcomes and it is found that self-efficacy plays a crucial role at this stage because it influences the learners' abilities to judge their task performance and goal achievement (Collins 2011, p.28). In this light, teacher's feedback to students increases their self-efficacy (Zimmerman & Cleary 2006). What leads to the empowerment of learners' self-efficacy is the goal achievement coupled with the cognitive processing that is required to achieve the targeted goal (Collins 2011, p.37).

Self-regulation is among the transferable skills that can be developed in children through social interactions between adults and children as concluded by Vygotsky (1987 cited in Slavin 2011). Therefore, the emphasis on metacognitive strategies to be taught explicitly in the classroom is addressed in the literature (Balcikanli 2011; Lai 2011) by highlighting the effect of metacognitive teaching approach to enhance learning and metacognitive skills (Veenman 2011; Veenman, Van Hout-Wolters & Afflerbach 2006; Veenman, Elshout & Busato 1994). Students' engagement in metacognitive thinking requires teacher's guide through well-designed metacognitive activities which demand teacher's metacognitive awareness in the first place (Ku & Ho 2010; Rahman 2011). Studies (Veenman, Kok & Kuilenburg 2001; Zohar 1999) on teachers' metacognitive awareness indicate that many teachers lack sufficient knowledge about metacognition and their experience in implementing metacognitive strategies is inadequate.

Although several studies investigated the role of metacognition in teaching and learning, the cause and effect of implementing certain metacognitive strategies in specific domains is not explored deeply and openly in the literature (Lai 2011; Zohar & Barzilai 2013). Several metacognitive strategies empower metacognitive knowledge and skills in mathematics and science education like prompted reflection questions, modeling, thinking aloud, metacognitive scaffolding and self-questioning (Du Toit 2013; Haidar & Al Naqabi 2008; Ku & Ho 2010; Mevatech & Fridkin 2006; Parsons 2011). Using journals, interviews and learning logs as metacognitive tools in teaching and learning a certain subject or topic have proven that efficiency can enhance students self-knowledge (Boud, Keogh & Walker 1985; Morrison 1996; Murray 1999; Pintrich 2002; Stephens & Winterbottom 2010).

Flavell (1979, p.27) states “metacognition is congruent with the learners’ need and desire to communicate, explain and justify thinking to organisms as well as to himself”. Numerous studies in science and mathematics education (Gama 2004; Ku & Ho 2010; Rahman 2011) differentiate between metacognitive strategies and skills. This body of research concludes that metacognitively aware students are more strategic and perform better than students who lack such awareness (Bransford, Brown & Cocking 2000; Gama 2004). However, few studies are done about metacognitive awareness in mathematics and science education in the UAE. Haidar and Al Naqabi (2008) researched hundred and sixty-two grade eleven students’ implementation of metacognitive strategies and their influence on the former’s understanding of chemistry. The study debates that learners should be taught how to employ different metacognitive strategies to enhance their learning in chemistry. Similarly, Al Khatib (2010) investigated the relationship between self-efficacy, self-regulation and academic performance among 404 student-teachers using a self-report inventory to assess their motivational orientations and their use of different learning strategies. The results conclude that self-efficacy and self-regulation have positive significant effect on academic performance. Other studies’ results (Al Khatib 2010; Haidar & Al Naqabi 2008) indicate that engaging the learners in their learning processes has a strong influence on their academic performance and the recommendations are to conduct more studies in the field.

The literature review in the current study is aligned with the recent literature review about metacognition in mathematics and physics education (Balcikanli 2011; Lai 2011; Veenman 2012; Zohar & Barzilai 2013; Zohar & Dori 2012) and addresses the following gaps. Firstly, the focus on developing students' metacognitive skills is taking more empirical consideration than developing students' metacognitive knowledge that require more studies on students' metacognitive awareness which involves both of them. Secondly, there is a lack of empirical research that employs cause and effect approach to study the effectiveness of implementing certain metacognitive strategies such as reflection on students' metacognitive awareness and self-efficacy in mathematics and physics. Thirdly, there is an insufficient number of studies on metacognitive awareness of high school students. Thus, the implications of these gaps within the literature are addressed in this current study. The next chapter will outline the research design, methodological approach and participants of this present study so it can contribute to the growing body of literature in the realm of metacognition in mathematics and physics education.

Chapter Three: The Present Study

The previous chapter has showed that there are a limited number of studies which have investigated the effects of implementing a prompted reflection approach in mathematics and science classes. By taking into account the methods used in previous studies on instruction towards developing metacognitive strategy, this study uses prompted metacognitive reflections (Collins 2011; Davis 2003; Fogarty 2006; Surgenor 2011) as metacognitive intervention. The purpose of the current study is to find the effects of prompted reflections on high school students' metacognitive awareness and self-efficacy in physics and mathematics. In this chapter, the quasi-experimental research design employed in the current study is discussed along with the research approach. The quantitative aspect of the quasi-experimental research methodology is addressed and site, participants and instrument are also discussed. Finally, ethical concerns are presented.

3.1 Research Design

By taking into account the literature and the methods used in previous studies about metacognitive activities in mathematics and science education, the current study has applied a quantitative approach to discover the effects of prompted metacognitive reflections (Collins 2011; Davis 2003; Fogarty 2006; Surgenor 2011) on students' metacognitive awareness and self-efficacy in mathematics and physics classes. Many tools are commonly used to measure students' metacognitive awareness and self-efficacy. The literature review points to the variance in students' responses between subject areas and over time so the study has focused on studying the effect of metacognitive intervention within a context-related scope and specific subject on the individual or group of learners (Thomas, Anderson & Nashon 2008; Veenman 2013; Zohar &

Dori 2012). The aim of this study is to discover the cause and effect relationships between particular variables within a quasi-experimental approach with experimental and control groups (Fraenkel, Wallen & Hyun 2012). Experimental research is one of the most powerful research approaches to find the "cause-and-effect relationships among variables" (Fraenkel, Wallen & Hyun 2012, p.265) and directly tries to influence a specific variable.

Quasi-experimental approach is defined as "experimental situations in which the researcher assigns, but not randomly, participants to groups because the experimenter cannot artificially create groups for the experiment" (Creswell 2012, p.626). Moreover, in experimental studies, the variables are more controlled than any other type of research and the threats that might affect the study's internal validity are minimized (Fraenkel, Wallen & Hyun 2012, p.268). Hence, in educational research random choice of participants in control or experimental groups is not always possible and will disrupt the classroom (Cohen, Manion & Morrison 2007, p.283; Creswell 2012, p.309). As such, a pretest-posttest nonequivalent group experimental design with naturally occurring comparison groups is selected to be as similar as possible (Fraenkel, Wallen & Hyun 2012, p.271). So one of the main advantages of the quasi-experimental study is to study the phenomena in its natural setting which satisfies the external validity of the study while maintaining moderate to high control.

A pretest-posttest quasi-experimental design was adopted to fulfill the study purpose to find the effect of students' reflection in enhancing their metacognitive awareness and self-efficacy in physics and mathematics classes. Therefore, the purpose is to compare the effect of prompted reflections as metacognitive treatment (independent variable) on the learner's metacognitive awareness (dependent variable) and self-efficacy (dependent variable) for the experimental group. Figure 2 represents the current study design. The following sections describe the site and population, the specific research approach employed for sampling, data collection, analysis and interpretation.

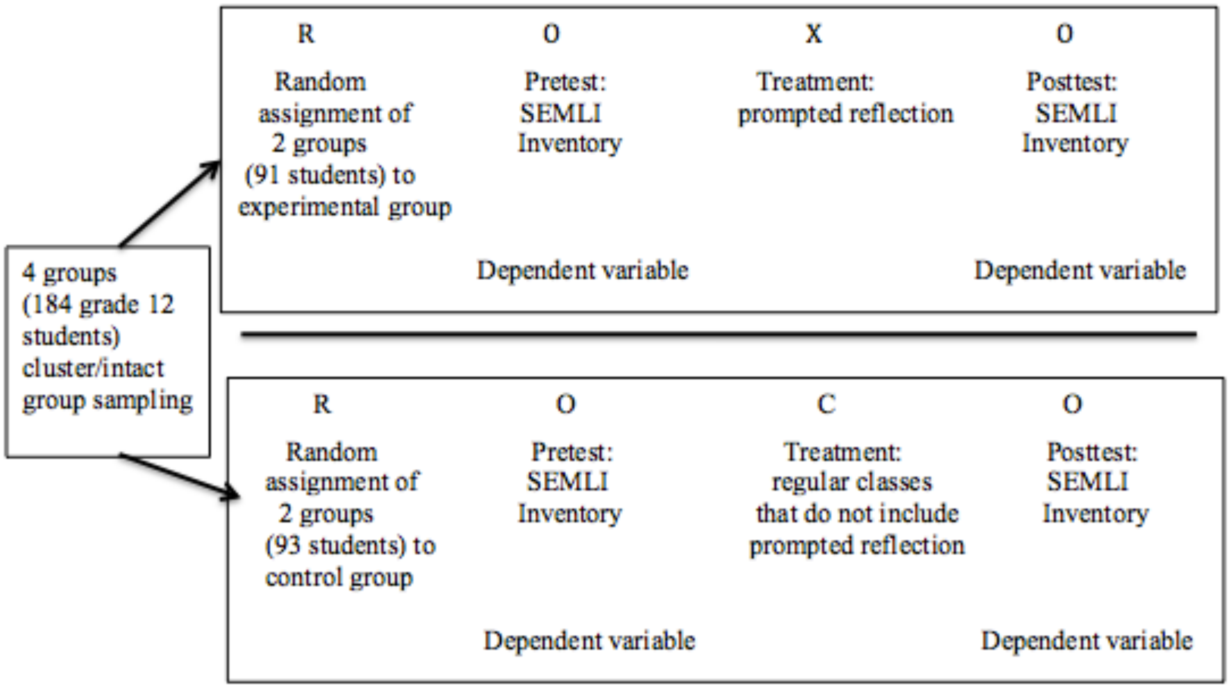

Figure 2: A Pretest-Posttest Control Group Design

In the current study there are two dependent variables: students' metacognitive awareness and learning self-efficacy. The independent variable is the students' prompted reflections. The relationship between these variables are chosen to be studied together because it was found that metacognition alone does not influence learning outcomes and it should be studied in relation to other elements of learning strategies, self-regulation, and metacognition (Thomas, Anderson & Nashon 2008; Veenman, Van Hout-Wolters & Afflerbach 2006; Zohar & Dori 2012).

The operational definitions of the variables are as follows:

- Metacognitive Awareness (MA): means the individuals' awareness of how they learn, how they think and self-reflection. Metacognitive awareness also includes the awareness of planning, monitoring and assessing own cognitive processes in relationship to further learning (Hennessey 1999; Nelson 1992; Schraw & Dennison 1994).
- Learning Self-Efficacy (SE): is the students' perception of their belief in their ability to complete the required tasks and achieve the learning goals.
- Prompted Metacognitive Reflections: refers to the prompted reflection questions that the students answer as they work their way through mathematics and physics learning to trigger their reflective cognition and to help them to connect the learning experience and content knowledge to unfamiliar contexts (Collins 2011; Davis 2003; Hoffman & Spatariu 2008; Wiezbicki-Stevens 2009).

As presented in Chapter 1, the present study was undertaken to address the following question:
To what extent does prompted reflection affect physics and mathematics students' metacognitive awareness and self-efficacy?

The following hypotheses were formulated to guide the study:

Ho 1: There would be a significant difference in the metacognitive awareness scores of the students who participated in the prompted reflections activities and those who did not.

Ho 2: There would be a significant difference in the self-efficacy scores of the students who participated in the prompted reflections activities and those who did not.

Initially, a pilot study was conducted at another American curriculum school for purposes of validity and reliability. Details of the pilot study are given later in this chapter. The main study itself took place over an eight-week period in a K-12 American curriculum school with 184 twelfth-grade students. A pretest was administered to both groups but metacognitive intervention activities were applied on the experimental group only. Finally, the posttest was administered with both groups to assess the effect of the intervention on the experimental group and to find the difference between the two groups (Fraenkel, Wallen & Hyun 2012, p.310). In a quasi-experimental design "the researcher does not use random assignment of subjects to groups" (Fraenkel, Wallen & Hyun 2012, p.275) instead, to reduce the threats to the study's internal validity, the intact groups are randomly assigned to the treatment so the experimental group can hopefully improve their metacognitive skills in the physics and mathematics classes by participating in prompted reflections.

Both the experiment and control groups completed the Self-Efficacy and Metacognition Learning Inventory (SEMLI) in the beginning of the study (week 1), and then again after 6 weeks at the end of the study (week 8). It was made explicitly clear to the students that their responses to the inventory should be related to their physics or mathematics learning processes. Figure 3 below represents the study plan. Only the students in the treatment group participated in prompted reflection tasks twice a week over a period of six weeks, while the students in the control group continued their normal lessons. The researcher created the prompted reflection questions and the teachers gave them to the students twice a week for six weeks where the students independently answered the questions related to the concept studied in the current lesson. They then returned the answers to their teacher. The prompts got the students to think and develop their self-reflection. Every time the students answered the questions, their answers were reviewed and based on the answers, new reflection questions were prompted based on the students' previous reflections. At the same time, the students in the control group received no additional activities and continued their normal lessons. The prompted reflection questions as metacognitive intervention did not require extra instruction time for the experimental group. Therefore, the control group was not disadvantaged in any way with respect to instruction time.

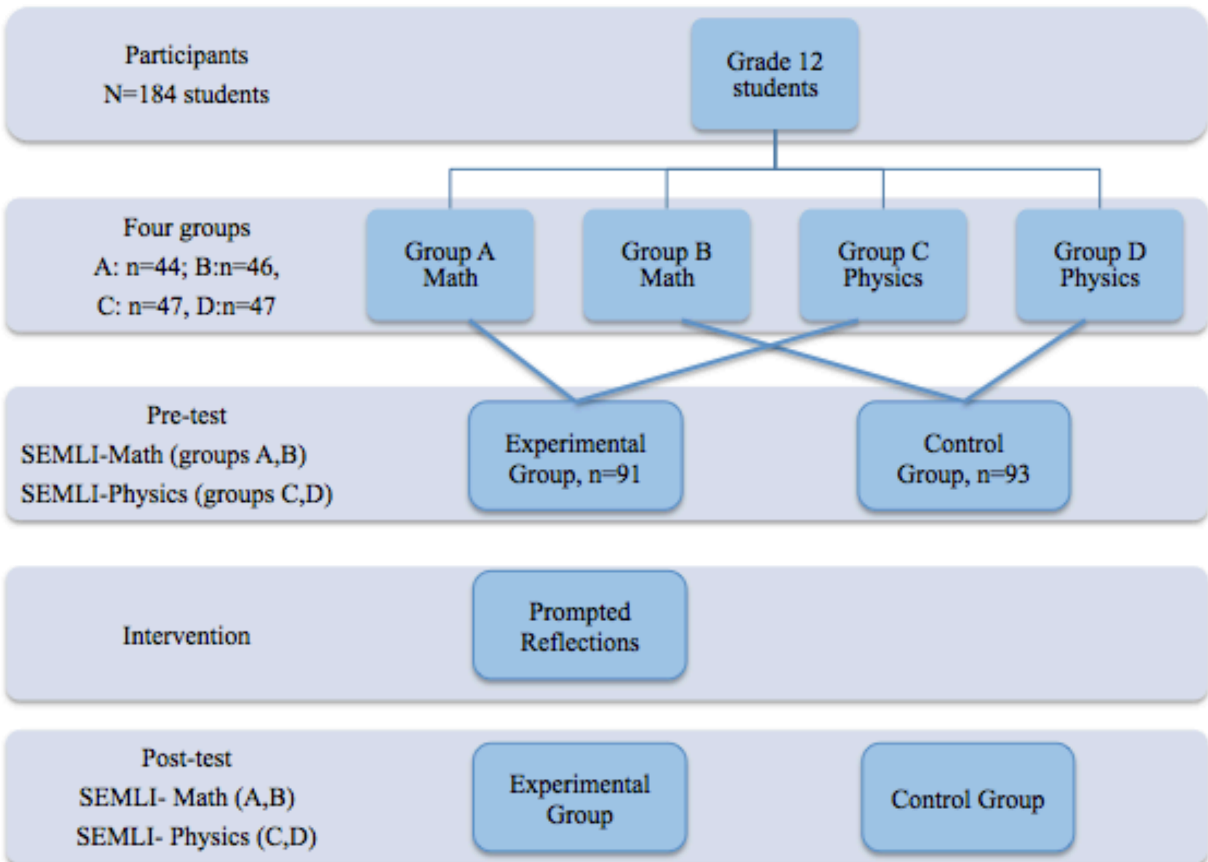

Figure 3: Study Plan

3.2 Instrumentation

Following an extensive review of the literature on metacognition and after taking the several dimensions of metacognition into consideration, two instruments were utilized to collect data in the study:

- The Self-Efficacy and Metacognition Learning Inventory (SEMLI) was used as a pretest and posttest for experimental and control groups.
- Prompted reflection questions for the experimental groups only.

3.2.1 Self-Efficacy and Metacognition Learning Inventory (SEMLI)

The student questionnaire consisted of two sections: section one included the purpose of the study, how to answer the questions, participants' demographic information and course information while the second section was the Self-Efficacy and Metacognition Learning Inventory, one for Math and one for Physics. The inventory consists of 30-items with three subscales of a five point Likert scale (1=strongly disagree, 2=disagree, 3=neutral, 4=agree and 5=strongly agree). Both questionnaires SEMLI-Math and SEMLI-Physics are attached in Appendix 1 and 2 respectively.

The Self-Efficacy and Metacognition Learning Inventory-Science (SEMLI-S) which was originally developed by Thomas, Anderson and Nashon (2008) was modified for this study. The original SEMLI-S is built on the broad scope of metacognition supported by extensive literature review on the relationship between metacognition, cognition and self-regulation. Therefore, the inventory includes items that reflect the conscious interrelation and association of concepts and ideas which are related to learning processes alongside other items that are associated with self-efficacy as part of the self-regulated learning. The inventory's reliability and validity was assessed and the results indicate that SEMLI-S fits the Rasch model well, has reliable Cronbach's-Alpha scores of (0.68 to 0.85), and has significant correlation between the five subscales. The SEMLI-S factor analysis indicates that it can be used for all its factors simultaneously or for each factor separately to assess individual metacognitive science learning orientations (Thomas, Anderson and Nashon 2008, pp.1709-1716).

Thus, SEMLI-S was modified in the current study to be in two forms, one for physics (SEMLI-Physics) and the other for mathematics (SEMLI-Math) to reflect a physics context or a mathematical context respectively. The researcher developed the SEMLI-Physics and SEMLI-Math by modifying items from the 5-subscales of SEMLI-S to be applicable for the current study as shown in Figure 4 below. The modified versions were named SEMLI-Math and SEMLI-Physics and each consists of 30 self-report items that assess different aspects of metacognition and self-regulation and classified into three factors/subscales (metacognitive knowledge MK, metacognitive regulation MR and self-efficacy SE) under two broader components: metacognitive awareness and self-efficacy. Each subscale reflected a dimension of students' self-perceived metacognitive learning orientation in mathematics and physics. Two subscales represented the metacognitive awareness components: metacognitive knowledge and metacognitive regulation (Schraw & Dennison 1994) and the third subscale represented the executive processes of metacognition which is self-efficacy (Veenman 2012; Zohar & Dori 2012).

- Metacognitive Awareness Subscales (MA):

1. Metacognitive Knowledge (MK): includes items that explore students' perceptions of learning processes about connecting the information and knowledge studied in different study contexts such as laboratories, projects or fieldtrips in physics and mathematics.
2. Metacognitive Regulation (MR): includes items that explore students' perceptions of awareness of task performance and its impact on their learning, monitoring of own cognition, planning activities and evaluation of the effectiveness of strategies.

➢ Self-Efficacy:

3. Learning Self-Efficacy (SE): explores students' perceptions of their belief in their ability to complete the required tasks and achieve the learning goals.

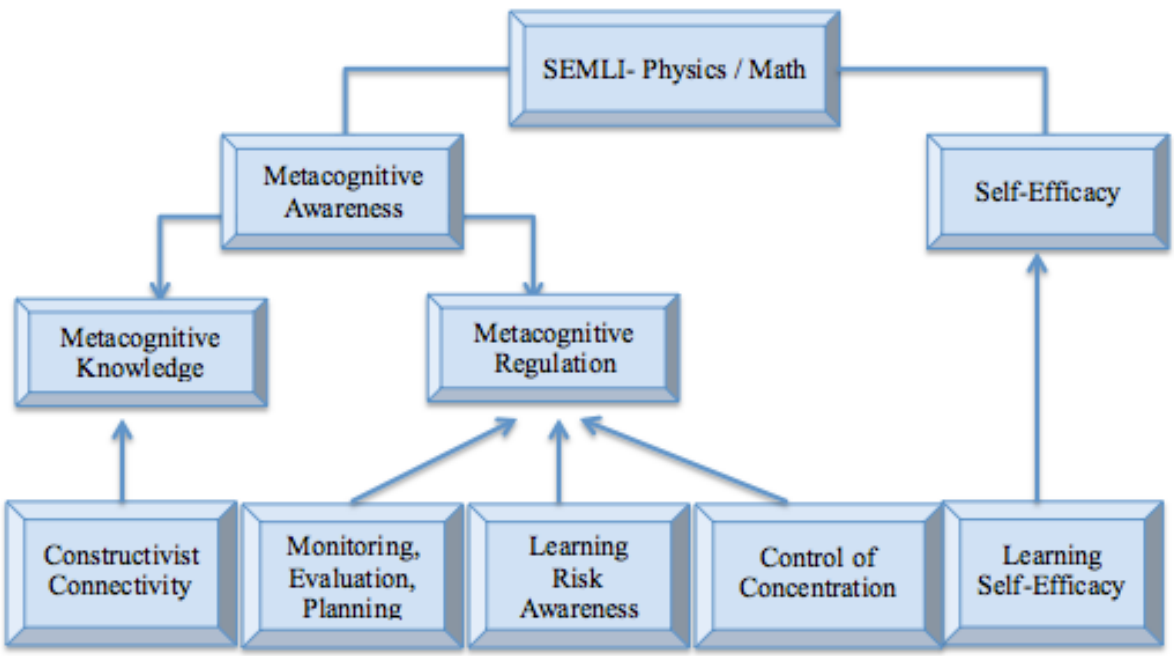

Figure 4: SEMLI Subscales Structure

Table 2 below represents the distribution of the statements under each subscale. The questionnaire (see Appendix 1 & 2) given to the students did not include the subscales for the purpose of validity and reliability because providing categories might influence the students' responses.

Metacognitive Knowledge (MK)	
SN	**Statement**
1	I seek to connect what I learn from math/physics classes in daily life without needing more math/physics information from outside classroom.
5	I seek to connect what I learn from out-of-school math/physics activities with what happens in the math/physics classroom.
11	I seek to bring in what I learn in my life outside of classrooms to math/physics classes.
15	I seek to connect the information learned in math/physics classes with what I already know.
20	I seek to connect what I learn from out-of-class of the math/physics activities with what happens inside the math/physics classes.
25	I seek to connect what I learn from what happens in the math/physics classroom with out-of-school math/physics.
30	I seek to connect what I learn from what happens in the math/physics classroom with out-of-school math/physics.
Metacognitive Regulation (MR)	
SN	**Statement**
2	I adjust my plans for learning tasks if I am making in them the progress I think I should do.
4	I am aware of when I am about to have a challenge in learning.
6	I plan to check my progress during a learning task.
7	I adjust my level of concentration, depending on the learning situation.
8	I try to understand clearly the aim of a task before I begin it.
10	I evaluate my learning processes with the aim of improving them.
12	I am aware of when I am about to loose track of a learning task.
13	I consider what type of thinking is best to use before I begin a learning task.
16	I am aware of when I don't understand an idea.
17	I consider whether or not a plan is necessary for a learning task before I begin that task.
18	I adjust my level of attention depending on the difficulty of the task.
21	I stop from time to time to check my progress on a learning task.
22	I am aware of when I have learning difficulties.
24	I try to predict possible problems that might occur with my learning.
26	I am aware of when I am not concentrating.
27	I assess how much I am learning during a learning task.
29	I adjust my level of concentration to suit different math/physics topics.

Learning Self-Efficacy (SE)	
SN	**Statement**
3	I know I can understand the most difficult material presented in the readings for this subject.
9	I know I can master the skills being taught in this course.
14	I am confident I can do a good job on the assignments and tests in this math/physics class.
19	I believe I will receive an excellent grade in this course.
23	I am confident of understanding the most complex material presented by the teacher in this course.
28	I am confident of my understanding of the basic concepts taught in this subject.

Table 2: Distribution of the Statements in the SEMLI

3.2.2 Prompted Metacognitive Reflection Questions

Only the students in the experimental group participated in a prompted metacognitive reflection questions twice a week over a period of six weeks. Guided reflection and prompted reflections are found to be effective for developing the learners metacognitive awareness (Collins 2011; Hennessey 1999; Hoffman & Spatariu 2008; Nelson 1992; Schraw & Dennison 1994) which refers to the individual's awareness of how they learned, how they think, how they self-reflect and how they were aware of monitoring and assessing their own cognitive processes in relationship to further learning. The researcher developed prompted reflection questions in the form of open-ended questions (Appendix 3) which consisted of self-reflection and reflective questions related to a specific concept that was taught in the subject. The students answered the questions twice a week. The researcher reviewed the answers and based on the answers, new prompts were created guided by the students' answers. Each group of prompted reflections was given to the students on a worksheet at the end of the period which was handed back to the teacher the next day. The prompted reflection questions were designed to gauge students' perceptions of math and science learning processes, their awareness of learning goals, to monitor, evaluate and plan.

3.3 Participants and Site

The participants were a hundred eighty-four grade twelve students (ninety-three female and ninety-one male) in a K-12 private school in Dubai, the UAE. One mathematics teacher taught the math groups and one physics teacher taught the physics groups. The school follows the American curriculum and English is the language of instruction. The students start grade one at age five and finish high school at age 16. The classes have an average of 23 students and boys and girls are in separate classes from grade four until grade twelve. The participants represent a sample of the total 493 grade 9-12 high school students. The students starting from grade 11 can select specific courses related to higher education requirements and their academic achievement. Grade 12 students were chosen to be the participants in the study because this group studies both physics and mathematics courses.

The experimental group and the control group may have different characteristics; such as age, gender, in addition to the learners' achievement levels in mathematics and physics that could influence the independent variables (Fraenkel, Wallen & Hyun 2012, p.267). Therefore, to increase the internal validity of the study, a pretest-posttest quasi-experimental design with naturally occurring comparison groups has been deemed as the best approach. The sampling method in the current study is a "cluster random sampling" (Fraenkel, Wallen & Hyun 2012, p.96) where the researcher selected already existed clusters or intact group "classes" to be assigned randomly to experimental and control groups. The classes are randomly divided into four groups: two control groups (one group mathematics and one group physics) and two experimental groups (one group mathematics and one group physics). The procedure of the cluster group sampling is shown in Figure 5.

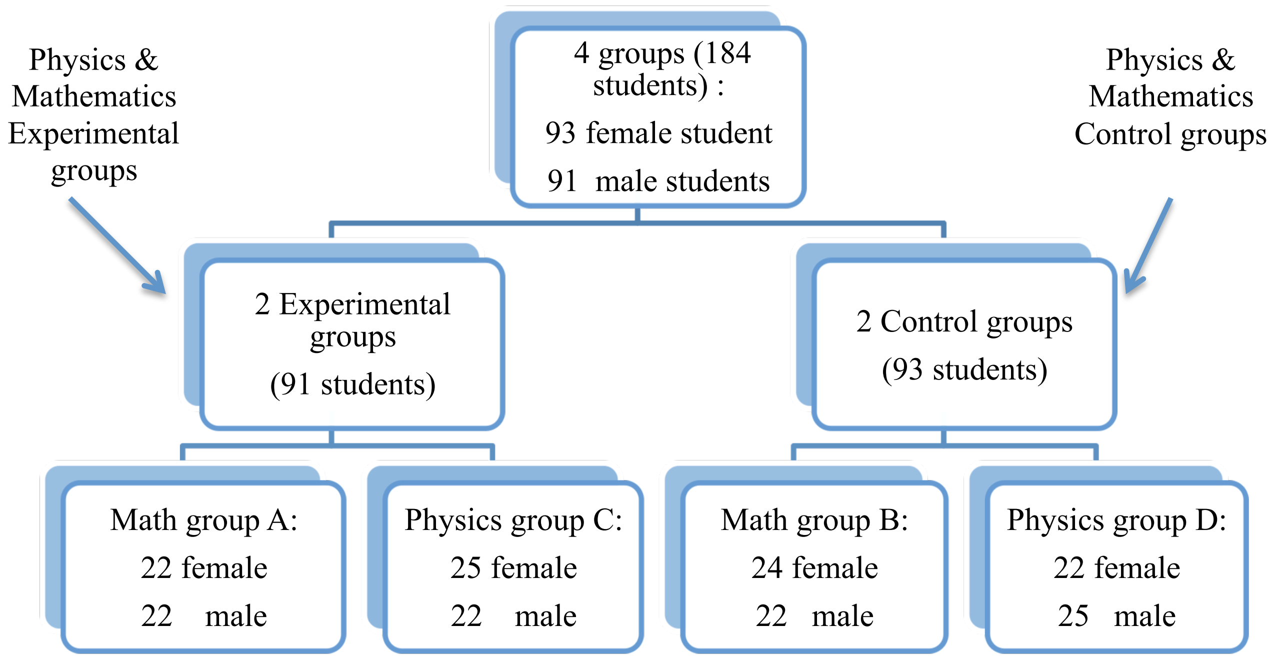

Figure 5: Cluster/Intact Group Sampling

The students are from the same cultural and socio-economic background with age range from 16 to 17. The average of the students' academic achievement in mathematics and physics reflect an equivalent distribution of the students on both control and experimental groups as shown in Tables 3 and 4. The teachers of experimental and control groups are equivalent of each other in term of age, gender, academic and professional qualifications and years of experience as shown in table 5.

Subject / Group	No of Students	Average	Standard Deviation
Mathematics A (Experimental)	44	75.4	6.85
Mathematics B (Control)	46	79.1	5.73
Physics C (Experimental)	47	76.5	7.35
Physics D (Control)	47	77.2	7.09

Table 3: Students Academic Achievement per (Subject & Group)

Group	Subject	Gender	No of Students	Average	Standard Deviation
A	Mathematics A (Experimental)	Female	22	78	6.37
		Male	22	72.8	7.33
C	Mathematics B (Control)	Female	24	79	5.25
		Male	22	79.2	6.21
D	Physics C (Experimental)	Female	25	74.3	7.37
		Male	22	78.8	7.33
E	Physics D (Control)	Female	22	76.1	6.74
		Male	25	78.3	7.44

Table 4: Students Academic Achievement Per (Subject, Group & Gender)

Teachers	Gender	Academic Qualification	Professional Qualification	Years of Teaching Experience
Mathematics Teacher	Male	Bachelor of Science in Mathematics	NA	13 Years
Physics Teacher	Male	Bachelor of Science in Physics	NA	10 Years

Table 5: Teachers Demographic Information

3.4 Pilot Study

For validity and reliability purposes the instruments were piloted as recommended by Fraenkel, Wallen and Hyun (2012) before the study started. Various parties, including the researcher's academic supervisor, math and science teachers from different American curriculum school, checked the SEMLI questionnaire and the prompted reflection questions. The questionnaire was piloted with sixty-two Grade 12 students from another American curriculum school. Few words were changed for more clarification according to the feedback from the participants in the piloting process. The teachers also revised the prompted reflection questions and the questions were customized to suit certain concepts in mathematics and physics that were covered in the time of the study. The feedback was used to finalize the SEMLI form and the recommendations were considered in the study instruments.

Validity is defined as "the appropriateness, correctness, meaningfulness, and usefulness" (Fraenkel, Wallen & Hyun 2012, p.148) of the evidence collected by the researcher based on the study data. Several indications of validity are related to the content of the instrument and its consistency with the variable and the sample to be measured (Fraenkel, Wallen & Hyun 2012, p.148). Internal and external validity were the main considerations in developing and evaluating the instrument. While the internal validity focused on testing what the SEMLI was supposed to measure, the external validity focused on the possible generalization of the SEMLI to the population of the study and the degree to which the interpretations of the instrument's scores are supported by the literature and theory (Creswell 2012).

The reliability of a quantitative study refers to the consistency of the inventory measurement (Cohen, Manion & Morrison 2007; Fraenkel, Wallen & Hyun 2012, p.154). SEMLI was tested for reliability as shown in table 6 below. The reliability result of Cronbach's-Alpha test = 0.939 indicated a high level of internal consistency for the 30 items. The detailed reliability results per item are attached (Appendix 4).

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.939	0.939	30

Table 6: Reliability Test Results

The correlation between the inventory subscales shows high level of correlation at significant level of $\alpha = 0.05$ and the relations between variables are positive. The inventory was also subjected to factor analysis (Table 7) to provide an empirical test of the credibility of the three-factor structure (MK, MR, SE) of the modified version of SEMLI-Math and SEML-Physics. Moreover, the factor analysis' results of the 30-items and of the subscales/factors support the factorial validity of the SEMLI inventory where the KMO values are closer to 1 and the significant level of the sphericity test is 0.000. These results are consistent with the literature review about the relationship between metacognitive awareness components and self-efficacy (Lai 2011; Veenman2012). The detailed factor analyses are attached in Appendices 5 & 6.

Item/ Subscale	Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO)	Bartlett's Test of Sphericity Approx. Chi-Square	df	Significance
30-items SEMLI	0.925	4824.353	435.000	0.000
Metacognitive Knowledge MK	0.865	677.651	21.000	0.000
Metacognitive Regulation MR	0.910	2273.981	136.000	0.000
Self-Efficacy SE	0.821	475.456	10.000	0.000

Table 7: Factor Analysis Results- KMO and Bartlett's Test

3.5 Data Collection and Analysis

The research plan was executed and quantitative data were collected in the form of the SEMLI scores from the pretest and posttest. The pretest and posttest scores for the study groups, 91 students in the experimental group and 93 students in the control group, were saved in Microsoft EXCEL file then analyzed statistically using the Statistical Package for Social Science (SPSS) software. Since the participants were more than 30, a parametric test will be used to test the hypotheses (Field 2009). Descriptive and inferential statistical tests were used to answer the research questions by finding the statistical significance of the differences in the mean of the SEMLI scores on the pretest and the posttest between the experimental and control group and within each group to test the study hypotheses (Field 2009).

As outlined in chapter 1, two hypotheses were formulated to guide the study. Hence, two different groups were investigated for one independent variable (prompted reflections), therefore t-test for independent samples will be used to compare the variables within each group in order to determine the statistical significance of the differences between the means of the pretest and posttest SEMLI scores. T-test for independent variables will also be used for two levels of each independent variable.

3.6 Ethical Considerations

Ethical issues arise when reliable and valid data are collected (Cohen, Manion & Morrison 2007), therefore, official permission to conduct the study was obtained from the school management to run the study on a voluntary basis and without mentioning the school's name or the participants' names. The school management and participants were informed about the aim of the study and they signed the consent forms (Appendices 7, 8, 9). The students' questionnaire included the purpose of the study and participation was totally voluntary. The school management and participants showed positive attitude and enthusiasm to participate.

The students of the experimental group were not exposed to any pressure to answer the prompted reflection questions. The metacognitive intervention does not require extra instruction time for the experimental group. Therefore, the control group was not disadvantaged with respect to instruction time. The study did not intend to reflect negatively on the participants or their teachers but to enhance the students' learning and metacognitive awareness in mathematics and science classes. The results might point to the poor learning skills of some students but the report of the results will be given to the school management and the data is going to be presented in an exploratory manner to interpret the findings from different perspectives. The next chapter will present the findings of this present study and analyze them in light of the research question and hypotheses explained earlier.

Chapter Four: Data Analysis and Results

Chapter four presents the analysis of collected data from the pre- and post-test scores of Self-Efficacy and Metacognition Learning Inventory for mathematics (SEMLI-Math) and for physics (SEMLI-Physics). A pretest-posttest quasi-experimental design was applied to fulfil the study purpose to determine the effect of prompted reflections on students' metacognitive awareness and self-efficacy in physics and mathematics classes. Therefore, the purpose is to compare the effect of prompted reflections as metacognitive treatment (independent variable) on the learner's metacognitive awareness (dependent variable) and self-efficacy (dependent variable) for the experimental group versus the control group which did not have the intervention. The participants were hundred eighty-four grade twelve students in mathematics and physics classes in K-12 American curriculum school in Dubai. In accordance with the study purpose, two hypotheses were formulated to guide the study's investigation to answer the study question: To what extent does prompted reflection affect physics and mathematics students' metacognitive awareness and self-efficacy?

Study data were analysed according to the following sequence: First, in studying the effect of an independent variable on dependent variables, the data collected from the pretest was analysed using independent t-test for the experimental and control groups to determine if the groups are equivalent and the sampling is adequate. Second, descriptive statistics were applied to compare the mean scores of experimental groups and control groups for math and physics simultaneously. Hence, two different groups were investigated for the effect of one independent variable (prompted reflections); therefore, inferential statistics were adopted by applying paired t-test on independent variables to compare the variables within each group in order to determine the statistical significant differences between the mean scores of pretest and posttest, if any. Then, the second step was repeated but for each subject separately. Finally, the effect of prompted reflections on students' metacognitive awareness (metacognitive knowledge, metacognitive regulation subscales) and self-efficacy components were investigated by calculating the differences between the mean scores of pretest and posttest scores for each subscale of the inventory individually.

4.1 Experimental and Control Groups' Equivalency and Adequacy

The participants were hundred eighty-four grade twelve students in four classes. The classes were randomly selected to form four groups. Therefore, the results are extracted from two experimental groups: one mathematics group (A) of 44 students (22 female and 22 male) and one physics group (C) of 47 students (25 female and 22 male) and two control groups: one mathematics group (B) of 46 students (24 female and 22 male) and one physics group (D) of 47 students (22 female and 25 male). In order to study the equivalence of the four groups, they were pre-tested and the results were compared. Independent t-test has been applied and p value of statistical significance was calculated. Table 8 below represents the results.

Subject	Group	No of Students N	Mean M	Standard Deviation SD	df	Independent t-test	P*
Math	Experimental (A) & Control (B)	90	106.02	13.02	182	0.0750	0.94
Physics	Experimental (C) & Control (D)	94	105.83	20.38			
Math & Physics	Experimental (A&C)	91	104.73	14.96	182	0.7046	0.48
	Control (B&D)	93	106.35	16.36			
Math	Experimental (A)	44	104.50	14.25	88	1.1047	0.27
	Control (B)	46	107.54	11.79			
Physics	Experimental (C)	47	106.49	18.89	92	1.0719	0.29
	Control (D)	47	102.21	19.78			

*p is significant at p<0.05, df=degree of freedom

Table 8: Comparisons of Pretest Scores for Experimental and Control Groups

As shown in table 8, there was no significant difference in the pretest scores for mathematics experimental and control groups (M= 106.02, SD= 13.02) and physics experimental and control groups' (M= 105.83, SD= 20.38) conditions: t(182) = 0.0750, p=0.94. There was also no significant difference in the pretest scores of mathematics and physics control groups (M= 107.08, SD= 17.07) and mathematics and physics experimental groups' (M= 104.77, SD= 17.73) conditions: t(182)= 0.7046, p= 0.48. When analyzing each subject group separately, it was found that there is no significant difference in the pretest scores for mathematics experimental group

(M= 104.50, SD= 14.25) and mathematics control group (M= 107.54, SD= 11.79) conditions: t(88)= 1.1047, p= 0.27. There is also no significant difference in the pretest scores for physics experimental group (M= 106.49, SD= 18.89) and physics control group (M= 102.21, SD= 19.78) conditions: t(92)= 1.0719, p= 0.29.

Hence, it can be construed that there is no significant difference between the groups in terms of pretest mean scores either within the same subject or across subjects, and experimental and control groups had similar starting point before the intervention so this study can be deemed as appropriate for the current groups. Kaiser-Meyer-Olkin (KMO) test was also applied to measure the sampling adequacy which yielded KMO = 0.925, so the results indicate a sizeable sampling adequacy in the study.

4.2 Students' Metacognitive Awareness and Self-Efficacy

This section includes the descriptive statistics and inferential statistics of SEMLI scores to find out the effects of prompted reflections on students' metacognitive awareness and self-efficacy. The first level of analysis is to find the relationship between the mean scores of math and physics experimental groups combined and compare them to the mean scores of math and physics control groups combined. The next level will be to compare the experimental group with the control group for each subject respectively.

4.2.1 Overall Analysis

A descriptive statistics and paired t-test were applied to find out if there is any significant difference between the students' pretest and posttest scores within the same group. An independent t-test for variables was also applied to find out if there is any statistical significant difference between posttest scores for both experimental and control groups.

Subject	Group		N	Mean M.	S.D.	Paired t-test	df	P
Math & Physics	Experimental (A&C)	Pre	91	104.73	14.96	6.4977	90	0.000
		Post	91	117.75	12.26			
	Control (B&D)	Pre	93	106.35	16.36	1.7945	92	0.076
		Post	93	110.17	16.12			

Table 9: Descriptive Statistics and Paired T-Test Results Between Both Experimental and Control Groups Pre-Post SEMLI Scores

Paired t-test results in Table 9 above indicate that there is a high significant difference between the pretest and posttest scores for the experimental group $t(90) = 6.4977$; $p < 0.05$ at significant value $p=0.000$. While in the control group $t(92) = 1.7945$; $p>0.05$ and $p=0.076$ means there is no significant difference between pretest and posttest scores. These findings partially answer the study question that there is significant improvement in the students' metacognitive awareness and self-efficacy for both the math and physics groups who participated in prompted reflections while the students who did not participate in prompted reflections did not show any improvement.

Table 9 above shows also that the mean scores in experimental group before the treatment was 104.73 with the standard deviation at 14.96. After they had been exposed to prompted reflections, their mean scores increased to 117.75 with standard deviation at 12.26. Similarly, the mean scores in the control group were 106.35 with standard deviation at 16.36 and after 6-weeks without treatment, their mean scores were 110.17 with standard deviation at 16.12. The difference between mean scores of experimental group in the pretest and posttest was 13.02, which is greater than the difference between mean scores of control group (=3.82) as shown in Figure 6 below. This confirms that the total participating students from both math and physics experimental groups had the greater gain compared to the control groups with less variation compared to control group. In addition, the standard deviation of the experimental group decreased after the treatment, while the standard deviation of the control group has almost remained the same which indicates the variation of scores from its mean score. These results also answered the study question about the extent of the effect of prompted reflections on students' metacognitive awareness and self-efficacy.

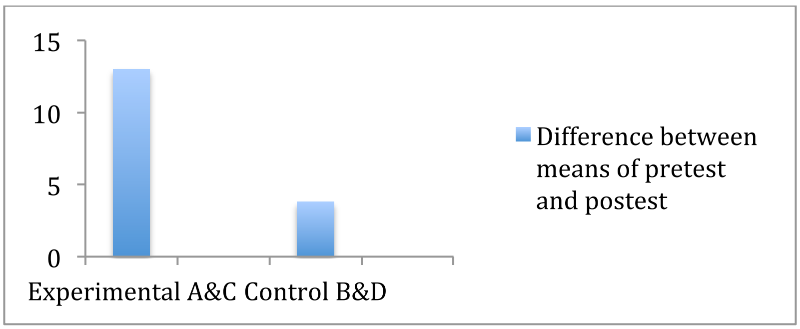

Figure 6: Difference between Mean Scores of Experimental and Control Groups Pretest and Posttest

In order to answer the study question by comparing the posttest scores of the experimental and control groups to determine if there is any effect of prompted reflections on students' metacognitive awareness and self-efficacy, an independent t-test was conducted. These results revealed that there the treatment caused significant difference between experimental and control groups at a high significant value of $p=0.000$ where $t(182) = 3.2812$: $p<0.05$ as shown in Table 10 below. Moreover, the mean score of the experimental group is $M=117.75$ while the mean score of the control group is $M= 110.17$. The standard deviation of the control group is greater than the standard deviation of the experimental group which indicates a higher variation of students' scores from the mean in the control group than the experimental group. The detailed analysis is attached in Appendix 10.

Posttest SEMLI								
Subject	**Group**		**N**	**Mean M.**	**S.D.**	**Independent t-test**	**df**	**P**
Math & Physics	Experimental (A&C)	Post	91	117.75	12.26	3.5812	182	0.000
	Control (B&D)	Post	93	110.17	16.12			

Table 10: Descriptive Statistics and Independent T-Test Results for Posttest SEMLI Scores for both Experimental and Control Groups

The next two sections compare the difference between the students' SEMLI scores in the experimental and control groups to show if there is effectiveness of the prompted reflections on the students' metacognitive awareness and self-efficacy in each subject separately. The full analyses are displayed in Appendices 11 and 12.

4.2.2 Mathematics Groups

Table 11 below shows that the paired t-test results indicate that the difference between mean scores of experimental group pretest and posttest is highly significant $t(43)= 5.044$, $p<0.05$ while in the control group, $t(45)= 0.330$, $p>0.05$ is not a significant difference. The mean scores of SEMLI-Math in the experimental group increased and the standard deviation decreased after the treatment. Similarly, the mean scores of the control group increased slightly but the standard deviation increased too. This result addresses the study question that there is significant improvement in the math students' metacognitive awareness and self-efficacy after the prompted reflections while the students who did not experience prompted reflections did not improve significantly in their metacognitive awareness and self-efficacy.

Subject	Group		N	Mean M.	S.D.	Paired t-test	df	P
Mathematics	Experimental (A)	Pre	44	104.50	14.25	5.044	43	0.000
		Post	44	119.94	11.18			
	Control (B)	Pre	46	107.54	11.79	0.3303	45	0.742
		Post	46	108.33	18.64			

Table 11: Descriptive Statistics and Paired T-Test Results of SEMLI-Math Scores for Experimental and Control Groups

4.2.3 Physics Groups

Table 12 below shows that the paired t-test results show that the difference between mean scores of experimental group in pretest and posttest is significant where $t(46)= 2.7701$, $p<0.05$ while in the control group $t(46)= 1.1027$, $p>0.05$ is not significant. The mean score of SEMLI-Physics in the experimental group increased and the standard deviation decreased after the treatment. Similarly, the control group's mean scores increased and the standard deviation decreased too. These results indicate that there has been a significant improvement in physics students' metacognitive awareness and self-efficacy after the prompted reflections while the physics students who did not participate in prompted reflections did not experience significant improvement in their metacognitive awareness and self-efficacy levels.

Subject	Group		N	Mean M.	S.D.	Paired t-test	df	P
Physics	Experimental (C)	Pre	47	106.49	18.89	2.7701	46	0.008
		Post	47	115.34	13.16			
	Control (D)	Pre	47	102.21	19.78	1.1027	46	0.275
		Post	47	106.21	16.31			

Table 12: Descriptive Statistics and Paired T-Test Results of SEMLI-Physics Scores for Experimental and Control Groups

These results corroborate the overall findings given earlier that there is significant difference between the metacognitive awareness and self-efficacy level of both the mathematics and physics students who participated in prompted reflections and the students who did not. There has been an increase in the metacognitive awareness and self-efficacy of the participating students in both the experimental group and the control group but the students in the control group have not experienced the same level of change in the same skills. Simultaneously the experimental groups, both in mathematics and physics, had greater gain compared to the control groups.

4.3 Effect of Prompted Reflections on Students' Metacognitive Awareness

To test the first study hypothesis that there would be a significant difference in the metacognitive awareness scores of the students who participated in the prompted reflections and those who did not, an independent t-test was conducted between the experimental and control groups' posttest scores. The mean scores of the pretest and posttest obtained from the metacognitive awareness subscales (Metacognitive knowledge and Metacognitive Regulation) in the SEMLI inventory for each group were also compared and a paired t-test was applied as shown in Tables 13 and 14 below.

Posttest SEMLI										
Subject	**SEMLI Subscales**	**Group**		**N**	**Mean M.**	**S.D.**	**Independent t-test**	**df**	**SE**	**P**
Math & Physics	MA	Experimental (A&C)	Post	91	94.00	10.34	2.723	182	1.71	0.007
		Control (B&D)	Post	93	89.32	12.81				
Mathematics	MA	Experimental (A)	Post	44	95.73	8.87	0.8351	88	2.335	0.405
		Control (B)	Post	46	93.78	12.83				
Physics	MA	Experimental (C)	Post	47	92.38	11.40	1.865	92	2.61	0.065
		Control (D)	Post	47	87.51	13.80				

Table 13: Comparisons of Posttest SEMLI Scores for both Experimental and Control Groups

Table 13 indicates that there is significant difference between the metacognitive awareness level of the students in all the math and physics experimental and control groups, which indicates the treatment effect is significant $t(182) = 0.5476$: $p<0.05$ and $p=0.007$. However, in the math groups only, there is no significant difference between the posttest scores of experimental and control groups while in physics groups the p value is very close to significant level where $p=0.065$. The mean scores of metacognitive awareness in all the experimental groups are higher than the control groups. Simultaneously, the standard deviation of each control group is greater than the standard deviation of the experimental groups which indicates a higher variation of students' metacognitive awareness from the mean in the control group than the experimental group. These results accept the first hypothesis that there would be a significant difference in the metacognitive awareness scores of the students who participated in the prompted reflections and those who did not regardless of their subject. However, for each subject respectively, there is no significant difference between the students' metacognitive awareness who participated in prompted reflections and those who did not.

The comparison between the students' metacognitive awareness scores before the prompted reflections and after as shown in table 13, indicates that there is a significant difference in the scores for math and physics students. The value of significance is high for all the experimental groups. Moreover, the mean scores of metacognitive awareness in all the experimental groups increased after the treatment and are higher than the mean scores of metacognitive awareness in the control groups. The same comparison among the students who did not experience any prompted reflections indicates that there is no significant difference in their scores. These results answer the study question by concluding that the students who did not experience prompted reflections did not demonstrate the same level of improvement in their metacognitive awareness level.

Subject	SEMLI Subscales	Full Score	Time	Experimental Group							Control Group						
				N	Mean M.	S.D.	Paired t-test	df	SE	P	N	Mean M.	S.D.	Paired t-test	df	SE	P
Math & Physics	MA	120	Pre	91	81.81	13.15	7.092	90	1.71	0.000	93	87.02	12.60	1.376	92	1.67	0.172
			Post	91	94.00	10.34					93	89.32	12.81				
Math	MA	120	Pre	44	80.41	8.49	7.826	43	1.95	0.000	46	91.91	8.82	1.538	45	1.78	0.130
			Post	44	95.73	8.87					46	93.78	12.83				
Physics	MA	120	Pre	47	83.13	16.35	3.391	46	2.72	0.001	47	85.30	16.11	0.773	46	2.86	0.443
			Post	47	92.38	11.40					47	87.51	13.80				

Table 14: Descriptive Statistics and Paired T-Test Results of SEMLI Subscales Scores in Math & Physics

By looking at the metacognitive awareness subscales as shown in Appendix 12, the comparison between the students' metacognitive knowledge and regulation scores before the prompted reflections and after indicates that all the mean scores increased and there is a significant difference in the scores for math and physics students. The p value is highly significant ($p=0.000$) for all the students except for metacognitive knowledge in physics $t(46)= 2.112$, $p= 0.040$. The same comparison among the students who did not experience any prompted reflections treatment indicates that although the mean scores increased, there is no significant difference in their scores. These results conclude that the UAE high school students have experienced significant improvement in their metacognitive knowledge and metacognitive regulation after prompted reflections while the students who did not participate in prompted reflections did not improve.

4.4 Effect of Prompted Reflections on Students' Self-Efficacy

To test the study's second hypothesis that there would be a significant difference in the self-efficacy scores of the students who participated in the prompted reflection activities and those who did not, independent t-test and paired t-test were calculated and the mean scores of pretest and posttest obtained from the self-efficacy subscale in the SEMLI inventory for each group were compared, and presented in Tables 15 and 16 below.

Posttest SEMLI										
Subject	**SEMLI Subscales**	**Group**		**N**	**Mean M.**	**S.D.**	**Independent t-test**	**df**	**SE**	***P**
Math & Physics	SE	Experimental (A&C)	Post	91	23.32	3.51	0.051	182	0.57	0.958
		Control (B&D)	Post	93	23.35	4.28				
Math	SE	Experimental (A&C)	Post	44	24.59	2.94	0.143	88	0.767	0.886
		Control (B&D)	Post	46	24.48	4.20				
Physics	SE	Experimental (A&C)	Post	47	22.13	3.62	0.162	92	0.79	0.870
		Control (B&D)	Post	47	22.26	4.10				

Table 15: Comparisons of Posttest Self-Efficacy SEMLI Scores for both Experimental and Control Groups

Table 15 indicates that there is no significant difference between the self-efficacy level of all experimental groups and control groups. While the mean scores of self-efficacy in all the experimental and control groups are almost similar, the standard deviation in the experimental groups is smaller than the standard deviation in the control groups. These results accept the alternative hypothesis that there would not be a significant difference in the self-efficacy scores of the students who participated in the prompted reflection activities and those who did not. To answer the study question about the extent of effectiveness of prompted reflections on self-efficacy, the students' self-efficacy scores before the prompted reflections and after were compared and as shown in table 16, the results indicate that there is a significant difference in the scores of math students $t(43)= 3.575$, $p< 0.05$ while there is no significant difference in the physics students' scores t(46) =0.200 , p> 0.05. The same comparison among the students who did not experience any prompted reflections indicates that there is no significant difference in their scores. These findings indicate that the math students who participated in prompted reflections improved significantly in their self-efficacy while the physics students did not improve. In comparison, the math and physics students who did not participate in prompted reflections did not improve in their self-efficacy levels.

Subject	SEMLI Subscales	Full Score	Time	Experimental Group							Control Group						
				N	Mean M.	S.D.	Paired t-test	df	SE	P	N	Mean M.	S.D.	t	df	SE	P
Math & Physics	SE	30	Pre	91	22.19	4.39	2.118	90	0.53	0.036	93	22.46	4.21	1.627	92	0.54	0.107
			Post	91	23.32	3.51					93	23.35	4.28				
Math	SE	30	Pre	44	22.43	3.46	3.575	43	0.60	0.000	46	23.63	3.19	1.298	45	0.65	0.200
			Post	44	24.59	2.94					46	24.48	4.20				
Physics	SE	30	Pre	47	21.96	5.14	0.200	46	0.84	0.842	47	21.32	4.78	1.058	46	0.88	0.295
			Post	47	22.13	3.62					47	22.26	4.10				

Table 16: Descriptive Statistics and Paired T-Test Results of SEMLI Self-Efficacy Scores in Math & Physics

4.5 Summary of Results

After analysing all the data, Figure 7 below presents the mean SEMLI scores of both the experimental and control groups for mathematics and for physics together and individually.

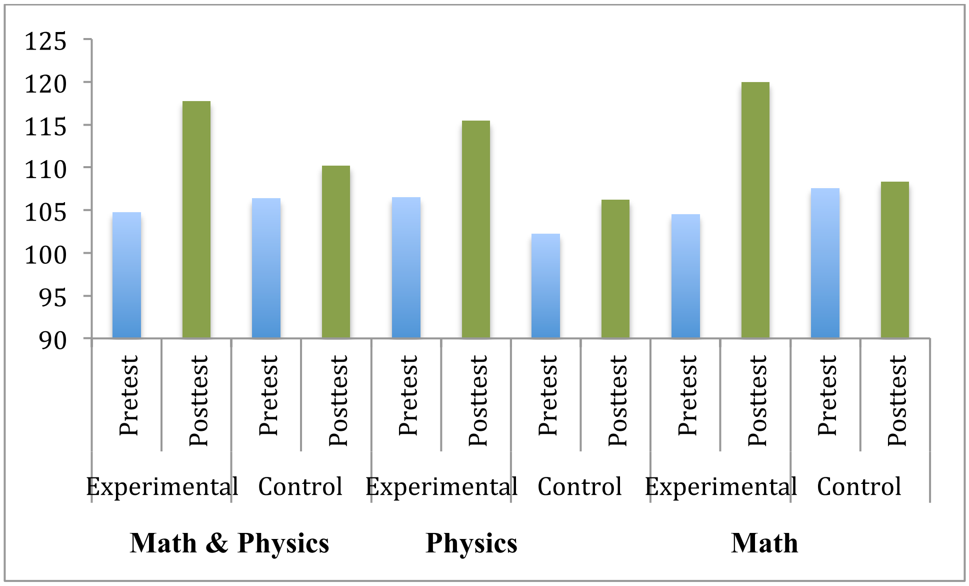

Figure 7: Mean SEMLI Scores of Pre-test and Post-test of both the Experimental and Control Groups

The graph shows an increase in the mean scores of posttest in all the groups which can be seen as proof of increase in the students' metacognitive awareness and self-efficacy. However, the difference between the pretest and posttest scores is not significant in both the math and physics control groups but is significant in both the experimental groups except for self-efficacy in the physics group.

The following graph (Figure 8) summarizes the effect of prompted reflections on students' metacognitive awareness subscales and self-efficacy in the mathematics and physics groups through differences between the students' average scores in posttest and pretest.

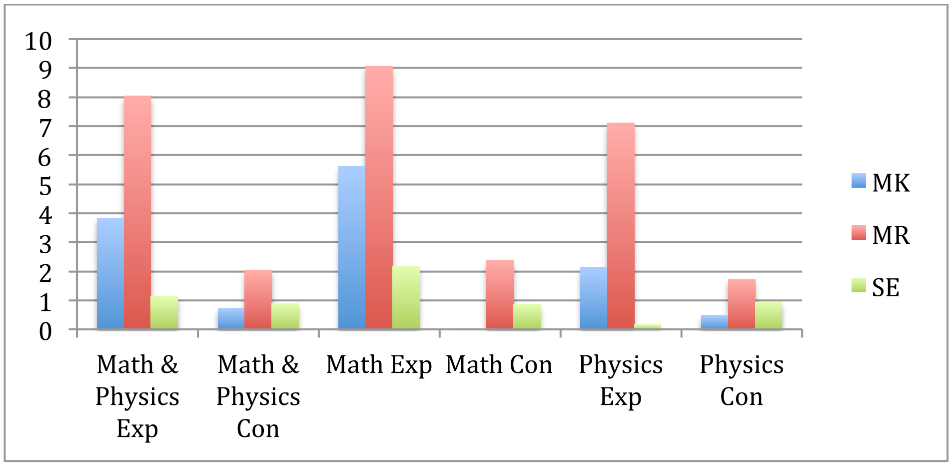

Figure 8: Comparison of Difference between Pretest and Posttest Mean SEMLI Scores for Experimental and Control Groups

The combined information obtained from graphs 2 and 3, in accordance with previous results, answered the study question by concluding that prompted reflections in the treatment groups have led to a significant difference between the mathematics and physics experimental and control groups in terms of the level of metacognitive awareness and self-efficacy. It can be safely concluded there has been an increase in metacognitive awareness of students in the experimental groups while the students in the control group did not experience such a change in metacognitive awareness. The first hypothesis was accepted, as there was a significant difference in the metacognitive awareness scores of the students who participated in prompted reflections and those who did not. The results also indicate that prompted reflections led to significant improvement in the students' self-efficacy in mathematics but not at the same level in physics. Simultaneously, the students who did not experience prompted reflections treatment have not improved in their self-efficacy level.

Based on these results, the following chapter will discuss these findings in light of previous studies, and make suitable recommendations in the area of improving metacognitive awareness and self-efficacy among mathematics and science students.

Chapter Five: Discussion and Conclusions

This chapter discusses the findings of the study, analyses the latter within the realm of theoretical and practical implications, and makes suitable recommendations for improving metacognitive awareness and self-efficacy among mathematics and science students.

5.1 Discussion

The main purpose of the current study was to find the effects of prompted reflections on high school students' metacognitive awareness and self-efficacy in mathematics and physics. Thus, a pretest-posttest quasi-experimental design was adapted to address the following main question:

To what extent does prompted reflection affect physics and mathematics students' metacognitive awareness and self-efficacy?

Data were analysed on several levels to answer the study question. First both physics and mathematics experimental groups combined were compared to control groups. Then in each group, pretest and posttest scores were compared. The prompted reflections were intended to provide opportunities for each student in the experimental group to self-reflect on their learning experiences related to a specific concept that was taught in the subject. The findings revealed that the students' metacognitive awareness and self-efficacy were positively affected and there had been high significant improvement. On the other hand, the students who did not participate in prompted reflections did not experience the same change in their metacognitive awareness and self-efficacy levels. These findings are expected as they align with previous studies and literature about the influential role of metacognitive strategies generally (Du Toit 2013; Mevarech &

Fridkin 2006; Nashon & Nielsen 2011; Ozsoy & Ataman 2009; Silver 2013; Zohar & Dori 2012), reflection and prompted reflection (Collins 2011; Davis 2003; Fiorella, Vogel-Walcutt & Fiore 2012; Flick & Tomlinson 2006; Surgenor 2011; Wiezbicki-Stevens 2009) to improve the learners' metacognitive awareness and self-efficacy.

To fully answer the study question and to test the hypotheses, the level of effectiveness of prompted reflections on the students' metacognitive awareness and self-efficacy was investigated for both subjects combined then individually.

Ho 1: There would be a significant difference in the metacognitive awareness scores of the students who participated in the prompted reflections activities and those who did not.

Study findings indicated a significant difference in the UAE high school students' metacognitive awareness, in both math and physics, between the experimental and control groups. These findings fulfill the first study hypothesis. This conclusion is supported by previous studies (Berthold, Nuckles & Renkl 2007; Hoffman & Spatariu 2008; Hubner, Nuckles & Renkl 2006; Krause & Stark 2010; Wiezbicki-Stevens 2009) that have shown the effectiveness of prompted reflections as one of the metacognitive strategies and a method of reflection to help students think, explore and evaluate their actions and empower their knowledge of their learning processes besides regulating and controlling new knowledge gained in different study contexts. For math and physics groups respectively, the results revealed that prompted reflections caused significant improvement in the students' metacognitive awareness scores where the math group had the greater gain compared to the physics group although they were given the same intervention which echo earlier findings that students' development of metacognition varies across domains and tasks (Sperling et al. 2002). Simultaneously, the results indicated a higher difference in metacognitive awareness level between physics, experimental and control groups than between math groups, which influenced the total findings. Moreover, at the end of the study the increase in the students' metacognitive awareness level of math control group was higher than the physics control group. These findings are consistent with the theoretical views about the multivariate nature of metacognition (Lai 2011; Magno 2010; Rahman 2011; Veenman 2012). Other factors might have affected the results as concluded by previous studies like the teacher's metacognitive awareness level (Balcikanli 2011; Rahman 2011), and teaching strategies applied in the class (Ozsoy & Ataman 2009; Zohar & Dori 2012). Scores for metacognitive awareness factors, metacognitive knowledge and regulation showed had high significant improvement after prompted reflection activities for math and physics students except the physics students' metacognitive knowledge scores that were the lowest in the improvement level. These findings also concur with previous studies (Mevarech & Fridkin 2006; Nashon & Nielsen 2011; Ozsoy & Ataman 2009) that the learners' metacognitive knowledge and metacognitive regulation can be developed differently and at similar levels. Moreover, metacognitive awareness factors were also found to be affected by task and context and varied between subject domain and duration (Veenman, Van Hout-Wolters & Afflerbach 2006).

Ho 2: There would be a significant difference in the self-efficacy scores of the students who participated in the prompted reflections activities and those who did not.

An interesting finding in the study is that there was no significant difference in the UAE high school students' self-efficacy posttest scores between all the participants, both math and physics combined or individually, experimental or control groups. This result then accepts an alternative hypothesis that there would not be a significant difference in the self-efficacy scores of the students who participated in the prompted reflection activities and those who did not. By studying the self-efficacy scores for each subject respectively it was found that the math students had the greater gain compared to the physics students. Therefore, there was significant improvement in the math group but not in the physics group which indicates that the math students' self-efficacy scores were the influential factor to achieve the significant results. The literature in this field has pointed to some studies that have shown the effective role of reflection to improve students' self-efficacy (Du Toit 2013; Silver 2013; Wu & Looi 2013). Still, other studies' findings debate the latter (Papinczak et al. 2008) by concluding that after implementing metacognitive intervention, the students' self-efficacy level decreased due to motivational reasons and subject or task difficulties. By trying to understand the non-significant effect of prompted reflections on self-efficacy scores of physics experimental group it was found that their posttest mean scores increased with less variation than the pretest scores. It should be also mentioned that among all the experimental groups, the lowest significant value is the metacognitive knowledge subscale of the physics group and the highest variation of scores from its mean is the metacognitive regulation. These findings are consistent with the literature review about the positive correlation between metacognitive awareness components and self-efficacy (Efklides 2011; Veenman 2012) where for many learners a vicious circle may develop, with low levels of self-efficacy leading to a failure to apply effective learning strategies or develop metacognitive knowledge. One of the reasons that might have affected the physics students' self-efficacy scores is the topic or domain difficulty (Kaplan et al. 2013).

One of the main concerns in mathematics and physics education, in the UAE and internationally, is that the low level of metacognitive awareness might affect students' results in problem solving, establishing proof and reason and applying prior knowledge on new situations. Moreover, low self-efficacy is also said to affect career choices that are related to mathematics and science (Aurah 2013). Metacognitive awareness and self-efficacy also have strong effects on students' understanding and therefore on academic achievement as was justified by studies in the UAE (Al Khatib 2010; Haidar & Al Naqabi 2008). This present study's findings are in agreement with the results of previous research that metacognitive awareness can be developed through metacognitive strategies (Ozsoy & Attaman 2009; Zohar & Dorri 2012). Prompted reflections are proven to facilitate metacognitively regulated learning and cognitive learning strategies (Berthold, Nuckles & Renkl 2007; Hubner, Nuckles & Renkl 2006; Krause & Stark 2010) and subsequently, to increase students' willingness to focus and concentrate.

5.1.1 Theoretical Implications

Consistent with cognitive and metacognitive theories, the results of this study qualify the prediction that prompted reflections will have an influence on learners' metacognitive awareness and self-efficacy. As has been established by prior research and confirmed by the findings, metacognitive awareness and self-efficacy are positively improved by metacognitive prompted reflections. Hence, metacognition does not influence learning outcomes when it is isolated but rather is related to other elements of learning theory. The literature related to this matter (Lai 2011; Schraw, Crippen & Hartley 2006) indicates that students' use of metacognitive awareness and metacognitive strategies in learning processes are subsets of self-regulation such as self-efficacy, where the learner's self-confidence about performance and goal attainment influence the learning outcomes.

Several frameworks were developed to categorize metacognitive components. In the current study, it is clear that after 6 weeks of prompted reflections, the students significantly improved in both metacognitive knowledge and regulation. The study findings conclude that there is no difference between the level of students' awareness of their metacognitive knowledge and regulation which are supported by previous research about the significant correlation between metacognitive components (Flavell 1976; Balcikanli 2011; Rahman 2011; Schraw & Dennison 1994).

The difference between metacognitive knowledge and skills is highlighted, where metacognitive skills represent the self-regulatory processes of metacognition (Zimmerman 1995) so self-efficacy is considered as the executive process (Veenman 2012). The learners with less successful strategies are the individuals who are deemed as having low levels of self-efficacy (Collins 2011, Veenman 2012). Simultaneously, the students with high level of self-efficacy often persevere longer with tasks and are more likely to set and monitor their goals (Collins 2011;

Britner & Pajares 2006; Zimmerman & Cleary 2006). These metacognitive theories are supported by this study's findings where it was found that the students with low metacognitive knowledge levels are the ones who did not improve significantly in self-efficacy. While metacognitive awareness plays significant role in self-regulated learning, self-efficacy is important to help learners to have the belief that they can perform tasks and achieve goals (Zimmerman & Cleary 2006). Therefore, to empower learners' self-efficacy, goal achievement coupled with cognitive processing that is required to achieve the targeted goal should be developed (Collins 2011, p.37).

One of the major implications of this study is the validity and reliability of the Self-Efficacy and Metacognition Learning Inventory SEMLI (SEMLI-Physics & SEMLI-Math) in assessing the different aspects of metacognition and self-regulation using three factors: metacognitive knowledge (MK), metacognitive regulation (MR) and self-efficacy (SE) under two broader components, which are metacognitive awareness and self-efficacy where self-efficacy represents the executive part of metacognition (Veenman 2012; Zohar & Dori 2012). The factor analysis results support the factorial validity of the SEMLI inventory which follows the categorization of Schraw & Dennison (1994) and Schraw, Crippen & Hatley (2006). Furthermore, the factorial design of the inventory allows for broader interpretation of the results and gives more opportunity for interpretation about each of the variables (Howell 2010). It would be interesting to use the same inventory in a comparison study to assess the students' metacognitive awareness and self-efficacy, and then compare it with other inventory results.

5.1.2 Practical Implications

From a pedagogical perspective, the study findings are encouraging. Prompted reflections can be applied to any subject area that allows a well-structured and schematic presentation of learning matter. This strategy is promising especially for students with low confidence and motivation skills or in need to improve their proof, reasoning and problem solving skills. Research has shown that prompted reflections can be an effective tool to develop learners' metacognitive awareness and self-efficacy. The findings about the effective role of prompted reflections can be aligned with previous empirical studies (Boud, Keogh & Walker 1985; Collins 2011; Hoffman & Spatariu 2008; Lai 2011; Morrison 1996; Murray 1999; Pintrich 2002; Zohar & Dori 2012) that have demonstrated the efficiency of different types of reflection tools such as journals, self-reflection, metacognitive prompting and guided reflection especially when used in specific subjects. The effectiveness of prompted reflections has been demonstrated in several domains. Prompted reflections are seen as effective for knowledge use in problem solving, learning and improving students' metacognitive knowledge and skills in mathematics and physics (Davis 2003; Collins 2011; Wiezbicki-Stevens 2009; Krause & Stark 2010). Although, metacognitive tools such as portfolios, learning logs and journals have been highlighted in mathematics and science education, they are fairly new tools in education in the UAE and have been explored by several studies and recommended for further research (Forawi, Almekhlafi & Al-Mekhlafy 2011; Tubaishat, Lansari & Al-Rawi 2009).

The general nature of metacognitive skills has implications for the instruction and training of those skills. Helping students to develop their own metacognitive awareness and self-efficacy using reflection activities requires the teacher to be a model and a facilitator by helping the learners to develop their reflective quality and therefore making the learners' own metacognitive processes explicit. The teachers' role in this aspect is crucial to provide the students with opportunities to reflect and to guide them and give them feedback about the quality of their reflection. Promoting a feedback loop of metacognition helps students to improve and to monitor their progress. The key to implement this is to plan explicit teaching of metacognitive strategies.

This study encourages more implementation of metacognitive strategies in classroom settings to engage the students in metacognitive thinking through well-designed metacognitive activities. Hence, metacognitive awareness starts at a tender age and grows during adolescence, the emphasis on metacognitive strategies to be taught explicitly in the classroom is recommended (Balcikanli 2011; Lai 2011). Three essential principles have been highlighted for effective metacognitive teaching approach to enhance learning and metacognitive skills (Veenman 2011; Veenman, Van Hout-Wolters & Afflerbach 2006; Veenman, Elshout & Busato 1994). First, metacognitive strategies should be integrated in the context of the task to help the learner to connect and to apply the task related condition knowledge to the procedural knowledge required in the context of the task. Second, teachers should inform the learners on the usefulness of applying metacognitive skills. Third, instruction and guidance should be extended to allow for the information of production rules and to ensure the regular and sustained application of metacognitive skills. Veenman (1998) called these principles the "WWWH" strategy where the focus is on *what to do, when, why, and how*. Other studies (Kramarski 2013; Kramarski & Mevarech 2003; Schellings et al. 2013) which expounded on successful teaching and learning strategies found that these principles are best implemented within instruction.

The study results are also aligned with previous studies in the UAE that have already shown that prompted reflections can lead to a significant improvement in students' metacognitive awareness and self-efficacy. These studies have also emphasized the importance of students' reflections in learning mathematics and science. These findings conclude that reflection can be used as a tool in order to develop students' metacognitive awareness and self-efficacy (Lai 2011; Collins 2011; Wiezbicki-Stevens 2009) which are proven to be important for the development of problem solving skills and inquiry skills that tend to be included among the primary objectives of mathematics and physics education. Results of the study also showed that supporting students with questions regarding their own metacognitive skills during task performance are potential triggers in developing metacognitive awareness. For this reason, implementing metacognitive prompted reflections before, after and during mathematics and physics lessons or tasks in schools will be useful for students. Teachers' roles in implementing metacognitive strategies and designing tasks to empower students' metacognitive awareness and self-efficacy are likely to have positive effect on their learning outcomes.

5.2 Conclusion

The purpose of this study was to provide empirical evidence and determine the effect of metacognitive intervention on high school students' metacognitive growth as well as their self-efficacy growth. A pretest-posttest quasi-experimental study design was adopted with hundred eighty-four high school students in mathematics and physics classes who participated in the study from an American curriculum private school in Dubai for 8 weeks. The quantitative approach applied in this study was mainly to find the effect of independent variable on dependent variables rather than for generalization purposes. SEMLI-S inventory was adapted from Thomas, Anderson & Nashon (2008) then modified to SEMLI-Mathematics and SEMLI-Physics.

The present study findings indicate that students' self-efficacy and metacognitive awareness are closely related. The results corroborate with overall findings given earlier that prompted reflections have affected the UAE high school students' metacognitive awareness and self-efficacy positively and there has been significant improvement in metacognitive awareness and self-efficacy of students in the experimental groups. Thus, the onus on teachers to find the most effective metacognitive strategy that suits the learners' needs which demand that the teacher must be metacognitively aware in the first place (Balcikanli 2011; Ku & Ho 2010; Rahman 2011). Teachers should improve their metacognitive teaching approach by enhancing their knowledge about the useful strategy, why it is useful and how and when to be implemented in the classroom by practicing reflective teaching (Deymoke 2013). Studies (Balcikanli 2011; Ku & Ho 2010; Rahman 2011) on teachers' metacognitive awareness indicate that many teachers lack sufficient knowledge about metacognition and their experience in implementing metacognitive strategies is inadequate. So teachers' metacognitive awareness should be the starting point for sustained change in teaching practice and development programs. Adding to that, the teachers' role in improving metacognitive awareness in their students should be clearly defined and supported through a pedagogical framework. School academic supervisors should also encourage teachers to implement metacognitive strategies and give them appropriate professional development and training.

The generality of metacognition was demonstrated by the converging features of metacognitive awareness that is required for problem solving, proof and reasoning, and inquiry learning in mathematics and science education (Zohar & Dori 2012). The metacognitive awareness components such as planning, monitoring and evaluation of task performance are crucial for all learning processes in science and mathematics education. All teachers should implement metacognitive strategies simultaneously in order to attain transfer across tasks and subdomains of science and mathematics education. Indeed, such a synchronized teaching program demands intensive administration, teaching commitment and coordination, but the long-term results are potentially extremely valuable (Zohar & Dori 2012). One way to engage students is to help them become involved in and be responsible for their own learning, make decisions about how they go about learning in addition to deciding what they want to learn and how they want to use that learning. Metacognition allows students to make decisions about how they learn best by helping them become aware of what they are doing when they are learning (Tarricone 2011). The difficulty arises when teachers and students are unable to detect their own metacognition consequently it leads to struggles in employing their metacognitive knowledge and skills. This is where teachers and students' themselves need to be guided to recognize their capabilities in order to regulate their metacognition activities toward improving their metacognitive knowledge. The current study's findings can help researchers and educators understand better how metacognitive strategies can be implemented as a tool to improve students' metacognitive awareness and therefore to enhance learning outcomes. It is hoped that the current research will add to the body of knowledge about metacognition and will aid in bridging the gap that currently exists between metacognitive theories and its applications in mathematics and physics classes.

5.3 Limitations

One of the main limitations of this study is that the students' prompted reflections were not analyzed. It would have been interesting to investigate how the students' metacognitive awareness and self-efficacy scores were related to the quality of students' reflections. Another limitation is the students' motivation to complete the survey accurately. Using a self-reporting inventory has the same issue as using a questionnaire because individuals may not really do what they say or represent exactly what happened. Due to the quasi-experimental nature of this study, there were threats to internal and external validity that must be addressed. As the participants were already in groups (classes), the randomization of sampling was limited to intact (class) random sampling instead of individual random sampling. Finally, despite similar prompted reflective questions, the mathematics and physics groups' varied experiences in terms of curriculum content and teaching strategies may have also impacted the way they perceived themselves as learners and their learning styles. Nevertheless, the teachers' equivalency in academic qualifications and years of experience besides the prompted reflections that was created by the researcher, not the teachers, helped to increase the internal validity of the study.

5.4 Recommendations for Further Research

Based on the study findings and the related literature, the following recommendations are suggested for further research to improve metacognitive awareness and self-efficacy in mathematics and science education. While the sample in the study involved high school students in American curriculum school, the study could ideally be repeated with different samples from different curriculums. The effect of prompted reflections can also be studied in a longitudinal study and with analysis of the students' reflections to find other factors that might influence the results like the quality of students' reflections and the type of questions used to develop students' metacognitive awareness and self-efficacy. It will also be beneficial to conduct a comparative study between offline and online methods of assessing metacognitive skills to investigate if they have different effects on study outcomes. Another field of study is to assess teachers' metacognitive awareness, and their teaching of metacognitive strategies, and discover the impact of both on their students. This study, like previous research, contends that reflection is most effective when its task related. Further research is recommended in the field to explore the different types of reflection and to analyze the quality of reflection using mixed methods approaches.

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Appendices:

Appendix 1 - Students Questionnaire: Self-Efficacy and Metacognition Learning Inventory-Mathematics (SEMLI-Math)

Students' Questionnaire

Section 1: Directions

1. Purpose of the Questionnaire

This questionnaire asks you to describe HOW OFTEN you do each of the following practices when you learn Mathematics. There are no right or wrong answers. This is not a test and your answers will not affect your assessment. Your opinion is what is wanted. Your answers will enable us to improve future Maths classes.

2. How to Answer each Question

On the next pages, you will find 30 sentences. For each sentence, circle only one number corresponding to your answer.

3. Students and Course Information

Please provide information in the box below. Please be assured that your answers to this questionnaire will be treated confidentially.

Name			
Gender	Male ( ) Female ( )	Age	
Grade/Year-level		Subject	

4. Completing the Questionnaire

Now turn the page and please give an answer for every question.

Section 2: Self-Efficacy and Metacognition Learning Inventory SEMLI-Math

There are no right or wrong answers in this list of statements. It is simply asking for your opinion. Read every statement carefully and put (**X**) the appropriate box that best describes you. Thank you very much for your participation.

1= Strongly Disagree 2= Disagree 3=Neutral 4= Agree 5= Strongly Agree

SN	Statement	1	2	3	4	5
1	I seek to connect what I learn from what happens in the Math classroom with out-of-class Math activities.					
2	I adjust my plan for a learning task if I am not making the progress I think I should do.					
3	I know I can understand the most difficult material presented in the readings for this course.					
4	I am aware of when I am about to have a learning challenge.					
5	I seek to connect what I learn from out-of-school Maths activities with what happens in the math classroom.					
6	I plan to check my progress during a learning task.					
7	I adjust my level of concentration, depending on the learning situation.					
8	I try to understand clearly the aim of a task before I begin it.					
9	I know I can master the skills being taught in this course.					
10	I evaluate my learning processes with the aim of improving them.					
11	I seek to connect what I learn in my life outside of class with Maths class.					
12	I am aware of when I am about to loose track of a learning task.					
13	I consider what type of thinking is best to use before I begin a learning task.					
14	I am confident I can do a good job on the assignments and tests in this Maths class.					
15	I seek to connect the information in Maths class with what I already know.					
16	I am aware of when I don't understand an idea.					
17	I consider whether or not a plan is necessary for a learning task before I begin that task.					
18	I adjust my level of concentration depending on the difficulty of the task.					
19	I believe I will receive an excellent grade in this course.					
20	I seek to connect what I learn from out-of-class Maths activities with what happens in the Maths class.					
21	I stop from time to time to check my progress on a learning task.					
22	I am aware of when I have learning difficulties.					
23	I am confident of understanding the most complex material presented by the teacher in this course.					
24	I try to predict possible problems that might occur with my learning.					
25	I seek to connect what I learn from what happens in the Maths classroom with out-of-school Maths activities.					

26	I am aware of when I am not concentrating.					
27	I assess how much I am learning during a learning task.					
28	I am confident of understanding the basic concepts taught in this course.					
29	I adjust my level of concentration to suit different Maths subjects.					
30	I seek to connect what I learn in other subject areas with Maths class.					

Appendix 2- Students Questionnaire: Self-Efficacy and Metacognition Learning Inventory-Physics (SEMLI-Physics)

Students' Questionnaire

Section 1: Directions

5. Purpose of the Questionnaire

This questionnaire asks you to describe HOW OFTEN you do each of the following practices when you learn physics. There are no right or wrong answers. This is not a test and your answers will not affect your assessment. Your opinion is what is wanted. Your answers will enable us to improve future physics classes.

6. How to Answer each Question

On the next pages, you will find 30 sentences. For each sentence, circle only one number corresponding to your answer.

7. How to Change Your Answer

If you want to change your answer, cross it out and circle a new number. For example:

8. Students and Course Information

Please provide information in the box below. Please be assured that your answers to this questionnaire will be treated confidentially.

Name			
Gender	Male ( ) Female ( )	Age	
Grade/Year-level		Subject	

9. Completing the Questionnaire

Now turn the page and please give an answer for every question.

Section 2: Self-Efficacy and Metacognition Learning Inventory-SEMLI- Physics

There are no right or wrong answers in this list of statements. It is simply asking for your opinion. Read every statement carefully and put (**X**) the appropriate box that best describes you. Thank you very much for your participation.

1= Strongly Disagree 2= Disagree 3=Neutral 4= Agree 5= Strongly Agree

SN	Statement	1	2	3	4	5
1	I seek to connect what I learn from what happens in the physics classroom with out-of-class physics activities.					
2	I adjust my plan for a learning task if I am not making the progress I think I should do.					
3	I know I can understand the most difficult material presented in the readings for this course.					
4	I am aware of when I am about to have a learning challenge.					
5	I seek to connect what I learn from out-of-school physics activities with what happens in the physics classroom.					
6	I plan to check my progress during a learning task.					
7	I adjust my level of concentration, depending on the learning situation.					
8	I try to understand clearly the aim of a task before I begin it.					
9	I know I can master the skills being taught in this course.					
10	I evaluate my learning processes with the aim of improving them.					
11	I seek to connect what I learn in my life outside of class with physics class.					
12	I am aware of when I am about to loose track of a learning task.					
13	I consider what type of thinking is best to use before I begin a learning task.					
14	I am confident I can do a good job on the assignments and tests in this physics class.					
15	I seek to connect the information in physics class with what I already know.					
16	I am aware of when I don’t understand an idea.					
17	I consider whether or not a plan is necessary for a learning task before I begin that task.					
18	I adjust my level of concentration depending on the difficulty of the task.					
19	I believe I will receive an excellent grade in this course.					
20	I seek to connect what I learn from out-of-class physics activities with what happens in the physics class.					
21	I stop from time to time to check my progress on a learning task.					
22	I am aware of when I have learning difficulties.					
23	I am confident of understanding the most complex material presented by the teacher in this course.					
24	I try to predict possible problems that might occur with my learning.					
25	I seek to connect what I learn from what happens in the physics classroom with out-of-					

	school physics activities.					
26	I am aware of when I am not concentrating.					
27	I assess how much I am learning during a learning task.					
28	I am confident of understanding the basic concepts taught in this course.					
29	I adjust my level of concentration to suit different physics subjects.					
30	I seek to connect what I learn in other subject areas with physics class.					

Appendix 3 – Prompted Reflection Activities

Name: ________________________ Subject:_____________

Grade: ________ (   ) Date :_____________

Reflection Questions (1)

Q1) What did you learn about *specific concept***?**

Q2) How did you learn it?

Q3) Do those concepts share anything in common with other concepts you have found easy to understand in the past? If so, what is common between them?

Q4) Identify one or more concepts remain unclear or confusing?

Name: ________________________ Subject:_____________

Grade: ________ (   ) Date :_____________

Reflection Questions (2)

Q1) List the activities or tasks you engaged in today?

Q2) What was your role in the task and what do you think about your role?

Q3) What is your overall idea or feelings about the tasks or activities you did today?

Q4) Identify one or more concepts remain unclear or confusing?

Name: ________________________ Subject:_____________

Grade: ________ (   ) Date :_____________

Reflection Questions (3)

Q1) What did you learn?

Q2) How does it fit with what you already knew?

Q3) How does it fit with the *specific concept***?**

Q4) What new questions did the today lesson generate?

Name: _________________________ Subject:_____________

Grade: ________ (   ) Date :_____________

Reflection Questions (4)

Q1) What was the essential question today?

Q2) What I know?

Q3) What I want to know?

Q4) What I learned?

Q5) Give example for

Cross curricular links

Real Life Application

Name: ________________________ Subject:_____________

Grade: ________ (   ) Date :_____________

Reflection Questions (5)

Q1) How can you connect what you learn from math with daily life?

Q2) Do you search outside (the class) resources to understand the *mathematics/physics* **application in real life?**

Q3) How is filed trip can help in learning *mathematics/physics* **?**

Q4) Do you find difficulty in connecting other subjects to the *mathematics/physics* **concepts?**

Name: ________________________ Subject:_____________

Grade: ________ (   ) Date :_____________

Reflection Questions (6)

Q1) How did you do *this* ?

Q2) What is your evidence?

Q3) How did it feel?

Q4) What did you learn about yourself? What next?

Name: ________________________ Subject:_____________

Grade: ________ (   ) Date :_____________

Reflection Questions (7)

1) I particularly enjoyed…
2) During my …………..lesson I demonstrated excellent inquiry skills when….
3) The role I learnt to develop in my lessons was …
4) When seeking and evaluating a range of points of view I learnt …
5) I experienced difficulties when …
6) I learnt to overcome these difficulties by…
7) I reaslise I now need to work on …

Name: ________________________ Subject:_____________

Grade: ________ ( ) Date :_____________

Reflection Questions (8)
Part A

Q1) What in my previous knowledge will help me with this *particular task?*

Q2) In what direction do I want my thinking to take me?

Q3) What should I do first?

Q4) How much time do I have to complete the task?

Name: ________________________ Subject:_____________

Grade: ________ (   ) Date :_____________

Reflection Questions (9)
Part B

Q1) How am I doing ?

Q2) How should I proceed?

Q3) Am I on the right track?

Q4) What information is important to remember?

Q5) Should I move in a different direction?

Q6) What do I need to do if I do not understand

Name: ________________________ Subject:_____________

Grade: ________ (   ) Date :_____________

Reflection Questions (10)
Part C

Q1) How well did I do ?

Q2) What could I have done differently?

Q3) Did my particular course of thinking produce more or less than I expected?

Q4) How might I apply this line of thinking to other problems?

Q5) Do I need to go back through this task to fill in any “blanks” in my understanding?

Name: ________________________ Subject:_____________

Grade: ________ (   ) Date :_____________

Reflection Questions (11)

Q1) Do you know the objectives? What do you want to achieve?

Q2) What is your plan to reach the target?

Q3) Did you use certain resources and feedback from others? Explain

Q4) What did you learn from your mistakes?

Q5) How did you plan to finish your task on deadline?

Q6) How do you evaluate your achievement?

Appendix 4 - Reliability Test:

Table 1: Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.939	.939	30

Table 2: Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Q1	109.49	280.072	.572	.489	.936
Q5	109.40	279.410	.578	.529	.936
Q11	109.38	280.663	.497	.482	.937
Q15	109.19	282.385	.539	.408	.937
Q20	109.38	278.748	.597	.476	.936
Q25	109.18	281.926	.478	.446	.938
Q30	109.37	280.338	.556	.476	.937
Q2	109.42	281.559	.610	.581	.936
Q6	109.27	280.590	.591	.447	.936
Q8	109.38	280.138	.551	.497	.937
Q10	109.33	283.144	.515	.473	.937
Q13	109.28	283.580	.514	.454	.937
Q17	109.17	278.462	.609	.556	.936
Q21	109.24	281.577	.568	.472	.937
Q24	109.12	282.074	.537	.418	.937
Q27	109.32	282.842	.503	.392	.937

Q3	109.39	282.186	.519	.526	.937
Q9	109.17	280.700	.565	.495	.937
Q14	109.20	277.720	.604	.568	.936
Q19	109.13	282.122	.544	.466	.937
Q23	109.22	281.406	.596	.493	.936
Q28	109.00	280.086	.643	.545	.936
Q4	109.12	282.859	.493	.465	.937
Q12	109.14	280.238	.611	.514	.936
Q16	109.02	280.449	.542	.544	.937
Q22	109.10	281.379	.586	.458	.936
Q26	109.14	279.737	.557	.436	.937
Q7	108.97	278.797	.690	.605	.935
Q18	109.21	280.355	.553	.546	.937
Q29	109.12	278.377	.612	.519	.936

Appendix 5 - Factor analysis test for Self-Efficacy and Metacognition Learning Inventory-SEMLI (30 –items):

1) The correlation matrix:

The results are analyzed in excel file named "results" and indicate highly correlated between all variables.

2) The Kaiser-Meyer-Olkin and Bartlett test of Sphericity:

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.925
Bartlett's Test of Sphericity	Approx. Chi-Square	4824.353
	df	435.000
	Sig.	.000

The value of the test statistic for sphericity is = 4824.353 and the associated significance level is = .000. Therefore, we accept the hypothesis that the population correlation matrix because the observed significance level is larger than alpha, so the using of the factor model should be reconsidered.

KMO = 0.925. The KMO closer to 1 and that indicate a sizeable sampling adequacy in this study.

Interpretation:

The factor analysis model assumes that variables are determined by common factors and unique factors. All unique factors are assumed to be uncorrelated with each other and with the common factors and this is not available in our study.

Appendix 6 - Factor analysis test for each subscale of Self-Efficacy and Metacognition Learning Inventory-SEMLI

1- Metacognitive Knowledge Subscale- MK:

A) Correlation Matrix

		Q1	Q5	Q11	Q15	Q20	Q25	Q30
Sig. (1-tailed)	Q1		.000	.000	.000	.000	.000	.000
	Q5	.000		.000	.000	.000	.000	.000
	Q11	.000	.000		.000	.000	.000	.000
	Q15	.000	.000	.000		.000	.000	.000
	Q20	.000	.000	.000	.000		.000	.000
	Q25	.000	.000	.000	.000	.000		.000
	Q30	.000	.000	.000	.000	.000	.000	

B) KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.865
Bartlett's Test of Sphericity	Approx. Chi-Square	677.651
	df	21.000
	Sig.	.000

2- Metacognitive Regulation Subscale- MR:

A) Correlation Matrix

	Q2	Q4	Q6	Q8	Q7	Q12	Q10	Q13	Q17	Q16	Q18	Q22	Q21	Q24	Q27	Q29	Q26
Q2		.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
Q4	.000		.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
Q6	.000	.000		.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
Q8	.000	.000	.000		.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
Q7	.000	.000	.000	.000		.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
Q12	.000	.000	.000	.000	.000		.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
Q10	.000	.000	.000	.000	.000	.000		.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
Q13	.000	.000	.000	.000	.000	.000	.000		.000	.000	.000	.000	.000	.000	.000	.000	.000
Q17	.000	.000	.000	.000	.000	.000	.000	.000		.000	.000	.000	.000	.000	.000	.000	.000
Q16	.000	.000	.000	.000	.000	.000	.000	.000	.000		.000	.000	.000	.000	.000	.000	.000
Q18	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000		.000	.000	.000	.000	.000	.000
Q22	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000		.000	.000	.000	.000	.000
Q21	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000		.000	.000	.000	.000
Q24	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000		.000	.000	.000
Q27	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000		.000	.000
Q29	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000		.000
Q26	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	

B) KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.910
Bartlett's Test of Sphericity	Approx. Chi-Square	2273.981
	df	136.000
	Sig.	.000

3- Self-Efficacy Subscale- SE:

A) Correlation Matrix

		Q9	Q14	Q19	Q23	Q28
Sig. (1-tailed)	Q9		.000	.000	.000	.000
	Q14	.000		.000	.000	.000
	Q19	.000	.000		.000	.000
	Q23	.000	.000	.000		.000
	Q28	.000	.000	.000	.000	

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.821
Bartlett's Test of Sphericity	Approx. Chi-Square	475.456
	df	10.000
	Sig.	.000

Appendix 7 – Letter to School Permission

الجامعة البريطانية في دبي
The British University in Dubai

Date: September 10th, 2013

Dear Mr./Mrs.,

The British University in Dubai offers a Master's of Education (Med) degree to interested students, teachers, and professionals in the United Arab Emirates to maximize their career opportunities and increased their knowledge. The MEd program is designed in collaboration with the School of Education of the University of Birmingham, one of Britain's leading schools of education. The Med program is approved and accredited by the Ministry of Higher Education and Scientific Research, UAE and has graduated many students since its start in 2005 in several different areas in education. The purpose of this letter is to kindly ask you to allow Lames Abdul Hadi, a student in this program, to be able to conduct a research by conducting interviews, survey or observations as appropriate to the study, as would be agreed by your teacher(s) and our student. Data collected will be anonymous and will be treated with utmost confidentiality.

Finally, we look forward to your kind cooperation. If you require any additional information, please don't hesitate to contact Dr. Sufian Forawi (MEd Program Coordinator) at sufian.forawi@buid.ac.ae or 050 1270746.

Sincerely Yours

Dr. Sufian A. Forawi,
Science Education Associate Professor

Appendix 8 – Participants Letter

To Whom It May Concern

I am conducting this research study in the specialization of Science Education from the British University in Dubai. The purpose of the research is to find the effect of prompted reflections on high school students' metacognitive awareness and self-efficacy in mathematics and physics. The study will develop metacognitive inventory for local use. As I receive your permission, I will give the physics and mathematics teachers questionnaire and the reflection tasks to administer them to their students.

The information collected from the teachers and students will be kept confidential and will be used only for this research. If you have any enquiries about this research study, please contact the undersigned. Thank you for your cooperation in this academic endeavor.

Best Regards,

Lames Abdul Hadi
0508470920
rafa_ad99@yahoo.com
September 2013

Appendix 9- Consent Form

PARTICIPANT CONSENT FORM

Provide a brief introduction indicating the purpose of the research study and the tool.

Please tick (✓) the following boxes to indicate your agreement:
☐ I have read the information provided about the purpose of the study.
☐ I understand that the data collected will be completely anonymous and that my privacy and confidentiality will be respected.
☐ I understand that I have the right to withdraw from this study at any time without prejudice.
☐ I understand that any reports that will result from the data collection will not identify any individual participants.
☐ I am willing to participate in the survey.
☐ I am willing to participate in a classroom observation.

Name: ________________________________

Signature:____________________________ Date: _______________

Appendix 10- Comparisons of Posttest SEMLI Scores for both Experimental and Control Groups

Posttest SEMLI										
Subject	**SEMLI Subscales**	**Group**		**N**	**Mean M.**	**S.D.**	**Independent t-test**	**df**	**SE**	***P**
Math & Physics	MA	Experimental (A&C)	Post	91	94.00	10.34	2.723	182	1.71	0.007
		Control (B&D)	Post	93	89.32	12.81				
	SE	Experimental (A&C)	Post	91	23.32	3.51	0.051	182	0.57	0.958
		Control (B&D)	Post	93	23.35	4.28				
Mathematics	MA	Experimental (A&C)	Post	44	95.73	8.87	0.8351	88	2.335	0.405
		Control (B&D)	Post	46	93.78	12.83				
	SE	Experimental (A&C)	Post	44	24.59	2.94	0.143	88	0.767	0.886
		Control (B&D)	Post	46	24.48	4.20				
Physics	MA	Experimental (A&C)	Post	47	92.38	11.40	1.865	92	2.61	0.065
		Control (B&D)	Post	47	87.51	13.80				Not quite sig
	SE	Experimental (A&C)	Post	47	22.13	3.62	0.162	92	0.79	0.870
		Control (B&D)	Post	47	22.26	4.10				

*p is significant at p<0.05, MA= Metacognitive Awareness, SE= Self-Efficacy

Appendix 11- Descriptive Statistics and Paired T-Test Results of Metacognitive Awareness and Self-Efficacy Scores in Math & Physics

Subject	SEMLI Subscales	Full Score	Time	Experimental Group							Control Group						
				N	Mean M.	S.D.	Paired t-test	df	SE	*P	N	Mean M.	S.D.	t	df	SE	*P
Mathematics & Physics	MA	120	Pre	91	81.81	13.15	7.092	90	1.71	0.000	93	87.02	12.60	1.376	92	1.67	0.172
			Post	91	94.00	10.34					93	89.32	12.81				
	SE	30	Pre	91	22.19	4.39	2.118	90	0.53	0.036	93	22.46	4.21	1.627	92	0.54	0.107
			Post	91	23.32	3.51					93	23.35	4.28				
Mathematics	MA	120	Pre	44	80.41	8.49	7.826	43	1.95	0.000	46	91.91	8.82	1.538	45	1.78	0.130
			Post	44	95.73	8.87					46	93.78	12.83				
	SE	30	Pre	44	22.43	3.46	3.575	43	0.60	0.000	46	23.63	3.19	1.298	45	0.65	0.200
			Post	44	24.59	2.94					46	24.48	4.20				
Physics	MA	120	Pre	47	83.13	16.35	3.391	46	2.72	0.001	47	85.30	16.11	0.773	46	2.86	0.443
			Post	47	92.38	11.40					47	87.51	13.80				
	SE	30	Pre	47	21.96	5.14	0.200	46	0.84	0.842	47	21.32	4.78	1.058	46	0.88	0.295
			Post	47	22.13	3.62					47	22.26	4.10				

*p is significant at p<0.05, MA=Metacognitive Awareness, SE= Self-Efficacy, SE= Standard error of Difference

Appendix 12- Descriptive Statistics and Paired T-Test Results of Metacognitive Awareness Components and Self-efficacy Scores in Math & Physics

Subject	SEMLI Subscales		Full Score	Time	Experimental Group							Control Group						
					N	Mean M.	S.D.	Paired t-test	df	SE	*P	N	Mean M.	S.D.	t	df	SE	*P
Mathematics & Physics	MA	MK	35	Pre	91	22.81	5.25	5.694	90	0.67	0.000	93	24.85	4.74	1.189	92	0.62	0.237
				Post	91	26.64	3.90					93	25.59	4.85				
		MR	85	Pre	91	59.00	9.33	6.656	90	1.21	0.000	93	63.72	10.05	1.590	92	1.28	0.115
				Post	91	67.05	7.80					93	65.76	10.79				
	SE		30	Pre	91	22.19	4.39	2.118	90	0.53	0.036	93	22.46	4.21	1.627	92	0.54	0.107
				Post	91	23.32	3.51					93	23.35	4.28				
Mathematics	MA	MK	35	Pre	44	21.27	3.97	7.101	43	0.79	0.000	46	21.70	2.48	0.034	45	0.62	0.972
				Post	44	26.89	3.49					46	21.72	4.39				
		MR	85	Pre	44	59.14	6.56	6.097	43	1.48	0.000	46	67.09	6.70	1.549	45	1.53	0.128
				Post	44	68.20	7.23					46	69.46	10.31				
	SE		30	Pre	44	22.43	3.46	3.575	43	0.60	0.000	46	23.63	3.19	1.298	45	0.65	0.200
				Post	44	24.59	2.94					46	24.48	4.20				
Physics	MA	MK	35	Pre	47	24.26	5.90	2.112	46	1.01	0.040	47	24.87	5.38	0.511	46	0.95	0.611
				Post	47	26.40	4.28					47	25.36	4.87				
		MR	85	Pre	47	58.87	11.40	3.760	46	1.89	0.000	47	60.43	11.66	0.832	46	2.07	0.409
				Post	47	65.98	8.23					47	62.15	10.10				
	SE		30	Pre	47	21.96	5.14	0.200	46	0.84	0.842	47	21.32	4.78	1.058	46	0.88	0.295
				Post	47	22.13	3.62					47	22.26	4.10				

*p is significant at $p<0.05$, MK=Metacognitive Knowledge, MR=Metacognitive Regulation, SE= Self-Efficacy, SE= Standard Error of Difference