Secondary Science Teachers' Awareness, Perceptions and Professional Development of Metacognition in Dubai Private Schools

وعي معلمي العلوم الثانوية وتصوراتهم وتطويرهم المهني لما وراء المعرفة في مدارس دبي الخاصة

by

MONA ALI KHREIS

A thesis submitted in partial fulfilment

of the requirements for the degree of

DOCTOR OF PHILOSOPHY IN EDUCATION

at

The British University in Dubai

April 2024

Investigating Secondary Science Teachers' Awareness, Perceptions, and Professionla Development of Metacognition in Dubai Private Schools

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Abstract

This concurrent parallel mixed method research investigates one of the main gaps in literature which is the perceptions of secondary science teachers in Dubai Private schools towards the awareness and use of metacognition. Moreover, it explores the development of metacognition skills -planning, monitoring and evaluating- in teachers after professional development interventions. In the quantitative approach, the survey revealed statistically significant high metacognition levels across the knowledge domains and the skills domains with an identified weakness in the monitoring skills. In addition, some demographic factors such as Nationality and Degrees play a role in teachers' perceptions to metacognition. In the qualitative approach, the PD sessions, lesson plans, lesson observations and semi-structured interviews revealed the importance of intervention to help teachers plan their lessons and choose their instructional strategies. However, while there is a general agreement on the importance of goal setting and the depth and flexibility of planning, monitoring strategies primarily rely on post-lesson reflections and students' achievements. This suggests potential areas for real-time adaptation and responsiveness to student needs during instruction. Moreover, reflection on teaching strategies and outcomes, although recognized as valuable, is not consistently practiced due to time constraints. In conclusion, teachers lean more towards teaching "For" rather than "With" metacognition. This research came into two main recommendations: (1) a need for flexibility and adaptability in curricula to allow teachers respond and adapt their instruction within the context of the lesson environment; (2) plan research based professional development interventions that are personalized to the needs of teachers.

Keywords: metacognition, planning, monitoring, evaluating, professional development

خلاصة

يبحث هذا البحث بالطريقة المختلطة في إحدى الفجوات الرئيسية في الأدبيات وهي تصورات معلمي العلوم الثانوية في مدارس دبي الخاصة تجاه الوعي واستخدام ما وراء المعرفة. علاوة على ذلك، فهو يستكشف تطور مهارات ما وراء المعرفة -التخطيط والمراقبة والتقييم- لدى المعلمين بعد ورش عمل في التطوير المهني. في النهج الكمي، كشف المسح عن مستويات ما وراء المعرفة عالية ذات دلالة إحصائية عبر مجالات المعرفة ومجالات المهارات مع وجود ضعف محدد في مهارات المراقبة. بالإضافة إلى ذلك، تلعب بعض العوامل الديموغرافية مثل الجنسية والدرجات العلمية دورًا في تصورات المعلمين لما وراء المعرفة. في النهج النوعي، كشفت جلسات التطوير المهني وخطط الدروس وملاحظات الدروس والمقابلات شبه المنظمة عن أهمية التدخل لمساعدة المعلمين على تخطيط دروسهم واختيار استراتيجياتهم التعليمية. ومع ذلك، في حين أن هناك اتفاق عام على أهمية تحديد الأهداف وعمق ومرونة التخطيط، فإن استراتيجيات المراقبة تعتمد في المقام الأول على تأملات ما بعد الدرس وإنجازات الطلاب. يشير هذا إلى المجالات المحتملة للتكيف والاستجابة في الوقت الفعلي لاحتياجات الطلاب أثناء التدريس. علاوة على ذلك، فإن التفكير في استراتيجيات التدريس ونتائجه، على الرغم من الاعتراف بقيمته، لا يتم ممارسته باستمرار بسبب ضيق الوقت. في الختام، يميل المعلمون أكثر نحو تدريس ما وراء المعرفة "من أجل" بدلاً من "مع". وخلص هذا البحث إلى توصيتين رئيسيتين: (1) الحاجة إلى المرونة والقدرة على التكيف في المناهج الدراسية للسماح للمعلمين بالاستجابة وتكييف تعليماتهم في سياق بيئة الدرس؛ (2) تخطيط تدخلات التطوير المهني القائمة على الأبحاث والمخصصة لاحتياجات المعلمين.

Dedication

To My Man, my husband- Samer- whom I would have never done it without his support and encouragement. To my children -Mado and Lily- for all missed out “family time” for the sake of this thesis.

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List of Abbreviations

DSIB	Dubai Schools Inspection Bureau
IBO	International Baccalaureate Organization
KHDA	Knowledge and Human Development Authority
KMO	Kaiser-Meyer-Olkin Test
MAP	Measurements of Academic Progress
MAI	Metacognitive Awareness Inventory
MAIT	Metacognitive Awareness Inventory for Teachers
MOE	Ministry of Education
OECD	Organisation for Economic Co-operation and Development
PISA	Programme for International Student Assessment
PD	Professional Development
PME	Planning, Monitoring and Evaluating
SOLO	Structure of Observed Learning Outcomes
SRL	Self-Regulated Learning
STEAM	Science, Technology, Engineering, Arts, Mathematics
TIMMS	Trends in International Mathematics and Science Study
UAE	United Arab Emirates

Chapter 1: Introduction

1.1 Background of the Study

Metacognition is a term used to describe one's own thinking. Metacognition was first identified by Flavell in 1976 as "one's knowledge concerning one's own cognitive processes, or anything related to them" (p. 232). Lately, metacognition is known to involve all of the followings: knowledge, regulatory skills and feeling state or experience (Moshman, 2018; Schraw & Moshman,1995). Many researchers in the field added to Flavell's definition to include all strategies and mechanisms required during and for the process of metacognition (Georghiades, 2004). In literature, metacognition refers to one's own knowledge, awareness of this knowledge and controlling the process of learning and building on this knowledge. Individuals utilize their metacognition to systemize their knowledge of the process and to plan their own activities within their own cognitive framework (Schraw & Moshman, 1995). Furthermore, metacognition extends to include not only cognition and knowledge but also psychological domains of social awareness, self-efficacy, self-regulation and self-awareness and ability to reflect on all these aspects (Flavell, 1987; Georghiades, 2004; Hadwin, Bakhir &Miller, 2018).

While the metacognition knowledge is divided into three domains which are declarative, procedural and conditional, the metacognition regulation or skills refer to four phases which are planning, monitoring, evaluating and concluding phases (Moshman, 2018; Schraw & Moshman, 1995). Metacognition knowledge includes the awareness of "what",

"why" and "when" to use the cognitive knowledge while perceiving a task. Using these three knowledge domains allows the learners to look into how, when and where to apply specific strategies suitable for each task or situation (Hadwin, Bakhir & Miller, 2018; Schraw & Moshman, 1995). This metacognition knowledge is usually coupled with regulating the learning process through planning the adequate strategies to be used to solve a certain task, monitoring the process used and evaluating its success. These regulatory steps are coupled with the ability to reflect and regulate one's own learning (Schraw & Moshman, 1995; Robson, 2010). Many experts in the field relate the planning, monitoring and evaluating learning model to increased efficacy and competence in learners (Amin & Mariani, 2021).

Metacognition is a crucial element in education. Studies relate metacognition knowledge and skills to help students improve their performance in different subjects as well as teachers' use of metacognition strategies during instruction to motivate and help students learn better (Panadero, 2017; Stephanou & Mpiontini, 2017; Sulaiman et al., 2018; Trinidad-Velasco et al., 2020). Very few studies investigate the role of metacognition in adults and more specifically in teachers' awareness and use of metacognition as they plan, deliver and reflect on their own performance (Sulaiman, 2021; Trinidad-Velasco et al., 2020; Yildiz & Akdag, 2017).

There is an emphasis on schools and the educational sector to embrace and develop metacognition through offering self-conscious learning experiences (Abdellah, 2015). Teaching with metacognition and for metacognition is critical for critical thinking, creativity and improving efficacy in education. Teaching with metacognition helps teachers gain

awareness of their thinking, control their thoughts and monitor and evaluate their teaching strategies according to the needs of their students within their cultural contexts (O'Hara, Pritchard & Pitta, 2019). This helps teachers choose effective strategies for teaching for metacognition. This highlights the need of raising awareness and use of metacognition skills in education.

Education in the Gulf region, mainly United Arab Emirates (UAE), is undergoing an educational reform to build a knowledge-based economy for the future generation. As outlined in the UAE vision 2021 and the 2030 agenda for sustainable development, the educational shift prioritizes students learning and empowers teachers to enhance the quality of teaching in order to build curricula that integrates the 21st century skills and promotes STEAM-based approached (Science, Technology, Engineering, Art and Mathematics) (UAE Vision, 2021; UAE National Committee, 2017). Furthermore, the Organization for Economic Cooperation (OECD) Learning Compass 2030 report emphasizes on three essential skills required for the future education: cognition and metacognition skills, social and emotional skills, practical and physical skills. Each of these have been identified as crucial elements for student's success in building their critical thinking, creativity, self-regulation and ability of learning-to-learn (Elsayary & Mohebi, 2023; OECD, 2018). As a result, metacognition is one current essential skill to be explored within the educational context in Dubai private secondary schools in order to address potential challenges and gaps in the development of education.

Metacognition skills are commonly regarded as skills that can be applied across different domains, subjects, and tasks. However, the transfer of metacognition skills does not

often occur naturally or spontaneously. Recent research conducted by Schuster et al. (2020) demonstrated that training interventions can have positive effects on both near and far transfer of metacognitive skills. This suggests that deliberate efforts to enhance metacognition abilities through targeted training can promote the application of these skills in diverse contexts (Stebner et al., 2022). This is further supported by another study by Wirth and colleagues (2020) who described how repetitive practice of metacognition skills of planning, monitoring and evaluating through training sessions would lead to automated use of metacognition skills in individuals.

Research relates teacher professional development to improved teaching performances once they are trained to adopt and use metacognitive instructional strategies and skills effectively (Abdellah, 2015). Regulating metacognition increases efficacy during task solving to shift from "seeking help to problem-solving attempts" (Bernacki et al., 2015, p.114). In their book, Lin and colleagues explain the teachers' needs for metacognitive adaptation to face the challenges within the wide range of instructional and social variability that they face in classrooms. Metacognition helps support teachers in unique classroom settings and helps them differentiate their tasks (Lin et al., 2018). Since metacognition is affected by social and cultural factors, it is expected that professional development and metacognition in middle east setting would vary as compared to designed professional development session in Europe and other cultural settings since social metacognition is known to be influenced by status effects, communication challenges, emotional conflicts, and cultural differences (Chiu & Kuo, 2010). Cultural metacognition is one way a teacher might refer to when using cultural knowledge as

they interact with their students or other teachers during the professional development sessions (Morris, Savani, & Fincher, 2019).

Review studies in literature identify metacognition as a powerful tool used within any instructional strategy to help students excel academically. The use of metacognition, classroom management, proper learning environments as social interactions are all factors that influence the teaching and learning experience (Langdon et al., 2019). The National Academy of Science in Washington and Hattie's research on Visible Learning rank metacognition and incorporation of metacognition strategies as prime factors that can enhance the learning experience, promote academic achievement, and improves efficacy of teachers (Brown et al., 1999; Hattie, 2015; Landon et al., 2019). This is an indicative tool for investigating factors that influence metacognition and impacts of metacognition in education.

1.2 Statement of the Problem

Metacognition is considered as a crucial element of effective teaching and learning practices in education (Amin & Mariani, 2017; Norman et al., 2019; Parsons et al., 2018; Rusyati et al., 2021; Sulaiman et al., 2021). Studies focused on "teaching for" metacognition in students at primary and secondary level. These studies discuss strategies and prompts teachers used to promote metacognitive skills in students as they work on their tasks (Akben, 2020; Avargil et al., 2018; Rusyati et al., 2021; Sulaiman et al., 2021). Very rare studies focus on "teaching with" metacognition or what is meant to be teachers using metacognitive skills for their own practice. Many studies consider metacognition in science lessons (Akben, 2020; Erenler and Cetin, 2019; Rand, 2005; Stephanou & Mpiontini, 2017; Sulaiman et al., 2021;

Zohar &Barzilai, 2013). Raising the metacognition skills in the science lessons help improve students' outcomes and attainment (Stephanou & Mpiontini, 2017; Zohar &Barzilai, 2013). Schools and leadership rely on teachers' role in building metacognition in students (Ben-David & Orion, 2013; Sulaiman et al., 2021; Zohar &Barzilai, 2013). Many research studies discussed the metacognitive strategies science teachers use in order to help students develop their thinking processes and successfully fit into the science dispositions (Akben, 2020; Rand, 2005; Sulaiman et al., 2021). Metacognitive strategies, self-regulated learning, problem-based learning and metacognitive interventions for students help them foster scientific thinking skills (Avargil et al., 2018; Downing et al., 2009). However, very few researchers discuss building metacognition skills and knowledge in science teachers themselves. Rusyati and colleagues (2021) in their research *A review of research trends on meta-cognitive in science education within the past decade* analyzed 30 available articles between 2009 and 2019 related to metacognition skills, knowledge and experience. Their study revealed gaps in studies on metacognition such as the science as a discipline-specific and use of metacognition in primary level. Another gap is in analyzing the planning, monitoring and evaluation phases of metacognitive skills in teachers as well as a lack of evaluating the metacognition knowledge of the chosen tasks and awareness of pedagogical instructions and experience in teachers. When teachers use their metacognition to observe their pedagogical skills and reflect on their instructions, they can deliver effective lessons and develop their performance (Cummings & Blatherwick, 2017; Du Toit & Kotze, 2009; Rusyati et al., 2021). Teachers' metacognition impacts their self-efficacy as they prepare effective instructions. This helps build motivation in teachers (Santisi et al., 2014; Rusyati et al., 2021).

Within the context of Dubai, the perception and uses of metacognition among science teachers in private secondary schools have not been extensively explored. Many studies relate to the use of metacognition by students in comprehension, reading or writing in schools of Dubai (Al Shabibi & Alkharusi, 2018; El Mekawy, 2014; Hamood Almamari, 2019; Tabar, 2012; Tang & Calafato, 2021; Yousef jarrah et al., 2023). Only few studies talk about metacognition in mathematics and science in Dubai (Al Shabibi & Alkharusi, 2018; Hadi, 2014). Within Dubai, schools follow different academic systems such as the British curriculum, the International Baccalaureate curriculum , the Indian curriculum or the national curriculum. Within all these curricula, metacognition is a hidden key indicator for teachers and students.

Teachers' competences and ability to plan proper instructions that cater to the needs of their students depend on their ability to reflect on their own practices at different contextual settings (Lin et al., 2018; Timperely et al., 2007). Some papers discuss the impact of self-reflections on teachers. Tavyl (2014) reveals how using reflective e-journals while training teachers increased their self-efficacy in designing their pedagogical material and planning their instructions. Zohar and Barzilai (2013) -while exploring instructional strategies that foster metacognition in students- identified several gaps in research such as the importance of metacognition knowledge rather than focusing on the skills only. They also indicated the lack of evidence that correlates effectiveness of metacognitive instruction in science. This might be due to the difficulty in measuring and evaluating the metacognition levels in individuals. Assessing metacognition is one of the challenges identified by experts in the field since metacognition is a complex indirectly observed process that involves knowledge and skills at

different contextual settings (Lai, 2011). Few self-report instruments have been developed and validated by some researchers to measure and/or evaluate metacognition such as the instrument developed by Sperling et al (2002), The Metacognitive Awareness Inventory (MAI) designed by Schraw and Dennison (1995) followed by another instrument developed by Santisi et al (2014), and recently the Teacher Metacognition Inventory (TMI) designed by Jiang, Ma and Gao (2016). In all of these, the instruments rely on self-report and sometimes on students' behavior to evaluate metacognition (Norman et al., 2019).

Planning, monitoring and evaluating (PME) represent the elements for metacognition as skills and are thought to be related to increasing academic achievement, critical thinking skills and self-regulated learning (Amin & Mariani, 2017; Panadero, 2017; Stephanou & Mpiontini, 2017). These skills are not only beneficial for the learning experience of students, they are also crucial for raising self-efficacy, motivation and performance (Perry et al., 2019; Nordin & Yunus, 2020; Ozturk, 2018). This area can be an area of focus to see how teachers respond to increasing their metacognitive skills of planning, monitoring and evaluating.

This research will aim at investigating the teachers' awareness and use of metacognition knowledge and skills. It will investigate the metacognition knowledge of secondary science teachers through checking if : (1) they are aware of how to choose the tasks, (2) they are able of selecting the proper strategies and (3) if they own the proper subject knowlegde while thinking of their pedagogical instructions. In the metacognition skills, it will investigate the teachers' ability to plan their instructional startegies, monitor their delivery of the planned instructions, and evaluate the success of the full process after the lesson. Within

this part, the role of some demographic factors such as nationality, age, years of experience and level of education on metacognition awareness and use would be investigated. In the second-fold, the research also investigates the impact of raising metacognition in science teachers on their performance in classroom. An in-service program (professional development sessions) will train teachers on using all phases of metacognition skills: planning, monitoring, and evaluating to investigate the impact of the training on improving teachers' competence and performance while planning, delivering, and evaluating their instructional pedagogies.

1.3 Purpose of the Study

The main purpose of the study was twofold: (1) to investigate the science teachers' perceptions related to awareness and use of metacognition alongside the teachers' demographic variations and (2) to explore how science teachers develop their metacognitive skills in planning, monitoring and evaluation (PME) through in-service professional development (PD) sessions in secondary schools in Dubai.

In the first part of this study, a quantitative approach is followed through using a questionnaire in order to investigate teachers' awareness and use of metacognition while acknowledging their different demographic variations. A questionnaire is the adequate self-reporting tool used to measure the awareness and use of metacognition by science teachers across Dubai private secondary schools for the first fold of the experiment. It also has a section that reveals demographic characteristics of the participants. Metacognition is described as the one's own cognition as person, task and strategy as described by Flavell (1979). Metacognition has been extended to include declarative, procedural, and conditional

knowledge as described by Paris, Cross, and Lipson (1984) as well as skills that entail planning , monitoring and evaluating as explained in Schraw's three regulation or metacognition skills elements (Schraw 1998). These are empowered by one's affective experiences integrated into intellectual endeavors (Teng, 2020). Since metacognitions entails knowledge, skills and experience, these three domains were included in the questionnaire.

The research approach and methods were designed to identify science teachers' ability to know what they know; how do they know and what do they do to know. In the second fold, PD sessions are designed to train the secondary science teachers on using all phases of metacognitive skills: planning, monitoring, and evaluating as they plan and deliver their instructional pedagogies within classroom settings. They are guided into how to plan their lessons, choose their pedagogical resources and select the adequate instructional strategies according to the needs of their learners. These were followed by lesson observations and interviews to see how teachers monitor and evaluate the delivery of their instructions. These sessions allow teachers to develop long-term training programs to help them strengthen their metacognitive skills in planning, monitoring and evaluating their instructions. This would increase their ability to know and use this knowledge in the proper strategies and according to the context of their classrooms.

1.4 Research Questions

While addressing the research questions below, it will be possible to evaluate the metacognition awareness and use in science teachers across all private secondary schools in Dubai as well as the metacognitive skills in some science teachers and their ability to reflect

on their own practices and the impact of these practices on improving their competence and efficiency as they deliver and monitor their delivery of the planned instructions. Therefore, the following research questions were addressed during this research:

(1) What perceptions do science teachers have regarding awareness and use of metacognition in Dubai private secondary schools?

(2) What demographic differences do science teachers have regarding their metacognition in science school teachers in Dubai private secondary schools?

(3) How do science teachers develop metacognitive skills for planning, monitoring and evaluating (PME) of instructional strategies based on in-service metacognitive professional development sessions in Dubai private secondary schools?

By addressing the above research questions, this research would provide insights into the current state of metacognition awareness and practices among science teachers in Dubai private secondary schools. Moreover, it would reveal some of the factors that may influence teachers' awareness and use of metacognition in their classroom practices. The findings contribute to the existing literature but within the context of Dubai private secondary schools. Moreover, it will inform the development of targeted professional development for science teachers to enhance their metacognition skills which would ultimately play a role in the improvement in the quality of science education in Dubai private secondary schools.

1.5 Significance of the Study

In most private schools in Dubai, teachers have to fill in self-evaluation forms for their appraisals. These are indicative tools for school leaders for the self-evaluation form that needs to be filled for the Knowledge and Human Authority (KHDA) school inspection bureau (DSIB, 2012). KHDA indicates that "accurate self-evaluation is a pre-condition for school improvement" in its school inspection framework publication (KHDA, 2017,p. 14). This reflects the importance of building metacognitive knowledge and skills in teachers to be able to plan their instructional strategies, monitor their implementation of the lesson plan, evaluate their pedagogical approaches, and finally conclude on how to improve their performance in their next planning phase. If teachers can build these skills, then it is expected to see progress in teachers' efficacy and performance level as well as in the students' response to the learning experience which would lead to their progress in the achievement level. Moreover, the increasing sophistication in using advanced learning technologies worldwide require developing the metacognition in education since metacognition is considered by researchers a significant high order of cognition that help increase academic performance and develop autonomous learners which are the main targets in the new educational reform (Azevedo, 2020). Furthermore, the different curricula in Dubai schools including the British system, IB programme, National programme as well as the Indian system have metacognition integrated within the hidden philosophy of these programmes. Therefore, raising metacognition awareness and use would indicate a better application of the curriculum in schools.

Many researchers in the field agree that although learners might receive much support, they may not be able to use the tools presented to them or choose the adequate one. This is mainly due to lack of the necessary metacognition knowledge and skills. Therefore, there should be a more focus on how tools are used via developing metacognition in individuals (Clarebout et al., 2013). For learners to perform better, gain motivation and increase their efficacy, they first should be aware of their own ways of thinking, choosing tasks and selecting the proper methods to solve these tasks. This represents the metacognitive knowledge. Then they should be able to plan for their work, monitor the way they approach their task and finally evaluate their work. These are parts of the metacognitive skills (Amin & Mariani, 2017; Firmanto et al., 2019; Langdon et al., 2019; Moshma, 2018; Schraw & Dennison, 1994; Stephanou & Mpiontini, 2017). Teachers train students to use metacognition skills during the lesson through teaching "for" metacognition and they do rarely focus on their own metacognition practice. As a consequence, this study focuses on the metacognition of teachers rather than students themselves. In part, it focuses on investigating the perceptions of teachers to awareness and use of metacognition in general in their daily practices. In the second part, it considers the metacognition skills during the planning, monitoring and evaluating phase of their teaching experience in class. If teachers are given the proper training and guidance on how to build their metacognitive skills at all phases, then this might impact the planning and implementation of instructional and pedagogical strategies in classrooms and in turn impact teachers' efficacy and competence alongside raising students' attainment.

The significance of this study lies in the importance of preparing teachers to equip their students with the future skills. Metacognition is a main skill for the vision of future learners

for 2030 (OECD Insight, 2017) and for UAE vision for 2030 (MOE, 2017). Consequently, if teachers master their own metacognition, then they will be able to teach it to their students. The outcome of the study will help understand what intervention is required to develop the metacognition skills in teachers and discover any demographic or other factors that would influence the development of metacognition skills in teachers. Another significant outcome to this study is raising positive attitudes and perceptions of teachers towards awareness and use of metacognition in order to advocate for better teaching and learning experience in classrooms.

1.5 Overview of the Study

Teaching with metacognition will benefit schools, teachers and students to help in the reform of education in the UAE and prepare successful citizens for future. This thesis will investigate teachers' perceptions to awareness and use of metacognition, and will explore the role of intervention in developing metacognition skills in teachers. These will be presented in five chapters.

Chapter one includes the background necessary for the topic of this study, the statement of problem addressed, the purpose of the study illustrating its main goal, the research questions guiding the researcher and finally the significance of the study that highlights the gap in literature and expects the impact of this study in the field of education.

Chapter two includes the conceptual and theoretical framework that guide this research alongside related literature review. The conceptual framework highlights all factors

influencing metacognition and the possible impacts of development of metacognition in teachers. The theoretical framework discusses the metacognition theory, the self-regulated theory and the Neo-Piagetian theory. Finally, related literature navigates through related recent studies and allows to identify gaps that lead to the formation of the research questions.

Chapter three discusses the methodology and research approach through the lens of the researcher. The research methods are discussed alongside the instruments used in data collection and analysis. Ethical considerations and limitations of the study are also presented in this chapter.

Chapter four presents the data analysis and results achieved from the quantitative as well as qualitative parts of this study in order to be able to answer the three research questions. The survey will represent data obtained from secondary science teachers in Dubai schools in order to investigate their perceptions and use of metacognition in relation to their variations in the demographic factors. The PD sessions and transcribed notes from observations and semi-structured interviews are presented to explore PD sessions and the metacognition skills in teachers in one of Dubai private schools.

Finally, chapter five discusses all the findings and draws conclusions in accordance with the results presented. Results from quantitative study and qualitative study and discussed in convergent approach to yield a full picture of metacognition use, awareness and PD sessions. It finally presents challenges and recommendations emerging from the results.

Chapter 2: Literature Review

2.1 Introduction

This chapter is divided into four sections. In the first section, a conceptual framework is designed to connect some of the influencing factors emerging from literature that could play a role in the level of awareness and use of metacognition and links them to expected outcomes when metacognition is properly implemented. Moreover, it discusses the possible impacts on teachers after trainings to raise awareness and use of metacognition according to different research work in the field.

The instructional strategies teachers use, the planning monitoring and evaluation (PME) model, and the contextual setting for delivery of the lessons are factors that could influence metacognition. In addition, some other demographic factors such as nationality, age, educational background and experience could have an influence of teachers' perceptions to metacognition awareness and use. Building awareness and use of metacognition through professional development sessions that focus on these factors would help in teacher's efficacy, performance, autonomy and motivation. In a similar way that literature expects these results in students.

In the second section, a theoretical framework presents all related theories used by the researcher as pillars for conducting this research. The main theory leading this research is the metacognition theory which is directly linked to the second theory "self-regulated learning theory". This research will also require the understanding of the teachers' professional

development theory, its development and its need. The study refers to awareness and use of metacognition and therefore, it requires the reference to cognitive development alongside the contextual effects that help in the buildup of metacognition. The Neo-Piagetian theory fits into the context of this research.

The third section is an overview of related literature work that led to the identification of the gap in the domain of metacognition and formation of the research questions of this thesis. In literature, many studies focus on metacognition in education at the students' level in primary and secondary schools as well as in different subjects- languages, STEAM subjects and mainly mathematics and sciences. In these studies, metacognition is correlated to improved academic achievement, motivation and autonomy in students. Few research studies focus on teachers' perceptions of metacognition or in their involvement in professional development sessions for awareness and use of metacognition. These studies also used different evaluative tools for metacognition measures. Therefore, the following themes emerged from the literature:

- Metacognition in Education
- Metacognition and Performance of Students and Teachers
- Teachers' Perceptions of Metacognition
- Metacogition and Educational Policies
- Evaluating Metacognition
- Professional Development Programs to Develop Teachers' Metacognition.

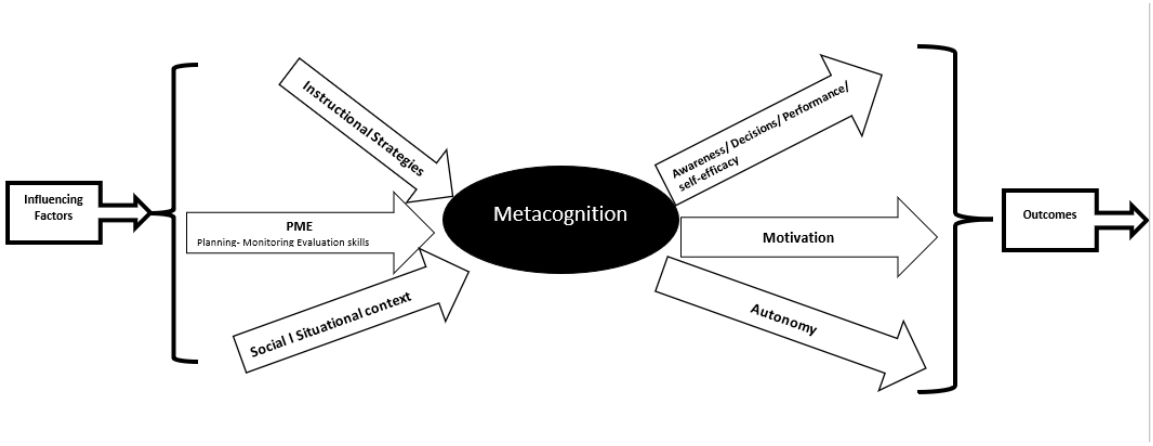
The final section sums up all the main aspects from the above sctions and especially the literature review.

2.2 Conceptual Framework

Many studies named different factors that may influence the awareness and use of metacognition in teachers and few others related metacognition awareness and use to improved autonomy, motivation, and competency in teachers (Fathima & Vimala, 2020; Langdon et al., 2019; Lynch, 2021; Pudiquet et al., 2019). The development of the planning, monitoring and evaluating phases of the instructional strategies followed by teachers in their own classroom settings could increase the competence, performance and efficacy of teachers within their contextual setting such as within their classrooms (Amin & Mariani, 2017). Therefore, the following presentation of the conceptual framework is considered in this study (Fig. 2.1). In this figure, instructional strategies, use of the PME model and the social context during the lesson delivery are all expected factors to influence teachers' metacognition. Once metacognition use is developed in teachers, autonomy, motivation and increased self-efficay are expected outcomes from teachers due to teaching with metacognition.

Figure 1

The Conceptual Framework



Note. Designed by the researcher

2.2.1 The influencing factors in the process of metacognition

2.2.1.1 Instructional Strategies. In literature, there are many definitions of instructional strategies. In the 1960s and 1970s Burner and Gagne were from the first experts in the educational field who identified instructional strategy as any form of activities arranged by someone to facilitate the learning of others and help them reach their goals (Akdeniz, 2016). Lately, many studies focus on how knowledge and skills are transferred "through coaching, scaffolding, interacting, assessing and reflecting in situated learning environments" (Hajian, 2019, p.94). While exploring the different forms of instructional strategies, researchers agree that any learning strategy can be re-enforced by fostering metacognitive intervention (Sato, 2021). Metacognitive prompts can be incorporated into any strategy-based instruction (Haukås et al., 2018).

Knowing that metacognition can be both a standalone strategy and/or a component of other strategies (Lai, 2011); teachers can make use of this aspect. When used as a learning strategy, metacognition involves thinking about what one already knows and what one still needs to learn, as well as reflecting on the effectiveness of different learning strategies. Whereas when incorporating metacognition with other effective learning strategies, teachers take an active role in their own learning process, setting goals, monitoring their progress, and making necessary adjustments. It also can be incorporated within the framework of problem-based learning to enable the learner to reflect on their thinking processes and monitor their own understanding of a problem.

When using metacognition as an instructional strategy on its own, teachers provide questions to students to help them plan how to solve the task in hand, what strategies to use and monitor their progress during the process of anwsering the task. Those questions can be either provided directly to students as checklist while attemtong their tasks or incorporated into the teaching process as feedback cycles from teachers with the class context (Tanner, 2017). The questions are usually designed to ask students on each stage of solving the task which are planning, monitoring and evaluating.

In his research, Hattie (2015) considered metacognition as one of the most influential factors on students' achievements. There is a wide range of metacognitive prompts that can be taught during any form of instructional strategies in classrooms in order to promote higher order thinking and critical thinking skills of the students. These metacognitive strategies might vary according to the different subjects, but all will serve improve the performance of students

(Downing et al., 2009; Stephanou & Mpiontini 2017; Zion et al., 2005). Teacher-pupil interactions, problem-based learning, thinking bulletin board, journal keeping, and thinking aloud are all strategies followed by teachers to raise self-awareness, self-regulation and metacognition in students (Branigan & Donaldson, 2020; Downing et al., 2009; Du Toit & Kotze, 2009; Sulaiman et al., 2021). Therefore, it will be crucial to understand how building awareness of metacognition in teachers would influence the use of metacognition in their instructions. Developing the strategies teachers follow to plan their instructional strategies, monitor and evaluate their plans would help improve their efficacy and increase their competence as they design their instructions in their classrooms. Firmanto and colleagues (2019) verified a strong correlation between teachers designing their instructions to suite the learning styles and desires of their students to enhancing their metacognition skills in learning. Many other studies consider that the instructional strategies that use metacognitive prompts can enhance the learning in lower and higher achievers (Amin & Mariani, 2017; Parsons et al., 2018; Sulaiman et al., 2021).

Marzano and colleagues identified nine-instructional strategies that are effective for teaching and learning and result in increasing student achievement; therefore, they are referred to as high-yield instructional strategies. Within these strategies, metacognition knowledge and skills are embedded in many of the categories of these instructional strategies and are considered as high-level domains that increase critical thinking in students (Haystead & Marzano, 2009; Marzano, 2001; Jusniar, 2021). Irvine (2017) explained how when using Marzano's strategies, teachers are encouraging metacognition since it utilizes self-awareness as well as knowledge domains with encouraging students to set targets.

Robert Marzano's nine learning strategies rely on research techniques to enhance students learning. These strategies are directly related to metacognition (Asha et al., 2022; Hasan et al., 2021; Hiss, 2021; Zimmerman, 2013).

1- The first strategy is identifying similarities and differences. This strategy involves metacognition knowledge since students need to be aware of their own thinking processes as they analyze, compare and contrast information to reflect a better understanding of the concepts explained.
2- The second strategy is summarizing and taking notes. This strategy also requires metacognition knowledge as students need to be aware of what to focus on and how to organize information presented to them.
3- The third strategy is reinforcing effort and recognizing students' hard work and progress. This raises students' metacognition and helps them be aware of their own effort and progress which in turn would help them feel motivated and celebrate their own success. This strategy entails metacognitive skills.
4- The fourth strategy is homework and practice which again require metacognition for students to become aware of their learning process and ability to identify their needs through monitoring and reflections. Monitoring and evaluating are main elements of the metacognitive skills.
5- Nonlinguistic representation to find the proper visual or physical representations that could help students better understand information is another fifth strategy that requires metacognitive knowledge and planning skills.

6- The sixth strategy is cooperative learning which requires social interactions through groups to learn and solve problems together. This directly relates to contextual effects while using metacognition.
7- The seventh strategy directly correlates to metacognitive skills since it is etting objects and providing feedbac. Thus strategy requires metacognition for students to identify their strengths and weaknesses and set their own goals accordingly.
8- Generating and testing hypothesisis another strategy that requires awareness of the though processes to use evidence to support hypothesis which is a component of metacognition skill.
9- Finally Cues, questions and organizers are strategies where metacognition is a crucial element to have them presented effectively.

If metacognition is required in all of the above strategies, then this reflects a need for teachers to develop their own metacognition to be able to implement these strategies effectively in class and monitor the success of the process. Especially that many studies encourage using Marzano as one of the instructional strategies.

One other strategy is using Bloom's Taxonomy as a framework for organizing lesson outcomes based on six cognitive levels, ranging from lower-order thinking skills such as remembering and understanding to higher-order thinking skills such as analyzing, evaluating, and creating. Bloom's Taxonomy can guide the development of metacognitive skills (Hattie, 2015). By providing a framework for thinking about educational objectives and outcomes, Bloom's Taxonomy can help teachers design learning experiences that promote metacognitive

skills and design assessment to measure students' metacognition (Meher, Baral & Bhuyan, 2021a). The students will need metacognition skills to monitor and regulate their higher order thinking and teachers would need metacognition skills to plan lessons that foster critical thinking and high-order questioning.

Marzano and Bloom are main strategies used in education (Kegan, 2007). Studies have shown that Marzano's strategies seem to play a stronger role in metacognition as compared to the revised Bloom's taxonomy that relies more on the knowledge domain only. This was further acknowledged in two studies by Ahmed (2020) and Almekhlafi (2020) in UAE who encouraged the use of Marzano's taxonomy to help students build their metacognition. Marzano's instructional strategies provide opportunities to practice metacognition at different contextual and situational settings (Ahmed, 2020; Almekhlafi, 2020).

While Bloom's taxonomy is a cognitive taxonomy used by teachers, Structure of Observed Learning Outcomes (SOLO) taxonomy refers to students' depth of understanding during their learning journey rather than the content itself. SOLO Taxonomy introduced by John Biggs and Kevin Collis focuses more on procedural and conceptual knowledge (Weay, Masood & Abdullah, 2016). Therefore, teachers using SOLO Taxonomy as a strategy to monitor the progress of their students and their ability to integrate the different aspects and dimensions of the topic are mainly referring to the metacognition level in their students and at the same time would require them to use their own metacognition to be able to relate to the level of understanding of their students and determine the scaffold required. Research findings suggest a correlation between metacognition skills and thinking skills reflected in the use of

SOLO Taxonomy (Nunaki et al., 2019). While Bloom's measures cognitive ability and is mainly refered to by the teacher, Solo taxonomy involves the student's ability to progress through the more complex cognitive processes using advanced prompts (Gulzar, 2021). This shows how metacognition is required as prompts to advance while using SOLO taxonomy and justifies why teachers could choose it to teach for metacognition. The use of SOLO taxonolmy gives the teachers the ability to give feedback and allows students to feed-forward and respond to teachers' feedback during the learning process. This requires high metacognition in both students and teachers to reach the feed-up stage (Gulzar,2021)

Other studies linked the use of 5E learning model or 7E learning model as strategies that best develop metacognition in students during instruction particularly in science lessons. Roger Bybee developed the 5E instructional model that encompasses five phases: Engage, Explore, Explain, Elaborate and Evaluate. The same model was further modified by Eisenkraft in 2003 to become a 7E model cycle that adds Elicit and Extend to Roger's 5E model (Chansana, Suksringarm & Parakham, 2008; Sanium &Buaraphan, 2019). Another study highlights the importance of using Argumentative Driven Instructional strategy by science teachers to promote awareness and use of metacognition in students (Erenler & Cetin, 2019). This strategy helps build the critical thinking skills in students. Therefore, if teachers choose to use this instructional strategy, then they are encouraging the use of metacognition skills and they are using their own metacognition to direct students through this process.

In summary, metacognition is a strategy on its own and is also used within other strategies to enhance learning and problem-solving skills. Many experts in the field look into

impact of metacognition in education when used as prompts during instruction using any teaching strategy or as a strategy used on its own by teachers in their classroom. This requires teachers to be able to teach with and for metacognition while planning for their lessons.

2.2.1.2 Planning, Monitoring, and Evaluating Learning Model (PME). According to researchers, metacognition can be taught when associated with successful learning experience (Halpern, 2013). While metacognition is mainly divided into two domains: Knowledge and skills, reflection is the main skill in metacognition and helps in developing the "Metacognitive Awareness" (Amin & Mariani, 2017; Moshman, 2018; Schraw & Dennison, 1994). Fogarty (1994) divided the reflection skills in metacognition into three phases: Planning, monitoring and evaluating (PME). The PME learning model was mainly introduced by Fogarty emerging from Darling-Hammond's model (2003) and is integrated as a strategy for building up the conceptual learning experiences for students especially in Mathematics lessons (Amin & Mariani, 2017; TEAL, 2012).

Teachers require instructional adaptations while planning their lessons (Parsons et al., 2018). Teachers aim to prepare effective instructional strategies and pedagogical resources through adjusting their plans according to the needs of the students at the social, linguistic, and cultural level as well as according to data (Parson et al., 2018). Planning lesson requires the use of differentiated instructional strategies and tasks as well as implementing formative assessment approach in order to monitor students, identify their needs and monitor their progress (Bondie, Dahnke & Zusho, 2019). Data decision making from students' achievement,

cognitive ability and class observations lead teachers' planning for differentiated tasks using the proper pedagogical strategies.

Teachers require "reflection-in-action" which is the mode by which they respond to students' interactions in class and attend to their understanding during the delivery of instruction. This is the monitoring skill part within the metacognition of teachers (Parsons et al., 2018). According to Danielson (2011) in his Framework for Teaching, teacher's flexibility and responsiveness allow experienced teachers to plan and deliver their instructions effectively through their ability to accommodate minor or major changes during lesson delivery and weave changes in response to the learning context within classroom. This requires teacher's knowledge of pedagogy and use of metacognition skills (Pasrsons et al., 2018). Finally, reflection-on-action is required from teachers after completion of their lesson to evaluate their instruction in classroom (Schon, 1983).

Sulaiman and his colleagues (2021) acknowledge that "teachers need to reflect, plan and evaluate learning outcomes" to enhance further in their teaching. Metacognitive strategies are important to help learners build their metacognition (as cited in Amin & Mariani, 2017; TEAL, 2012). The PME model emphasizes the students' need of planning for the task, selecting the proper strategies and evaluating the goals in order to improve their performance. Therefore, it is expected to see similar results as teachers plan and evaluate their instructions leading to re-enforcement in their metacognition. Most teachers use strategies that allow the students to plan, monitor, evaluate and regulate their work as they complete their tasks or try find solutions to their problems (Perry et al., 2019) and a similar approach if applied to

teachers is expected to improve their performance. Raising teacher's metacognition awareness would help them better use metacognition prompts in their instructions to help students build their own metacognition as well (Nordin & Yunus, 2020; Ozturk, 2018).

2.2.1.3 Social and Cultural Context. All experts relate the learning experience to collaboration and social cultural situation in classrooms (Amin & Mariani, 2017; Moshman, 2018). Learning experience adds to the power of metacognition in learners. Almost all research work on metacognition includes the contextual effect, the experience and emotional regulation as key elements for the success of the learning using metacognition prompts (Norman et al., 2019; Pennequin et al., 2020). Yanqun (2020) states in his study how many factors influence metacognition awareness and use such as resources, strategies, work, life, and time including the different physical, emotional and social states of the learner. In their book, Wiggins and colleagues (2005) focused on the influence of availability of resources and adequate materials to improve metacognition within classrooms. Furthermore, Chonjo (2018) emphasizes on the importance of availability of instructional resources as well as physical resources to help enhance the learning; in accordance, resourcing teachers and providing them with all material needed can help them plan and properly evaluate their instructional strategies. Other studies outline the importance of culture and environment on the academic performance of students; therefore, it is expected that the same factors would impact the teachers' performance in their classrooms (Mligo & Mshana, 2018; Tarimo, 2020).

Many studies relate metacognition to social contexts. A study Hadwin, Bakhir and Miller (2018) investigated how learners can develop their metacognition awareness when

placed within a social context. In collaborative learning settings, learners can utilize effective learning strategies, enhance their understanding of the task, and help them face challenges and change their perception of the task. This agrees with Robson's (2010) view of metacognition as a social form that embraces motivation and social regulation. Lin, Schwartz and Hatano (2018) talked about adaptive metacognition which allows teachers to continuously assess the needs of their students and adjust their instructional strategies to meet those needs. Here again social context plays a crucial role in the use of metacognition. This approach recognizes that every class, student, and situation is unique and requires a different approach and enables teachers to better engage their students and promote meaningful learning. Moreover, adaptive metacognition also involves the teacher reflecting on their own teaching and learning processes and making changes as needed. This type of self-reflection and self-correction is an important part of professional growth and development for teacher. Adaptive metacognition according to emerging situations and contextual effects is a crucial element of successful teaching and can greatly improve the teaching and learning experience for both teachers and students.

To conclude, teaching metacognitively refers to teaching for and with metacognition where teachers consider and think about "instructional goals, teaching strategies, sequence, materials, students' characteristics and needs, and other issues related to curriculum, instruction and assessment before, during and after lessons in order to maximize their instructional effectiveness" (Hartman, 2001, p.149). This shows how teachers should use the PME model while designing their instructional strategies before the lesson delivery, then followed by monitoring the delivery of the plan within classrooms according to emerging

contextual situations during the lesson delivery and finally reflecting on the whole process after the lesson delivery is completed (Hartman, 2001; Perry et al., 2019; Sulaiman et al., 2021).

2.2.2 The Expected Outcomes from Raising Awareness and Use of Metacognition

2.2.2.1 Self-efficacy and Motivation. Bandora (1997) defined the self-efficacy theory as confidence related to one's own belief in performing the tasks and he outlined four main sources for self-efficacy construct: mastery experiences, vicarious experiences, verbal persuasion, and physiological and affective states (Bandora, 1997; Elliot, 2021). Particularly in education, a teacher's self-efficacy is defined as the teacher's own belief in their capacity as they plan and deliver their instructions within specific contextual effects (Tschannen-Moran & Hoy, 2001; Wray et al., 2022). As discussed earlier, PME is a model that focuses on planning and monitoring the delivery of instruction; therefore, self-efficacy is directly linked to PME metacognition skills.

Studies show that using metacognitive strategies helps improve self-efficacy beliefs in teachers (Yildiz & Akdag, 2017). Some studies confirm a positive moderate correlation between metacognitive skills and critical thinking skills as well as between metacognition and academic self-efficacy in teachers (Karaoglan-Yilmiz et al., 2019; Ozturk, 2018). Another study by Fauzi and Sa'diyah (2019) concluded that Biology teachers need to be taught metacognition in order to improve their competence. It will be expected to see teachers' competence, self-efficacy and motivation progress in teachers if they are taught how to use metacognition during the planning, monitoring and evaluation. This could improve the

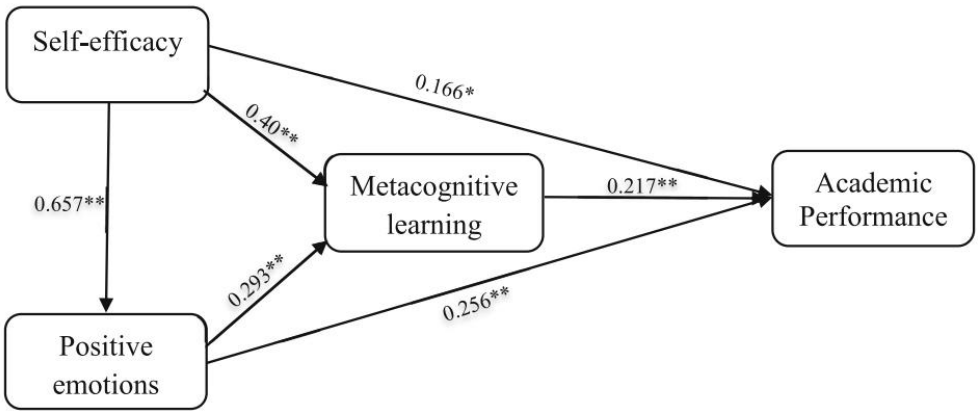
pedagogy, instructional strategies, content and organization in teachers. Although a study by Kuroch and colleagues (2020) did not provide evidence for increased self-efficacy in science teachers after self-reflection, the researchers emphasize on the need for professional development programs that can provide teachers with teaching strategies and motivational techniques. These are the main elements of metacognition.

A study by Hayat and colleagues (2020) provided statistical evidence of correlations between self-efficacy, metacognition and improved academic performance in medical students as shown in the figure below. The equational model shows that students' self-efficacy influences both their learning emotions and metacognitive learning strategies. Subsequently, these factors impact the students' academic performance. Moreover, emotions play a role in shaping metacognitive learning strategies leading to better academic achievement.

Figure 2.2 can be a starting point to consider the possible outcome for using PME with teachers as metacognitive strategy to increase their self-efficacy and performance as teachers. Many studies show that metacognition increases goal-focused motivation while using metacognition skills during the process of learning (Hayat et al., 2020; Nieto-Márquez et al., 2021). Since metacognition has been referred to influencing motivation, self-efficacy and performance in students, it is expected to have the same impact on teachers. This is statistically supported in one of the studies by Oz (2016) whose findings verified the relationship between metacognitive awareness and academic motivation in English teachers in Turkey.

Figure 2

Metacognition, Positive Emotions, And Self-efficacy in Relation to Academic Performance



Note. Statistical presentation of equational model that depicts the relationships among metacognitive learning, positive emotions, and self-efficacy with academic performance where ** indicates statistical significance at p<0.0s1 and * indicates statistical significance at p<0.05 taken from a study by Hayat et al (2020).

2.2.2.2 Self-regulation and Autonomous Teachers. In articles discussing metacognition on learners, researchers refer to "Self-Regulated Learning" (SRL) of students since SRL embraces cognition, metacognition, behavior, motivation and emotions. Self-regulated learning theories were first identified and modified by Zimmerman (Ozimik & Forester, 2021). These all are contextual factors that impact the learning of students (Panadero, 2017). A study by Stephanou and Mpiontini (2017) showed that metacognition empowered the students with the intrinsic self- regulatory learning ability and improved their performance expectations in languages and mathematics. Another study by Li (2018) promoted for the

cultivation of autonomous learning in students using metacognitive strategies while teaching English. Task based teaching using metacognitive prompts stimulate the students' intrinsic motivation and improves their metacognitive strategies and abilities (Li, 2018). Many studies in Scandinavia, Indonesia, China, Japan and UAE relate using metacognition in classrooms to be increasing the self-regulated learning efficiency in students and therefore growing their autonomic learning ability, motivation and performance especially in languages (Abdelrahman, 2020; Calafato, 2020; Li, 2018; Mekala & Radhakrishnan, 2019). Another study proved that raising the metacognition in students would enhance students' competency and learning autonomy especially during the monitoring and evaluating stages (Khulaifiyah et al., 2021).

Autonomy is defined as the ability to control one's own learning and take charge of monitoring the process of learning. It includes the ability to plan, monitor and evaluate the learning process which directly links to metacognition skills (O'Leary, 2018). Therefore, metacognition awareness and use directly correlates to building autonomy in individuals. In a study by Marantika (2021) a significant correlation between metacognition, autonomy and learner's success by focusing on the thinking process. The contextual setting should be designed to encourage independent autonomous learning experience. This increases the learners' abilities to express themselves, more creative, build self-esteem, and comprehend more challenging conceptual material (Marantika, 2021).

If metacognition can stimulate self-regulation and autonomy in students, then it is expected to reflect a similar impact on teachers. Only one study examined the correlation

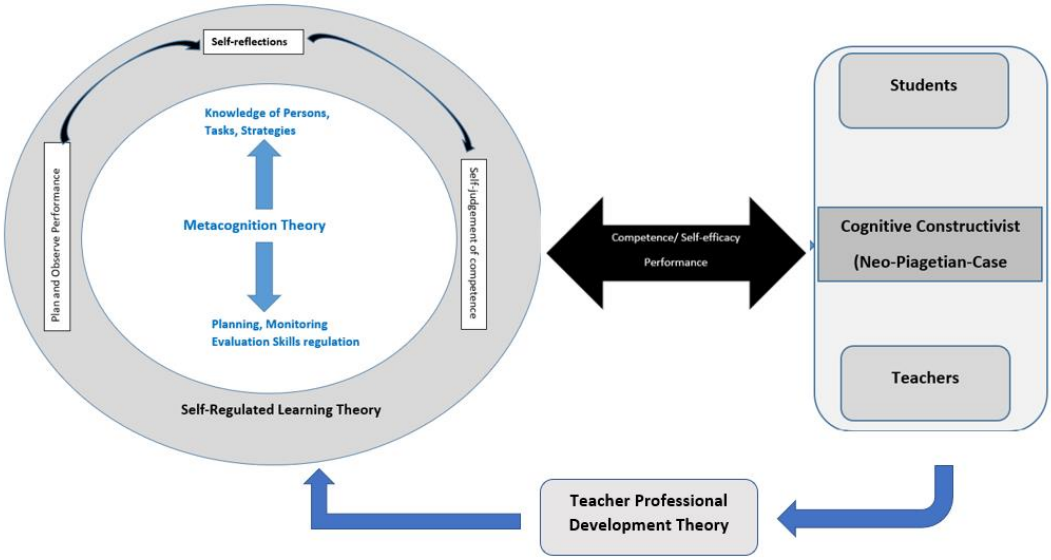
between autonomous learning and metacognition on the performance of pre-service science teachers rather than students (Pudiquet et al., 2019). The result indicated that metacognitive awareness and autonomous learning can be improved through teachers' collaborative planning and ability to reflect on their lessons.

2.3 Theoratical Framework

Four main theories underpin this research: The metacognitive theory, Self-regulated Learning Theory, Teacher Development Theory and Cognitive Constructivist Theory.

Figure 3

The Theoretical Framework



Note. These are the main theories that shape this research: The metacognitive theory, Self-regulated Learning Theory, Teacher Development Theory and Cognitive Constructivist theory interrelated. This framework is designed by the researcher.

2.3.1 The Metacognitive Theory

The development of "metacognition theory" in educational psychology initiated mainly by Flavell's definition "cognition about cognitive phenomena," or "thinking about thinking" (Flavell, 1979, p. 906). For Flavell, metacognition is about the person himself and task knowledge where a learner has the knowledge of the strategies used to solve problems and is aware of the appropriate strategy to be selected during the task due to experience. The metacognition further developed from only strategy knowledge as defined by Flavell (1979) into declarative, procedural and conditional knowledge as defined by Cross & Pain, 1988; Kuhn & Dean, 2004; Schraw et al., 2006 (as cited in Lai 2011). All experts in the field agreed that metacognition is not only about cognitive knowledge but also about cognitive regulation. Many empirical studies showed strong correlation between cognitive knowledge and regulation where knowledge facilitates the regulatory process (Schraw, 1988). Through the development of the metacognitive theory, it became a part of the "cognitive paradigm" (Postholm, 2012).

While Flavell introduced the term "metacognition" in 1970s as one's own cognition in his primary metacognition theory, many experts in the field discussed how learners become aware and even can control their own learning process in the secondary metacognition theory (Georghiades, 2004; Hennessey, 1999; Schraw & Moshman, 1995). The metacognition theory developed with time to include not only cognitive knowledge but also cognitive regulation (Balcikanli, 2011). Developing metacognition is linked to methods designed to develop metacognition and self-regulation at the same time (Schunk, 2008).

The metacognition knowledge includes knowing about the factors and skills that influence one's performance (declarative knowledge), how to apply these skills (procedural knowledge), and the time and reasons for applying cognition (conditional knowledge) (Cromley & Kunze, 2020; Lai, 2011; Schraw & Moshman, 1995). The regulatory cognition on the other hand involves selecting the appropriate strategies and resources required during one's performance in planning phase, awareness during the task performance in the monitoring phase, followed by appraisal of the process and product in the evaluation phase and finally gathering all information to improve competence and attention to details in the final conclusion phase (Lai, 2011; Moshman, 2018).These domains were further divided into general and specific domains according to situational effects, experience and emotions (Moshman, 2018, Pennequin et al., 2020). The development of the metacognition theory had been evolving to include knowledge, skills and experience at different levels and domains according to the cognitive requirements while planning, solving and monitoring any task while interacting with different factors arising within a certain sociosituational contexts. While metacognition was simply used to identify how, where, and when to use certain strategies before, during and after any task; it has evolved with time to encompass factors such as emotions, experience, culture, and context (Lai, 2011; Moshman, 2018; Pennequin et al., 2020; Siegal & Castel, 2019). These factors extend to our days now; therefore, making metacognition an element in education at all times and form of responsiveness to educational needs.

Figure 4

The Development of The Metacognition Theory Along the Years

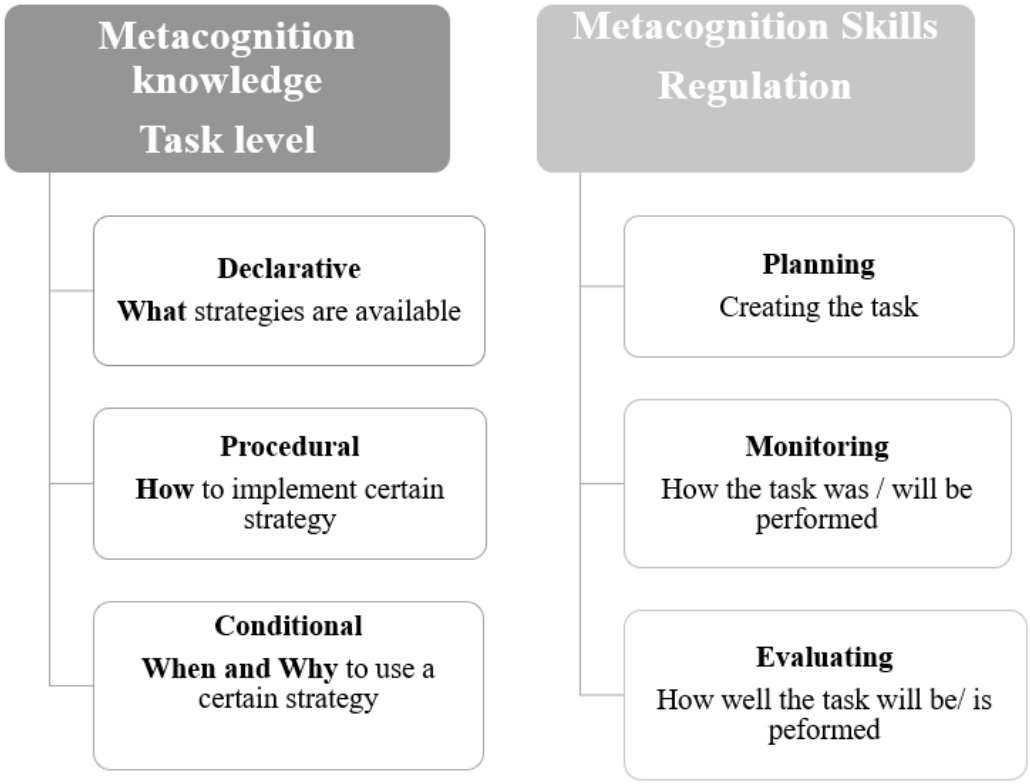
Metacognitive Component	Type	Terminology	Citation
Cognitive knowledge	Knowledge about oneself as a learner and factors affecting cognition	Person and task knowledge	Flavell, 1979
		Self-appraisal	Paris & Winograd, 1990
		Epistemological understanding	Kuhn & Dean, 2004
		Declarative knowledge	Cross &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

Note. adopted from "Metacognition : a literature review" by Lai (2011)

The development of the metacognition theory across the years from 1979 to 2009 lead to the identification of two main domains within metacognition. The metacognition knowledge domain and the metacognition skills or regulation domain. Each of these domains are divided into three main levels as shown in figure 2.5 below.

Figure 5

The Components of Metacognition



Note. Presented by the researcher

In literature, metacognition theory is linked to many other constructs such as critical thinking and motivation. Critical thinking relies on reasoning, evaluating and making decisions which show a strong link between critical thinking and metacognition regulation mainly monitoring and evaluating skills. Hennessey (1999) and Kuhn (2000) correlate the skills required for critical thinking to skills in metacognition. However, Schraw et al (2006) consider motivations, metacognition and critical thinking as part of self-regulated learning which is defined as the "ability to understand and control our learning environments" (p. 111).

These aspects allowed for the formation of the conceptual framework in this study and determined the underpinning theories. Metacognition encompasses motivation which defines the believes and attitudes that impact the use and development of metacognition skills (Lai, 2011). Motivation includes self-efficacy and epistemological beliefs according to Schraw et al. (2006). All the above studies verify the link among metacognition, motivation, critical thinking and self-regulation. These provide preliminary elements in this research where it predicts that raising awareness and use of metacognition in secondary science teachers can relate directly to teachers' improved motivation and efficacy in planning, monitoring and evaluating their instructional strategies.

Furthermore, metacognition is included within the adaptive learning theories since effiective teaching requires adaptive metgacognition. Adaptive metacognition is the ability of teachers to respond to the various social and instructional dynamics in class. Metacognition awareness is necessary for teachers to assist them recognize situations in a "critical event-based instruction" method (Beer et al., 2012, p. 245). This helps teachers respond to the unique environment of each classroom within an adaptive self-regulatory process that were identified and presented in the framework of studies by Lin (2001), Wells and Matthews (1996) and Wells' (2005).

Metacognition knowledge and skills develop at different rates according to Garcia and colleagues (2016) as well as due to different factors such as time with growing experience and ability to do self-reflections. It starts as "tacit" where metacognition is acquired without any awareness and develops into "explicit but informal" metacognition influenced by social and

personal experience and finally becomes “explicit and formal” metacognition where individuals become aware of the process and could distinguish the realistic influence of factors involved during the metacognitive process (Duell, 1986; Hennessey, 1999; Moshman, 2018). Therefore, this research focuses on the influence of developing this regulatory cognition on teachers after raising awareness of the knowledge, skills and uses of metacognition in classroom settings.

Age is one factor that influences the development of metacognition; metacognitive knowledge is the first to develop and followed by consolidating the metacognitive skills. The metacognition skills of monitoring and evaluating develop at the slowest rate due to complication required during the cognition process (Lai, 2011). Metamemory studies revealed a correlation between metacognitive accuracy for judging one's own capability and age. Age, experience and feedback cycles improve ability to monitor and assess information and skills required during task performance (Siegel & Castel, 2019). Different research work in different subjects, psychological situations and contexts discuss different factors that might influence metacognition development such as age, experience, internal and external motivation, modelling, strategy-feedback, presenting different skills, and mainly the contextual and situational effects (Garcia et al., 2016; Moshman, 2018; Siegal & Castel, 2019). This explains the expected factors that were added to the conceptual framework and to the tool for assessing teacher’s metacognition in this study.

This theory has been widely supported due to its relevance in identifying the key variables in metacognition: the individual’s experience, the task and the strategies (Schraw,

2001; Moshman, 2018). It highlights the importance of this theory in education and psychology during practice. Teachers use metacognition to train students acquire higher order thinking and psychology therapist use metacognition as a behavioral therapy using self-regulatory functions within patients (Pelley, 2021; Sharpe& Curran, 2021; Zion et al., 2005). Experts agree that metacognition becomes "more explicit, powerful and effective" with training and is used as a developmental strategy rather than just referring to the behaviorist theory in education which ignores emotions, critical thinking role and ways of learning due to social interactions (Kuhn, 2000; Pennequin et al., 2020; Pritchard, 2017). A study by Magno (2010) and another by Kozikoglu (2019) directly link developing metacognition to increasing one's critical thinking.

To consolidate the origin and development of the metacognition theory, metacognition evolved across time from being only identified as one's own knowledge of the task and strategy used to solve the task by Flavell in 1979, into involving declarative and procedural knowledge alongside planning and monitoring regulation by Cross and Paris (1988). Then, Schraw and Moshmann added conditional knowledge and evaluating skills in 1995 and 2006. Moreover, Kuhn described types of metacognition in his tacit theory in 2004. The progress through understanding metacognition continued to be studied and analyzed until this decade where researchers started to focus on the sociocultural impacts on the development of metacognition in individuals as discussed by Moshman and Castel in 2019.

Currently, metacognition researchers are interested in personal-level beliefs and knowledge in real-world settings (Fleming, 2024; Rollwage, 2021). Therefore, metacognition theory despite

being stated as early as 1970s, research continues to rise in this area due to impact of metacognition on the success of individuals as students and teachers.

Despite being widely accepted, metacognition theory was criticized for many aspects such as the tools and methods used to measure metacognition. Metacognition is an internal thinking process that can be altered or enhanced since it is presented as a journey from unconscious to a conscious way of learning with age and experience. Therefore, it questions how much metacognition can be controlled while measuring it (Flavell, 1976; Livingston, 2003). This is in addition to the fact that metacognitive measurement tools are mainly dependent upon self-regulatory thoughts and surveys (Jiang & Gao, 2016; Santisi et al., 2014; Schraw & Dennison, 1995). Critiques doubt the reliability of the tool since they question the extent at which self-regulation is conscious or unconscious in adults (Brown, 1987; Zohar & Barzilai, 2013). Additionally, many experts struggled to validate an instrument that can measure all three metacognitive domains: knowledge, skills and experience (Craig et al., 2020; Zohar & Barzilai, 2013). Moreover, it is thought that metacognition tools are not adequate for teachers since as adults' cognition have reached pinnacle where cognitive development mainly occurs during childhood and adolescence. This is in addition to the fact that teachers might be hesitant to acknowledge their cognitive challenges where such disclosure could undermine their credibility or efficacy in their educational institute (Rezaeisharif et al. 2024).

2.3.2 The Self-regulated Learning Theory

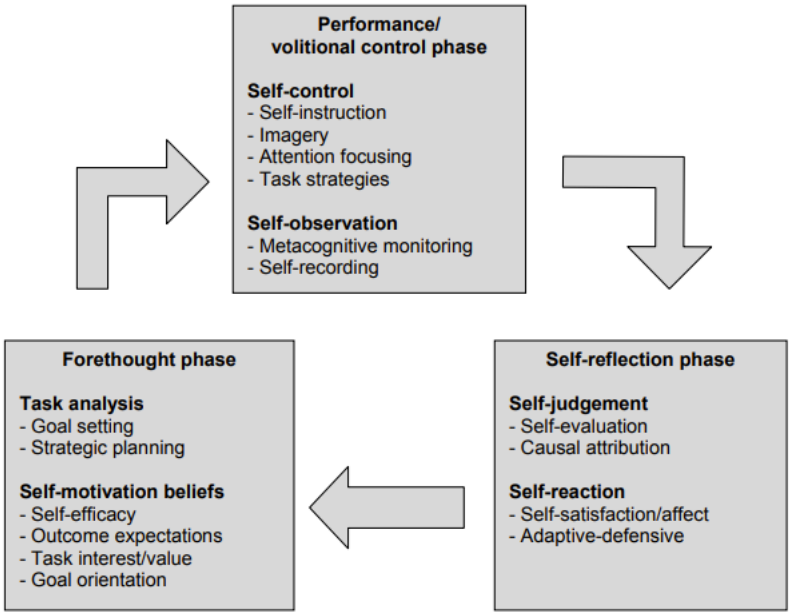
Even though there is no one unified definition of self-regulation, experts in the field defined it as the ability of the students to be active participants (Tascilar 2016) or as the ability

of an individual to monitor and control the learning process effectively while applying the efficient strategies, maintaining competence, motivation, diagnosing challenges and controlling any emerging environmental factors during the learning process (Guzenhauser et al.1994, p. 6-7).

Zimmerman (2013) introduced the self-regulated learning theory that includes the three components: forethought, performance and self-reflection. These three components encompass motivation, self-efficacy, self-control and self- evaluation by which they require metacognitive self-monitoring techniques. Self-efficacy using metacognitive judgements is one of the main components of self-regulated learning (Bernacki 2015). Therefore, a strong correlation lies between self-regulation and metacognition in teachers as Jaing et al (2016) acknowledged: "Teacher metacognition, symbolizing levels of self-awareness and self-regulation in teaching activities, plays an important role in teacher professional development and has been recognized as a powerful factor that impacts the quality of instruction in classrooms" (p. 411). Furthermore, Ghonsooly, Khajavy and Mahjoobi (2014) confirmed that a high level of metacognition in teachers leads to a higher self-efficacy and better performance. Therefore, promoting metacognition awareness and skills correlate to improved self-efficacy and competence of teachers (Babaie & Abednia 2016; Bars & Oral 2017; Ghonsooly, Khajavy & Mahjoobi 2014).

Figure 6

A Cyclical Model of Self-regulated Learning



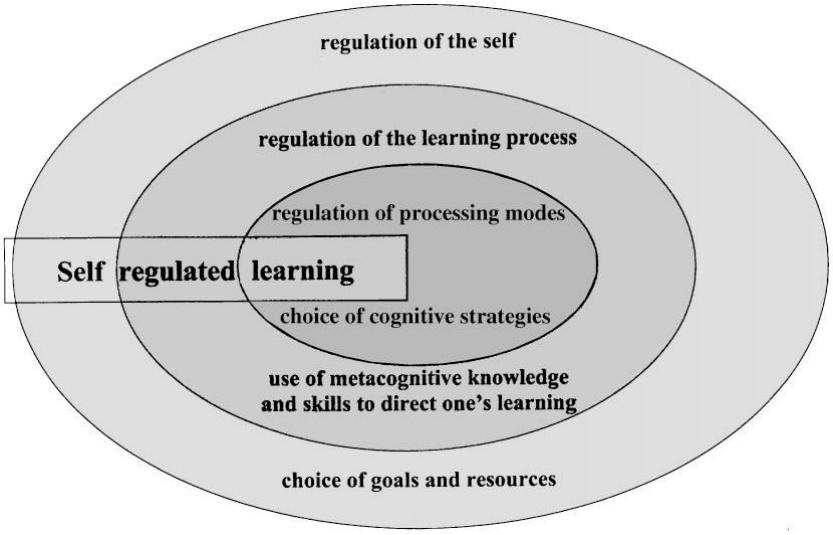
Note. Zimmerman, 2008

The conceptualization of the self-regulated learning (SRL) theory as defined and presented by Zimmerman (2008) has been linked to metacognition, motivation, strategies and contextual environment (Azevedo, 2020; Ben-Eliyahu & Bernacki, 2015). Therefore, this study needs to consider the SRL theory since all those linked factors wil be investigated alongside awareness and use of metacognition. The SRL framework includes the influence of many features such as (1) contextual factors which include the interactions within the learning environment, (2) contingencies which relate to how one contextual event leads to another and (3) dynamic relations which includes the interaction of two or more processes required during

the SRL (Ben-Eliyahu & Bernacki, 2015). These verify the influence of the social aspect and experience for the development of self-regulation. Some studies also relate to the influence of socio-emotional strategies used in classrooms (Muijs & Bokhove, 2020). Furthermore, unfolding the SRL aptitude and events during the learning process requires triangulation of the cognitive processes of affection, metacognition and motivation (Azevedo, 2020; Ben-Eliyahu & Bernacki, 2015). To be able to choose the goals and resources, select the strategy, and monitor the process, SRL requires the awareness and use of metacognitive knowledge and skills as seen in the Figure below (Boekart, 1999). This can be directly correlated to teachers as they plan their lessons and choose the strategies to help students learn and finally monitor the delivery of their instructions. So SRL in teachers would directly link to building their SRL of teaching instructions.

Figure 7

Self-Regulated Learning Theory



Note. as presented by Boekaerts (1999)

In different studies by Zimmerman (2001, 2002 and 2010) show how experts always exhibited higher SRL actions as compared to novice or non-expert learners in different fields (as cited by Panadero 2017). The SRL theory encompasses a strong metacognitive perspective where learners are involved in managing and monitoring their use of the metacognitive strategies (Panadero 2020). SRL was also found to be related to motivation and improved performance. These collective constructs relate to the aim of this research. Teachers would benefit from improving their awareness and use of metacognition, in order to acquire strong self-regulation which in turn leads to higher motivation and better performance as they plan and deliver their instructions.

While self-regulated learning theory is widely used with emphasis on its importance in the academic and psychological field, many experts critique its complexity and confusion with metacognition theory. This confusion arises from the commonality in terms associated to both theories such as : monitoring, controlling, regulating, cognition, motivation, behavioral and knowledge (Muijs & Bokhove, 2020.). Analyzing many studies by Dinsmore and colleagues (2008), they suggest that SRL theory and metacognition strongly use the terms mentioned above in their definitions at different extents (except for the term knowledge). While some experts consider SRL as part of metacognition theory, others think the opposite (Muijs & Bokhove, 2020). This is in addition to the tools used to measure SRL which also shows strong reliance on self-report strategies.

2.3.3 The Professional Development Theory for Teachers

Teachers' professional development (TPD) became a crucial element in the school improvement plans, during education reforms, and in education transformations (Borko et al 2010; Scott 2010). According to Darling-Hammond (1994), TPD is defined as the process by which teachers' awareness and knowledge are increased and expanded after investigating their practice by researchers (as cited by Helleve, 2010). It is an approach that defines how teachers learn and implement their knowledge within classrooms in practice to support the younger learners (Postholm, 2012). Teachers' success in their roles is influenced by internal and external factors. Internal factors include their perception of their capabilities and expectations to their role. This requires metacognition. The external factors include the expectation of stakeholders: students, parents and school leaders. Both these factors require professional development to allow teachers not only build their knowledge in their own subjects, but also be informed of pedagogical knowledge, competence in instruction and curriculum delivery (Makovec, 2018).

The educational shifts in cognition, learning and teaching lead to shifts in the understanding of high-quality and effective professional development (Borko et al 2010). The Professional Development theory requires the integration of cognitive and social learning aspects (Borko, 2004). This lead to paradigm shift from classical in-service PD sessions for teachers into new models of PD sessions that would include integration of class support, scaffolding according to teachers' needs and coaching. These have added much to the contextual and situational factors that influence teachers and may be referred to during PD

sessions (Borko et al., 2010). In pedagogical education, there are emerging situations such as the development of technology, the rise of online and blended learning, and socio-economic development. These require refinement of defining the TPD (Tregubova, Shibankova & Kats, 2020). Teacher's learning helps students learn better (Prostham, 2012).

The traditional in-service teachers' professional Development focused on the activities within workshops and seminars within limited duration. These strategies are now extended in the new model of PD to include building teachers' capacity within longer durations through in-class support, scaffolding and coaching. Moreover, traditionally, targets are set to develop new knowledge to be used within classrooms. Now, professionals cooperate with teachers to set targets that meet their needs and co-construct the agenda of the sessions. They prepare challenges that relate immediately to practice with all necessary scaffolding to reach outcomes. Traditionally, the focus was on developing the teachers regardless of the context factor. In the modern approach the context plays a crucial role in shaping the sessions that focus on not only teachers but also the instructional programme and the community during prolonged time and at different locations.

Changes in the society must be accompanied by changes at personal level especially at professional level in order to increase competence and expertise (Kusmaryani et al 2016). In his theory, Lewin (1935), professional development is a combination of personality and interactions between the person and the environmental factors. This agrees with Hoy's (2014) who considers PD should engage teachers during their practice for successful student learning experience. Therefore, many experts in the field tried to list some factors that influence TPD

such as competence, motivation, organization, personal, task and work environment, self-efficacy and metacognition (Kusmaryani et al., 2016) The emotional factor within teachers towards their roles plays a crucial role in building their professionalism.

Planning teacher professional development sessions require many elements to be considered modern, efficient and successful. First, it should cater to the needs and interests of the teacher, acknowledge the social aspect, allows for collaboration, moves beyond one-session shot into ongoing sustained sessions, and finally, link directly to teachers' practices to enhance teachers' pedagogical skills and knowledge. These all should be facilitated through guidance, inquiry and care (Patton, Parker &Tannehill, 2015).

Taking into consideration the development of the modern TPD, this thesis required designing PD sessions to investigate the awareness and use of metacognition in secondary science teachers. All elements of efficient and successful sessions were taken into consideration while planning the PD sessions that took place within different settings and for prolonged time.

2.3.4 The Neo-Piagetian Theory as a Cognitive-Constructivist Approach

Constructivism considers how someone learns and develops thinking to a higher order after putting the acquired knowledge into practice (Amineh et al., 2015). While Lev Vygotsky acknowledges the role of the community, culture and surrounding people on one's learning process, Piaget believes that one's development precedes his learning. Constructivists such as Piaget, Vygotsky and others relate social constructivism to education. They consider that

teachers should know their students, take into account their prior knowledge in order to provide the suitable learning experience in classrooms. This reflects the importance of constructivism in improving the teaching and learning in education (Downing et al 2009; Amineh et al., 2015). Teachers are challenged to improve their instructional effectiveness and pedagogical resources (Knight & Sutton, 2004) and the Neo-Piagetian theory provides promising tool to achieve this target. The Neo-Piagetian theory suggested by Robbie Case (1987) not only considers the stages of cognitive development with age as suggested by Piaget, but also refers to variations according to each learner's needs within domain-specificity. Therefore, this creates sublevels of cognitive development stages that are controlled by environmental factors, goal settings, and determining the strategies to achieve these goals. Moreover, learners would build their competency as they identify their problems, set their goals and design the proper strategies to solve their problems within their settings (Case, 1987; Sevinç, 2019).

Piaget cognitive theory considers the effect of age in the knowledge acquisition within four stages that follow hierarchical progression. On the other hand, the Neo-Piagetian theorists acknowledge the presence of substantial differences between and within individuals (Case, 1987; Mascolo, 2015). Five theories diverged from Piaget's theory to form the Neo-Piagetian approach for cognitive development: (1) Juan Pascual-Leone theory, Robbie Case theory, Graeme s. Halford theory, KurtW. Fischer theory, and Andreas Demetreau theory. The Neo-Piagetian theory involves the integration of cognition and emotions. The development in adults becomes more complex with interference of many factors such as the genetic, educational, socioeconomical, and acquired personal traits (Kallio, 2015). Pascual-Leone,

Demetriou, Fisher and Case are all experts who were identified as leading the development of the Neo-Piagetian theory which added value to the process, skills, strategies, schemas, affection, perceptions and situations during the cognitive development within learners (Case, 1987). The Neo-Piagetian models highlight the role of the psychological transformations that allow for differentiation in the hierarchical coordination of schemas and strategies followed (Mascolo, 2015).

Pascal-Leone in 1970 focused on the power of mind in determining the mental processing capacity. He believed that many factors influence the power of mind such as the emotional and personality factors. These factors boost one's cognitive development and is responsible for differentiating among students. Then, Robbie Case in 1980s came with an innovative approach to the Neo-Piagetian theory. He analyzed the mental structure of learners. For Case, the mental power is systematic in a way the learner build own cognitive ability. First it is goal directed as soon as the problem is presented, followed by determining the main objective for the task, and finally assemble strategies in a particular sequence to arrive to solving the problem or task. Accordingly the power of mind capacity is controlled by the operating space and short-term storage space of the learner. The development relies on schematic search for a suitable mental representation or schema for a new experience or information, followed by schematic evaluation of the schema based on existing knowledge and memory; and finally, there is the schematic retagging which involves updating the schema by adding new information and modifying it to better fit the new experience. This leads to schematic consolidation which strengthens and stabilizes the updated schema in long-term memory. These mechanisms work together to construct new structures in memory, allowing

individuals to better understand and remember new experiences (Demetriou, Shayer & Efklides, 2016). These steps correlate to the power of PME model used in metacognition skills.

Since metacognition theory relys on cultural learning, individual construction and peer interaction as sources for understanding how metacognition is formed during the learning process, there is a strong link between metacognition and constructivism (Moshman, 2018). Many experts referred to the Neo-Piagetian theory while studying metacognition since they focus not only on the development of the cognitive abilities of individuals at a universal level but also at the non-universal transformations in response to the emerging influences and contextual settings within particular situations (Case, 1986; Downing et al., 2009; Kallio, 2015; Pennequin et al., 2020). In classrooms, all the metacognitive skills and the emerging situational personal and social experiences are required during the process of learning. This further emphasizes the link between metacognition and cognitive-constructivism.

The Neo-Piaget theory eliminated the weaknesses of the Piaget theory. Despite the fact that the Neo-Piagetian theory resolved problems related to development of cognition with age through including external factors that influence and cause the changes in development among and within individuals, still there is a lack on how these cognitive processes vary and create flexible shifts. Studies lack on evidence of how capacity and efficiency of processes are strengthened during the cognitive development. The factors that impact memory development and attention according to situational experience are still to be further exploited in real life situations (Demetriou, Shayer & Efklides, 2016). This research focuses on building a

framework of awareness and use of metacognition in secondary science teachers based on neo-Piagetian theory.

In conclusion, each of the above theories directly relate to the purpose of this study. Teachers vary in their awareness and use of metacognition according to their own development process. Teacher professional development sessions can help build and assess the awareness and use of metacognition during the process of planning, delivering and evaluating their instructions. These integrate teacher's cognitive abilities to class context during delivery of instruction.

2.4 Related Literature

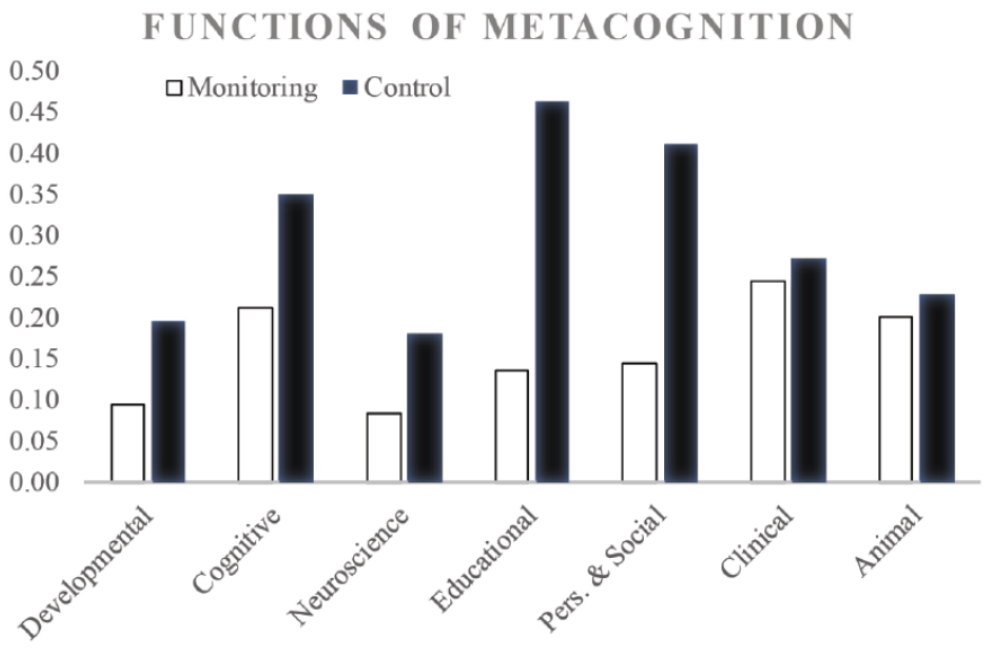
Based on the main purpose of the study, design of the conceptual framework and exploring the underpinning theoretical framework in this research, the following main themes emerged from literature to help shape this research and identify gaps in the field of educational psychology of metacognition. The first theme discusses the importance of use and building awareness of metacognition in education at primary and secondary levels, in students in different subjects and mainly in STEM and in teachers. The second theme oversees the relation between metacognition and performance of students and teachers. Then, the theme of teachers' perceptions to metacognition is discussed. These are followed by themes on metacognition in educational policy, evaluating metacognition and finally, the professional development programs designed to enhance teachers' metacognition.

2.4.1 Metacognition in Education

Metacognition plays a significant role in psychological theories and models mainly in cognitive and psychological psychology. Metacognition seems to be investigated mainly in the field of education especially at the regulatory domain as appears in the diagram below presented by Norman and colleagues (2019).

Figure 8

The Study of "Metacognition" in the Different Disciplines of Research



Note. as presented by Norman et al (2019).

Understanding metacognition helps explore how individuals perceive, evaluate and regulate their cognition which would allow for identifying learning difficulties, cognitive

development, decision-making biases and mental health. Metaocgnition offers a cognitive bridge between psychological research and ecducational practices.

Metacognition is a crucial element in education as indicated in the figure above (Norman, 2019) Many studies relate the use of metacognitive knowledge and skills in students to help them improve their performance and learn better in different subjects (Panadero, 2017; Stephanou & Mpiontini, 2017). Hattie (2015) considers metacognitive strategies as one of the most influential factors on students' achievement, while Fathima and Vimala (2020) acknowledged the role of implementing metacognitive intervention strategies on teachers to enhance their competency as they deliver their instruction. The effect of metacognition strategies was studied at different levels (primary and secondary school levels) and in different subjects (English, Mathematics, Sciences, STEAM…).

Many experts in the field encourage teachers to target fostering metacognition in students to help them improve their learning and achievement (Stanton, Sebesta & Dunlosky, 2021). Metacognition involves declarative, procedural and conditional knowledge in one aspect, and planning, monitoring and evaluating skills in another aspect (Willison et al., 2023). Moreover, experts in the firld included regulation and transfer of these skills across different contexts (Hegge,n 2008; Willison et al., 2023). Scientists believe that metacognition can improve critical thinking, problem solving and performance across different contexts (Adler, 2019; Garcia et al., 2016; Perry et al., 2019; Willison et al., 2023). This explains the importance of metacognition for teachers and students in education.

There are many studies that discuss metacognition prompts that teachers can use during instruction to help students build self-reflection skills, problem solving skills, critical thinking and decision making. All of these are integrated within the metacognition skills domain (Owen & Vista, 2017). Moreover, the effect of using metacognition in classrooms was investigated to study its effect on students' performance, self-efficacy and progress in different subjects in primary and secondary schools. Other studies explore teachers' perception of metacognition in their students.

2.4.1.1. Metacognition in Primary and Secondary School Students. According to educational and psychological studies, metacognition can be developed through interventions while teaching learners within their contextual setting and apart from intelligence, cognition, and motivation alone **(**Branigan & Donaldson, 2020; Pedone, 2014). Using metacognitive prompts and raising self-confidence help develop metacognition in students and teachers during the learning process according to situations. Some studies looked at metacognition of students in primary schools and others in secondary schools. Research focuses not only on training learners how to plan, monitor and reflect on their own learning, but also on teaching students how to identify the adequate strategy to solve a certain task or problem which highly depends on metacognition domain and procedural knowledge. These could vary according to age groups and strategies used by teachers within classrooms (Cromley & Kunze, 2020).

Branigan and Donaldson (2020) concluded that teachers in the primary school must facilitate metacognition within classrooms while planning their pedagogical resources in order to prepare students for "Structured Thinking Activities" and through promoting class discussions that require teacher-student interactions. A similar approach was followed by

Pedone (2014) in primary school in Spain which involved 60 primary level students and 4 teachers. Her study revealed how using metacognitive tools of concept mapping, rubrics, and think-aloud within teacher's instructions promote cognition and affective gains. The process of metacognition was evident during students' talk, collaborative tasks, and engagement in constructing concept maps. The study concluded that instructional intervention could promote the development of metacognitive knowledge in primary students (Pedone, 2014). Another study by Vickery and Dorjee (2016) highlights how primary students can increase their metacognition while participating in mindfulness programs and engaging in emotional well-being activities lead by their teachers. Additionally, a study by Aurah and colleagues (2011) found a statistical correlation between metacognition and problem-solving ability in 150 students at Muraka Primary school in Kenya. The study also found significant differences in problem-solving ability and metacognition level based on grade level. So the study concluded that metacognition ability develops with age where higher grade levels showed a higher metacognitive ability. Furthermore, the results suggest that teachers can help students improve their problem-solving skills and overall academic achievement by incorporating metacognitive skills into their instruction.

Similar studies investigated metacognition in secondary students. A study by Jaleel (2016) in an Indian secondary school where she encourages metacognition in secondary students to be embedded in the daily activities in classrooms through making the different strategies clear to the students to help them reflect on their learning and identify their strengths and weaknesses. This enables students to be more mindful of what, why and how they are acquiring these skills for long lasting impact on their learning. Olin-Scheller and Tengberg

(2017) also focus on the importance of metacognition in facilitating critical approaches in Swedish secondary schools. Therefore, most studies agree that metacognition plays an important role in classrooms at all school levels: primary and secondary for students as well as for teachers (Branigan & Donaldson, 2020; Fathima &Vimala, 2020; Olin-Scheller &Tengberg, 2017). Metacognition is one of the elements that if involved in secondary students' learning experience would create life-long learning attributes in different age groups, different class types and different education forms according to a study conducted in Budapest secondary school (Gogh & Kovari, 2018).

A study by Bakkaloglu (2020) highlights the importance of metacognition awareness at all ages in primary and secondary classes. The study does not show any significant differences in metacognition awareness between students at different grade levels and among boys and girls in Turkey and a similar result was in a study by Jaleel (2016) which also discuss metacognition awareness in students in different Indian schools. The study did not show any significant difference in secondary students' awareness and use of metacognition according to gender differences, type of school management and location: rural or urban. Many studies also discuss the strategies that teachers can follow in classrooms to allow students to use metacognition (Owen & Devista, 2017). This was further assessed in India by Nongtodu and Bhutia (2017) who identified a positive correlation between metacognition and academic achievement regardless of gender, streams, and areas in randomly selected 797 college going students of Meghalaya, India.

2.4.1.2 Metacognition in STEAM Subjects and Languages. STEAM – science, technology, engineering, arts and mathematics- is a transdisciplinary teaching conceptual model created by Cassie Quigley and Danielle Herro in which it promotes learners' engagement and allows contextualizing the classroom environment to meet the needs of the students and their communities and increase their motivation and engagement in connected learning opportunity (Quigley & Herro, 2019). One of the main strategies required in STEAM education is using metacognition in classrooms in order to develop inquiry, critical thinking, and dialogue in students (Shrestha et al., 2022). There are many studies that correlate metacognition to academic achievement in students across different subjects, particularly STEAM subjects. While these studies focus on students, the role of teachers and teacher's strategies is crucial in raising awareness and use of metacognition in students. Teachers need to incorporate metacognitive prompts into any instructional strategy to stretch their students and cater to their needs. Teachers need to plan the proper scaffolding questions that elicit the metacognition skills of monitoring and evaluation in students through incorporating prompts to their discussions (Engelmann, Bannert & Melzner, 2021). Those prompts are cues or questions designed to encourage learners to reflect on and monitor their own learning processes. Guiding students into self-regulated learning can enhance their academic achievements. Therefore, the student and teacher metacognition seem to be in tight correlation to impact efficiency of any lesson. Teachers need strong metacognition skills to plan for these prompts and to monitor the success of the process in class.

There are many studies on the impact of metacognition on students in mathematics. Lestari (2018) was able to conclude that using metacognition in collaborative setting had

positive effects on the performance of low and high achievers in mathematics classes in a secondary school in Indonesia. The students' conjecture, arguments and observation of patterns were used to measure the performance of the students with or without using metacognitive prompts. This was confirmed earlier with Du toit and Kotz (2009) who observed the metacognitive strategies of both learners and teachers in grade 11 mathematics classes in South Africa and deduced that planning and evaluating were the strategies mainly used by students and teachers. Another study in a primary school in Kosovo has proven statistically that students perform better in solving math word problems after providing metacognitive strategies and self-regulatory process in class (Vula et al., 2017). A similar study was conducted in Indonesia in a primary school and reflected statistical significance of the effect of the "Metacognitive-Based Contextual Learning" (MBCL) on solving word math problems (Ahdhianto, 2020). All these studies did correlate the metacognition in learners to the metacognitive strategies that teachers follow to improve the learning in their students (Du toit & Kotz, 2009; Lestari, 2018).

A study by Kohen and Kramarski (2018) emphasizes the important role of metacognition in mathematics education. Furthermore, they acknowledge the role of teachers in raising awareness and use of metacognition in students. Teachers who possess metacognitive skills can effectively cultivate metacognition in their students through explicit scaffolding and guidance. However, if teachers themselves lack metacognitive skills, they may face difficulties in promoting the development of metacognition in their students. Therefore, it is crucial for teachers to develop their own metacognitive abilities in order to support the growth of metacognition in their students. Furthermore, in the article "The Role of Perception

of Support in the Classroom on the Students' Motivation and Emotions: The Impact on Metacognition Strategies and Academic Performance in Math and English Classes", Trigueros et al. (2020) investigated the influence of teachers on motivation, metacognitive strategies and academic performance of 605 students of English and 547 students of mathematics aged between 13 and 19 in Almeria Provence, Spain. The study found that teachers influence students' motivation and help develop metacognition strategies that involve critical thinking and self-reflection in students through explicit instructions. All these studies, although focus on students, relate success of metacognition in students to teachers' own metacognitive strength in their subject area and in the instructional strategies used i.e in awareness and use of metacognition knowledge and skills.

Williams (2000) assessed the teacher's role in raising metacognition in students as they learn English Key stage 2. She discussed how teachers can raise the students' awareness towards their learning and the strategies used in class to deepen their knowledge and understanding. This can be promoted through teacher's skills in questioning, allowing students to self-assess, reflect and put their own targets during class discussions to enhance the metacognition in students. This was further verified in a study by Tian, Fang and Li (2018) who highlighted the pedagogical implications of using metacognitive prompts while teaching English in small undergraduate group settings. Self-regulated learning and using metacognitive prompts during collaborative work seemed to boost the reading comprehension and vocabulary learning of students (Tian et al., 2018). Furthermore, a study by Tanvyl (2014) revealed that the use of reflective e-journal, which is a main aspect of metacognition skill, by language teachers prepares them to become more efficient decision makers and competent

teachers. Moreover, Taghizadeh and Gohardan (2019) focused on the role of raising the self-evaluation of metacognitive knowledge and skills in language teachers to help them motivate their students during their learning experience.

2.4.1.3 Metacognition in Science Classes. The integration of metacognition into science education is considered an important step towards promoting meaningful understanding and lifelong learning in science (Avargil et al., 2018). In their study Avargil, Lavi and Dori (2018) focused on the importance of metacognition in teaching, learning and assessment in science as main components for students and teachers. For students, metacognition in science helps them build awareness of their own thought and learning strategies in order to be effective learners and develop deep understanding of scientific concepts and processes. Teachers can make informed decisions about which learning strategy is most effective for their students. Additionally, another study by Dori (2018) correlates context-based learning alongside metacognitive prompts to improving comprehension of scientific texts in students.

Zohar and Brazilai (2013) analyzed 178 studies from 2000 till 2013 that focused on metacognition in science. They found out that using metacognitive prompts during class instructions are the most prominent practices in science classrooms. They have also identified few gaps such as: the focus on the skills rather than the knowledge of metacognition, the lack of studies that provide empirical evidence of the impact of metacognition on the learning in science, there is a focus on secondary classes rather than preschool and early primary classes and finally there is a gap in exploring the teachers' knowledge of metacognition and providing

them professional development sessions on metacognition (Zohar & Brazilai, 2013). Moreover, Rusyati and colleagues (2021) analyzed 30 articles on metacognition in science from 2009 to 2019. They deduced that the studies focused on applying metacognition mainly in secondary school classroom settings. Studies generally considered general knowledge of strategies and skills of regulating metacognition. Therefore, there is a gap in assessing the planning, monitoring and evaluating metacognitive skills as well as metacognitive experience in these studies (Rusyati et al., 2021).

Sanium and Buaraphan (2019) analyzed 9 studies on the impact of metacognition in science lessons within the context of Thailand primary, lower and upper secondary schools. They concluded that developing metacognition in students in science classes leads to developing students' critical thinking skills, problem solving skills, decision taking skills as well as their academic achievement. Furthermore, students build awareness towards their behaviors and their impact on the environment around them. In the same study, Sanium and Buaraphan (2019) analyzed 7 studies that focus on the strategies used within science lessons that would enhance students' metacognition. These studies named some instructional strategies that help promote metacognition use in science students and impact their learning positively. These strategies include the 5E and 7E instructional model, open-ended problems, constructionist activities, and threefold learning approach. Another study by Erenler and Cetin (2019) suggest that using argumentative driven inquiry instructional strategies by science teachers, promote scientific literacy among students and help create authentic learning experience as students develop their critical thinking skills.

2.4.1.4 Metacognition and Academic Performance. Many studies confirm the correlation between metacognition and academic achievement. Schraw and Dennison (1994) found that metacognition awareness can directly improve academic performance in students. Metacognition, motivation and self-efficacy impact academic achievement (Landine & Stewart, 1998; Young & Fry, 2008). To investigate these correlations, Fidrayani and colleagues (2020) did a quantitative study on 263 students in Indonesia asking them about the academic achievement in its two domains: mastery goal which focus on skills and knowledge acquisition, and performance goals which focus on competence of students. The study concluded that when students are interested in a subject and build their metacognition, they will perform well academically. Furthermore, the researchers emphasized on the role of teachers in choosing strategies that promote metacognition to help students academically.

Many studies correlate metacognition to better self-regulated learning, improved learning outcomes, and better reflections to make proper adjustments in the learning experience in students. According to Stanton, Sebesta and Dunlosky (2021), students with strong metacognitive skills can effectively regulate their own learning and achieve better academic outcomes. They are able to identify areas where they need improvement, choose the most appropriate strategies for learning new material, and monitor their progress. By being aware of their own thinking processes and being able to reflect on their own learning, they are able to make adjustments and improvements as needed, leading to a more efficient and effective learning experience. Another study in Ajman University in UAE explains how students' metacognition awareness can be a strong predictor of academic success since students who are aware of their own thinking and can reflect on their own learning, can make

necessary adjustments during the learning experience to have more effective and efficient (Abdelrahman, 2020).

Another research by Pradhan and Das (2021) suggests that while metacognitive skills do play a role in academic achievement among undergraduate students in Tezbur, India, they only explain 43% of the variability in academic performance. This implies that there are other factors, such as learning style, that also contribute to academic achievement. However, despite the limited evidence for contribution of metacognitive skills to academic performance, it is still recommended to integrate these skills into the curriculum and teaching strategies to help students improve their ability to monitor and regulate their own learning. This can help students meet the challenges of academic society and potentially improve their academic performance. In a similar study by Yuruk, Yilmaz and Bilici (2019), the researchers concluded that metacognitive strategies students follow help them improve academic achievement. They have also recommended using infographic creations to improve students' metacognition skills which would lead in turn to improved academic achievements.

A study on the effect of metacognition, learning environment and self-regulation on 400 randomly selected students from rural and urban senior secondary schools in Punjabi district, India found that all these factors contribute positively to the academic achievement of these students (Kaur, Saini & Vig, 2018). This study used the metacognitive awareness inventory, the Dundee Ready Education Environment Measure, and the Self-Regulation Questionnaire to collect data. All of the above studies tackle impact of metacognition on students. Very few discuss its impact on teachers; however, expectations are if metacognition

improves self-regulated learning, performance and ability to adjust to needs after reflections then it will have same impacts on teachers as they need these traits for the success of their teaching practices.

2.4.2 Teacher's Perceptions of Metacognition

Few other studies investigated the teachers' perceptions towards using different strategies to help develop the metacognitive skills in students. Some insights drawn from these studies show the positive impact of metacognition on teaching and learning, strong possession of self-regulations and self-awareness in teachers, as well as improvement in teaching practices and continuous professional growth due to self reflective practices (Sulaiman et al., 2018, Trinidad-Velasco et al., 2020) . Metacognition improves the critical thinking skills and helps teachers prepare better problem-based learning experiences and efficient instructional strategies (Albalhareth, Paul & Alasmari, 2022; Kuvac &Koc, 2019). These studies are discussed below.

Sulaiman and colleagues (2018) discussed how primary science teachers have positive impact on the teaching and learning once they understand the importance of metacognition while planning their lessons and teaching their students metacognitive skills at the same time. Another study by Sulaiman (2021) emphasized the need of self-awareness and self-regulation which are main components of metacognition in primary science teachers to help adopt changes to their teaching.

On the other hand, very few studies investigate the role of metacognition in teachers themselves as they reflect on their own work to increase their competence and improve their performance. In one study, metacognition of chemistry teachers was used to do self-

reflections in order to identify their thoughts and decisions in relation to their pedagogical knowledge (Trinidad-Velasco et al., 2020). Another research by Mai (2015) reflected high level of perception about metacognition in 52 science teachers in Malaysia depending on The Metacognitive Awareness Inventory for Teachers (MAIT). The findings of another study by Yildiz and Akdag (2017) in Turkey revealed that the teachers' awareness of metacognition and self-efficacy increased after using metacognitive strategies in science primary classes in reference to Metacognitive Awareness Inventory (MAI) and Science Teachers' Self Efficacy Beliefs Inventory. Another study by Ozturk (2018) confirmed that teacher's awareness of metacognition is correlated to their ability to design instructions and teach with metacognition. All of the above studies highlight the pivotal role of metacognition in enhancing teachers' self-awareness, competence, and instructional practices.

Some studies emphasize on the integral role of metacognition and innovative teaching methodologies, such as Problem-Based Learning (PBL), in fostering creativity, enhancing metacognitive development, and improving problem-solving skills among teachers. For example, in a study by Huang and colleagues (2021), results from online questionnaire answered by 7187 teachers in China showed that metacognition in teachers play crucial role in driving creativity in classrooms. Another study by Kuvac and Koc (2019) on the relationship between Problem-Based Learning (PBL) and development of metacognition in pre-service science teachers concluded that PBL may help pre-service teachers to become more effective problem-solvers and decision-makers in their future teaching practices. PBL was more effective in promoting procedural knowledge, planning, and debugging skills compared to traditional teaching practices.

A study on “TEACHERS’ PERCEPTIONS OF METACOGNITIVE STRATEGIES AND ASSESSMENTS USED WITH D/DEAF AND HARD OF HEARING STUDENTS” the use of metacognitive strategies by two teachers during reading instruction and the types of assessments they used to evaluate their students' metacognitive strategies were examined qualitatively through semi-structured interviews and observations of instruction during lessons. The study found that the two teacher-participants spent a significant amount of time activating their students' prior knowledge and building vocabulary through incorporating think aloud strategy to examine metacognitive strategies that their students used during reading sessions. Moreover, the study suggests that there is a need to develop the evaluation strategies such as interviews and recommends teachers to use variety of instructional assessment methods to evaluate students’ metacognitive strategies (Albalhareth, Paul & Alasmari, 2022). Another study explored in-service mathematics teachers' understanding and perceptions of metacognitive awareness in their teaching practices through questionnaires and interviews for 213 secondary school teachers in Kenya (Wafubwa, Csíkos & Opoku-Sarkodie, 2022). The results of the study revealed that teachers had high perceptions of their levels of metacognitive awareness, especially knowledge at a lower level the metacognitive skills. Furthermore, the study found no significant difference of teachers’ perceptions of metacognition on gender, academic qualifications, and years of experience. The study concluded that there is a need for teachers to understand the role of metacognition in learning and to model metacognitive strategies to their students. It highlights the importance of incorporating professional development training programs for teachers to develop their metacognition strategies which will eventually enhance students’ academic performance and quality of education in general.

These studies show the importance of incorporating diverse assessment methods into teaching practices with an eminent need for continuous professional development to support teachers in effectively implementing metacognitive strategies and fostering students' metacognitive development . While teachers demonstrate high perceptions of their metacognition awareness, there is a need to shift the focus towards developing higher-level metacognition skills and effectively modeling these strategies to students (Albalhareth, Paul & Alasmari, 2022; Wafubwa, Csíkos & Opoku-Sarkodie, 2022).

2.4.3 Metacognition as a Policy

The government of United Arab Emirates (UAE) is aware of the importance of education for the nation and for the generations of the future. Therefore, in the National Agenda for 2021, one of the main national indicators is “First-Rate Education System” where there is an emphasis on having “exceptional leadership and internationally accredited teaching staff” to help prepare generation that ranks among the best in languages, mathematics and science (MOE, 2017). This has made schools in Dubai take an active role in the reform system and look into improving the teaching and learning in classrooms through training teachers and preparing strong curricula that meet the international standards. These would lead to the utmost target of preparing leaners with high learning and critical thinking skills and knowledge which aligns with international benchmarking systems. Therefore, teachers started to work towards identified key performance indicators that guided them through improving their performance and acknowledging the high expectations of the education system. This requires metacognitive skills and knowledge for teachers to reflect on their teaching and

instructional efficacy. Setting targets, planning instructions according to data and evaluating the outcomes are practices required in Dubai schools. In 2018, a policy brief for the reform of education in UAE published the role of "Building Teacher Capacity" through empowering teachers and providing adequate professional training sessions (Warner, 2018).

Many schools in Dubai adopt the International Baccalaureate Organization's programme as their curriculum approach. In 2020, the IBO published a whole document on metacognition as a policy in their system named "Making The Abstract Explicit: The Role Of Metacognition In Teaching And Learning" (Beach et al., 2020). In their publication, they explain the importance of metacognition to stakeholders in educational field. Studies show that metacognition is one of crucial 21st century skills that need to be taught to students as research show a strong correlation between student's performance and metacognition (Beach et al., 2020; Horvathova, 2019) a. Despite all, metacognition is rarely explicitly taught to students at any level of education. However, it is still possible for school leaders and teachers to incorporate metacognitive instruction into their classrooms to help students develop these important skills. In their policy, the IBO focuses on the need of building up teacher's beliefs and professional learning, integrating metacognition into the curriculum and creating a system to assess metacognition.

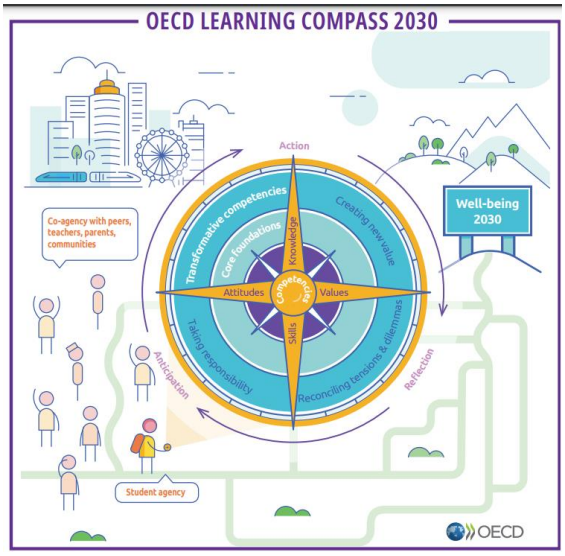
Even Cambridge Education System integrated a section in its policy on the importance and uses of metacognition in classrooms. They have included metacognition strategies and checklists for teachers to implement metacognition properly into their instructions and daily practices (Sawyer, 2005; OECD, 2019). Moreover, the Common Core State Standards in the

United States include metacognitive skills as one of the key College and Career Readiness Standards and provide guidance on how to incorporate metacognitive instruction into the standards. All of the above represent accredited organizations which educational schools align their curricula according to one of them. Each of the above requires and emphasizes the role of metacognition. The gap lies in how schools address these requirements and make them explicitly presented in their structure.

In their publication on "Future Education and skills for 2030" the Organization for Economic Cooperation and Development (OECD) put three main skills that are required by the learners of the future, and these are (1) Cognition and metacognition (2) Social and Emotional skills (3) Practical and Physical skills. Metacognition was the first skill that the conceptual framework focused on (Taguma & Barrera, 2019).

Figure 9

The OECD Learning Compass 2023 Framework



This framework is presented as the “OECD Learning Compass 2030” in 2030. This learning project highlights the importance of metacognition as a skill in each of the domains shown above to lead to competence (OECD Future of Education and Skills 2030). The OECD insight mentions “Too often, we teach students *what* to think but not *how* to think” (OECD, Insights (2014)). The OECD's Innovative Learning Environments framework emphasizes the importance of promoting metacognitive skills and provides guidance on how to design learning environments that support the development of these skills (OECD Peña-López, 2017). Furthermore, The Framework for 21st Century Learning, developed by the Partnership for 21st Century Learning, includes metacognition as one of its core competencies, and provides guidance on how to incorporate metacognitive instruction into classroom practices (Kirschner & Stoyanov, 2020). Many schools started giving attention to metacognition as a policy and gave some strategies that school implement for raising awareness and use of metacognition by students such as Leys School and Hillside Primary school United Kingdom and Swiss international school and Nord Anglia education in Dubai as stated in their websites.

Kaur, Saini and Vig (2018) suggested that educators and policymakers can focus on developing and implementing strategies that enhance metacognition, learning environment, and self-regulation in students since these factors were found out to significantly affect students’ achievements. This was also suggested by Smith, Black and Hooper (2020) who recommended that metacognition in its three domains knowledge, skills and awareness should be implemented as school policy to be a solution for improving the academic achievement in African American students in public schools in the United States. This agrees with the vision

of education in China, where a study by Yanqun (2019) confirmed a correlation between metacognition and developing competence, efficiency and autonomy in citizens. Even countries such as Changhai, Hong Kong and Finland include the policy of metacognition practices in schools (Perry et al., 2019). In their study, Perry and colleagues (2019) shed light on metacognition as a neglected area in school policy for the English government when compared to the high performing schools in Changhai, Hong Kong and Finland where metacognition and higher order thinking strategies are implemented into the school curricula. Another study by Kesici and colleagues (2021) compared the metacognition in education in two highly performing countries in the international Programme for International Student Assessment (PISA) which are Singapore and Japan and a lower performing country, Turkey. They concluded that metacognition levels and problem-solving skills are highly incorporated in the schools of Singapore and Japan and are predominant in most subjects as a policy in their educational programme; on the other hand, Turkey needs to incorporate problem-solving strategies more into its curricular design. Metacognition seems to be high only in language classes in Turkey. These studies provide strong correlation between the governments' vision on improving education and the implementation of metacognition in education to reach these goals; however, "metacognition" as a policy seems to be neglected or not clearly referred to.

2.4.4 Evaluating Metacognition

Metacognition can be evaluated in various ways, including surveys, assessments of student predictions versus performance on examinations, and investigation of students' decisions during their learning process. These methods can help educators identify students who may be struggling with metacognitive processes and provide interventions to improve

their learning strategies. Overall, understanding and developing metacognitive skills can help students become more effective learners and achieve their academic and personal goals (Rivers, Dunlosky & Persky, 2020).

Many experts in the field critique the tools used to measure or evaluate metacognition in education (Jiang et al., 2016). Sperling and colleagues (2012) initiated the call for an urge for a sound psychometric tool to study metacognition in students and juniors. So, they promoted the self-reported scales. Moreover, in the field of studying metacognition, most research work rely on surveys and observations of students' interactions in classroom settings. The tools used to evaluate metacognition vary according to the components measured (Ozturk, 2018).

Assessing metacognition knowledge is considered easier than assessing metacognition regulation. Assessing metacognition knowledge assesses what someone knows or is able to do; and this can be assessed through questionnaire and interviews (Baker & Cerro, 2010; Ozturk, 2018). These instruments used can generate results easily from large groups through off-line measures. Such as the Metacognitive Awareness of Reading strategies (MARSI) which was developed by Mokhtari and Reichard in 2002 to assesses awareness and perceived use of reading strategies, problem-solving strategies and practical support strategies i.e. the tool assesses domain specific metacognition.

Assessing metacognitive regulation requires more self-report and in-depth questionnaires. To assess the monitoring skills, individuals make self-report judgments about their expected and actual learning. Before performing a task, learners are asked to predict how easy or difficult the information to be learnt. Then, after completing the task, learners are

asked to make judgements about their learning and confidence in their performance (Ozturk, 2018). Those who accurately judge their own learning and confidence levels are considered good monitors regardless of their performance or knowledge level. The self-report Metacognitive Awareness Inventory (MAI) was developed by Schraw and Dennison (1994) to assess metacognition knowledge and regulation (Ozturk, 2018).

Questionnaires and interview protocols can also be used to assess metacognition regulation such as Learning and Study Strategies Inventory (LASSI) developed by Weinstein et al. in 1987 and validated in another study by Downing et al. in 2008 and assesses awareness and use of learning and studying strategies using Likert scale (Gascoine, Higgins & Wall, 2017; Ozturk, 2018). Another tool is "The Motivated Strategies for Learning Questionnaire" (MSLQ) that focuses on assessing the behavior in classrooms and was developed by Pintrich and DeGroot in 1990. The Self-regulated Learning Interview Schedule (SRLIS) is also another tool designed to assess the academic self-regulated learning by Magno (2010).

Assessing metacognition uses many categories and different approaches such as Multi-Method Interview and Swanson Metacognitive questionnaire developed in 1990. These tools rely on questionnaires followed by interviews (Sperling et al., 2012). Most of the tools rely on self-report; some focused-on task-based methods, few others relied on observation-based methods, rarely relied on teacher ratings. These tools at many occasions varied according to age groups. Most of those tools are considered offline; whereas using the think-aloud protocol (TAP) as a method is considered an online evaluative tool describes as "one of the most effective tools we have for gaining access to the online cognitive processing of readers and

writers" as defined by Mateos et al. (2008, p. 695). However, this online method has some limitations for the act of reflection-in-action that can be over-thought or retrospective tool.

To exemplify, assessing metacognition regulation requires prospective measures to assess how students would assess their skills prior to learning or attempting certain tasks, followed by concurrent measures that assess students during performance of the task. Certain strategies would help in addition to questionnaire such as think aloud and using mind maps. And, finally, retrospective measures that assess the performance after the task is completed. Using video and recording techniques during the process can help recall through the process and better assess the accomplishment of the tasks (Ozturk, 2015; Veenman 2005). These three phases discussed above will be used to assess the metacognition awareness and use in teachers in this research. Teachers will be given a task for planning lessons, allowed time to deliver their instruction and then allow them to monitor their delivery of the instruction once the task/lesson is over.

In their study Craig and colleagues (2020) identified 24,396 articles between 1982 and 2018 that evaluated metacognition through self-reports. Analyzing between 22 and 37 studies, they concluded that self-report can be a possible tool to correlate to metacognition knowledge, regulation and tasks but not the metacognition process itself nor metacognitive behavior. Overall, their results suggested that self-report can be useful tool for assessing some aspects of metacognition with some limitations related to interpreting results (Craig et al., 2020).

After lots of research on scholar google and British University in Dubai library research engine, there were only two metacognition self-report scales designed for teachers solely. The first is Metacognitive Awareness Inventory for Teachers (MAIT) derived from

MAI and developed by Blacikanlli (2011). The MAIT was the first tool dedicated to measure teachers' awareness of metacognition and its use in their classrooms. The second was the Teachers' Metacognition Inventory (TMI) developed by Jaing, Ma and Gao (2016) which assesses metacognition experience, knowledge and skills in teachers. The TMI questionnaire was validated as a proper psychometric tool for identifying teaching problems and instructional methods in a recent study by Rezaeisharif et al. (2024) where the explaratory factor analysis yielded values between 0.93 and 0.86.

A study by Abdellah (2015) targeted pre-service female teachers in Ajman University to study the correlations among academic achievement, metacognition awareness, and teacher performance through using Metacognition Awareness Inventory and Teachers' Performance Checklist for 75 female teachers. The results indicate that pre-service teachers with high metacognition tend to attain higher academic and teaching performance. The study concluded at encouraging university professors to use metacognition skills among their students in order to build better metacognitive skills, academic achievement and teaching performance in their students- the pre-service teachers.

2.4.5 Development of Metacognition in Teachers through Professional Development Program

Metacognition in teaching is indeed a critical aspect of effective instruction, and it involves both teaching with metacognition and teaching for metacognition. Teaching with metacognition is meant to be when teachers apply metacognitive strategies to their own teaching practices; on the other hand, teaching for metacognition refers to how teachers design

their instructions that aim at building the metacognition skills in students which is a gap in literature (Kaur, Saini & Vig, 2018; O'Hara, Pritchard & Pitta, 2019,2020).

Metacognition in teachers helps them reflect on their teaching and make informed decisions about how to approach instruction. By considering their students' needs and the sociocultural context, teachers can tailor their instructional goals and strategies to meet their students' learning needs. Through planning, monitoring, evaluating, and adjusting their teaching methods, teachers can continuously improve their teaching effectiveness and ensure that their students are engaged and motivated learners (O'Hara, Pritchard & Pitta, 2019; Sulaiman, 2021). The need for a tool to support teaching with metacognition is driven by promoting the professional growth of teachers and the academic development of students. By allowing teachers to teach with metacognition, teachers can more easily and effectively plan, monitor, evaluate, and adjust their instructional strategies in line with their students' needs and the sociocultural context. This could provide teachers with a structured approach to reflect on their own thought processes and teaching strategies, as well as provide insights and feedback on their impact on student learning. In turn, this can lead to more effective and engaging instruction, resulting in improved student outcomes. Therefore, metacognition can play a significant role in promoting the overall success of both teachers and students (O'Hara, Pritchard & Pitta, 2019; Zohar & Lustove, 2018).

In their book, Proust and Fortier (2018) explain the role of diversity in metcognition in relation to cultures. This diversity is mainly mirrored in "experience-based" metacognitive evaluation and "concept-based" metacognitive evaluation in teachers (Proust & Forties, 2018).

Moreover, intercultural interactions lead the social constructivists to consider the effect of ethnicity, religion and cultural influences on shaping metacognition in individuals (Morris, Savani, & Fincher, 2019; Proust & Forties, 2018). Studies from East Asian coutries reveal that students' cultural characteristics highly influence their metacognition and learning processes Muijs & Bokhove, 2020). This is also confirmed in studies related to cognition in Europe countries where cognitive psychology seems to place greater emphasis on classroom learning that focuses on the cognitive, affective, and social aspects of the students (Vos & Graff 2017). Van der Plas and colleagues (2022) supported these findings when they studied metacognition in Bejing, China, London and European countries and concluded that the metacognitive capacity is developed through sociocultural interactions.

In literature, many studies focus on the concept of strategic observation and reflection (SOAR) as a model for teacher development plans in languages, computer-based learning and mathematics (Jairam & Kiewra, 2010; O'Hara & Pritchard, 2016). Many other studies refer to the need to address metacognition in teachers through professional development programs. A study by Zohar and Lustov (2018) concluded that PD programs designed to plan high order thinking instructions reflect deficiency in teachers' metacognition knowledge especially regarding their fragile knowledge in strategies and pedagogical constructs. Another study by Zohar (2008) expresses the need of PD sessions for science teachers to bring about high-level class discussions within Biology lessons. Another study by Kohen and Kramarski (2018) stated how metacognition requires explicit scaffolding by teachers who if not trained on how to use metacognition skills will not be able to instill these skills into their students. Therefore,

research emphasizes on the importance of PD sessions to raise awareness of metacognition knowledge and skills in teachers to see better impact on students in the classroom.

After reading the analysis of 178 studies by Zohar and Brazilia (2017) and 22 studies by Sanium and Buaraphan (2019) , Sonium and Buaraphan concluded that there is a need to " the design of teacher education course as 'Metacognitive Teaching and Learning' for pre-service teachers in university or teacher colleges" p.1340. According to Hughes (2017) professional development (PD) designers can play a crucial role in enhancing teachers' learning abilities by incorporating metacognitive awareness development early on and throughout the PD. By identifying the teachers' level of metacognitive awareness, the PD designers can tailor the PD program to meet their specific needs in order to develop a better understanding of their pedagogical knowledge related to teaching and learning processes. Furthermore, developing teacher's metacognitive awareness can enhance their ability to transfer the learned content back into their classrooms effectively (Hughes, 2017; Hattie, 2015). In literature, the strategies followed in these PD sessions to raise metacognition in teachers vary accordingly: In Hughes (2017) study, he used MAI questionnaire, followed by interview. Accordingly, the teachers were trained by offering them contextual themes to grow their metacognitive awareness, and rubrics during their tasks to monitor metacognition regulation. Another study by Pratt and Martin (2017) acknowledged the importance of two effective components of professional development: reflective and collective reflection and a teacher-driven inquiry model. By integrating these two components, the professional development program can create a collaborative learning environment that empowers teachers

to take ownership of their own learning and engage in a deep exploration of their own practice.

In a guidance report by Education, Endowment Foundation on Metacognition, Quigley, Muijs and Stringer (2018), they explain how many teachers may not fully understand what metacognition is and how to effectively implement it in the classroom. This can lead to misconceptions and weak implementation, which ultimately limits the potential benefits for students. Therefore, it is important for teachers to receive adequate support, training, and time to practice implementing metacognitive strategies in their classroom. Consequently, Quigley, Muijs and Stringer called for effective continuing professional development (CPD) that should be long lasting for at least two terms and should be tailored to the needs of individual teachers and take into account their existing knowledge and experience.

Another study focused on the need of training teachers on assessment for learning as a process that can build the students' prediction and evaluation especially in mathematics classes. The sample of the study included 47 teachers and 803 students. The dynamic approach to teacher professional development was based on four principles: addressing professional needs, integrating skills, explaining underlying mechanisms, and implementing support and feedback. This approach aims to provide teachers with the necessary knowledge, skills, and support to effectively implement assessment for learning and metacognition in their classrooms (de Vries et al., 2023). Moreover, the development of teacher education programs to include training sessions that raises confidence in their ability to implement Self-Regulated Learning and Professional Practices is crucial for their proficiency in using these strategies

with their own students. Teacher education programs can enhance the teachers' self-efficacy via designing transformative learning experiences that improve their metacognitive skills such as collaborative inquiry (Brenner, 2024).

2.5 Conclusion

In reference to the above conceptual and theoretical framework and literature review, it is evident that metacognition plays a crucial role in education especially when studied in the classroom environment where situational factors interfere in the process of building and using metacognition. Metacognition is closely related to developing critical thinking skills, improving academic achievement, and emerging autonomic learners especially when incorporated within social and collaborative context. While many studies focus on the instructional strategies that teachers follow to raise metacognition in students; others relate students' performance to incorporating metacognitive prompts during task performing work; and very few look into the metacognitive skills in teachers themselves. This could be an identified gap in literature and provide an opportunity to investigate into how PD sessions can be designed to improve the planning, monitoring and evaluating phases of metacognitive skills in science teachers so that it increases their awareness and use of metacognition in classrooms. Similar to the impact of metacognition on students, metacognition in teachers could also lead to more effective teaching and learning experience in classrooms.

Chapter 3: Methodology

3.1 Introduction

In Chapter 3 “Methodology”, the research approach and methods of this study are fully explained in order to understand the phenomenon under investigation, kind of research, lived experiences, discoveries and considerations addressed during the planning and while conducting this research. The design and methods of the research attempted to answer the following three research questions:

1- What perceptions do science teachers have regarding awareness and use of metacognition in Dubai private secondary schools?
2- What demographic differences do science teachers have regarding their metacognition in science schoolteachers in Dubai private secondary schools?
3- How do science teachers develop metacognitive skills for planning, monitoring and evaluating (PME) of instructional strategies based on in-service metacognitive professional development sessions in Dubai private secondary schools?

Within this chapter, the research approach will be explained into how convergent mixed method would help collect data in a pragmatic lens to investigate the awareness and use of metacognition in teachers and the design of PD sessions to build the metacognition PME skills in teachers. This can help foresee metacognition in science secondary school teachers in private schools in Dubai within real world application. The instruments used to answer the research questions are identified. The process of verifying the validity and reliability of the

data collected in the quantitative approach will be explained. The trustworthiness of the tools used in the qualitative approach will be discussed.

3.2 Research Approach

The purpose and nature of the study would help determine the path of the research and its approach (Creswell, 2015). Since this research aims at investigating secondary science teachers' awareness and use of metacognition and at the same time how professional development sessions can be planned to develop the metacognitive skills of planning, monitoring and evaluating in secondary science teachers, a parallel convergent mixed method is used. Parallel convergent mixed method is a concurrent approach that involves the collection of quantitative and qualitative data simultaneously. Data from both qualitative and quantitative sources are combined and compared to merge into a complete picture (Edmonds & Kennedy, 2016).

In one phase, Dubai secondary school science teachers would fill in a questionnaire on their awareness and use of metacognition. This is a quantitative research approach that aims at gathering data from a sample of individuals using a questionnaire to gather information about attitudes, beliefs, and behaviors related to metacognition of teachers in education. In another phase, the volunteering science secondary school teachers will participate in long-term professional development planned to empower teachers with metacognitive skills of planning their instructional strategies, monitoring their pedagogical delivery in classroom and evaluating their lesson. This is a qualitative in-depth exploration of the development of metacognitive skills in teachers through PD sessions and observe them as they plan their

instruction and monitor its delivery within classroom setting to gain insights into teaching and learning practices after the PD sessions.

Research in education aims at gathering data to draw conclusions in relation to certain phenomenon in human sciences. In quantitative approach that relies on surveys uses quantative data collection; therefore, requires using numbers and data to draw conclusions (Fraenkel, Wallen & Hyun, 2019; Larini & Barthes, 2018). The research approach can be quantitative. In quantitative research, information collection occurs using questions that describe a particular aspect targeting a sample of a population; the data are analyzed using statistical tool to justify the significance of draw conclusions from data analysis (Array et al., 2018; Fraenkel, Wallen & Hyun, 2019). Therefore, quantitative research aims at following logical sequence of steps, starting with a theory or set of hypotheses, and then collecting and analyzing data to test those hypotheses and draw conclusions following a deductive pattern (Creswell, 2015; Johnson & Christensen, 2019). This method can be beneficial in this study to collect teachers' perceptions of their own knowledge and use of metacognition through a questionnaire.

The research approach can also be qualitative. In qualitative research, researchers use observations, interviews and descriptive data to find patterns or generate theories (Johnson & Christensen, 2019). Qualitative study does not try to find cause and effect relationship as in quantitative study but tries to interpret experiences using "words" rather than numerical as data (Johnson & Christensen, 2019; Merriem & Tisdell, 2015). It is described as a "bottom-up" method where interconnecting themes emerging from participants can generate a theory

(Creswell, 2015). In this research, qualitative approach can help assess the value of metacognition and improve awareness and use of metacognition by teachers.

With reference to the above information, quantitative research alone will not satisfy the purpose of this research nor the qualitative research on its own. Therefore, a mixed method design is chosen in this research to get a full understanding of metacognition in science secondary school teachers. The mixed method research has been considered as the third methodological movement or paradigm since it offers the opportunity to develop a synergy between qualitative and quantitative research (Cohen et al., 2018). Different approaches can integrate qualitative and quantitative methods: one-after-the other with preferences, side by side with some independence or a dominance on one over the other (Denzin, 2010; Sahin & Öztürk, 2019). This research will be designed to include quantitative and qualitative designs in a mixed method approach since they can complement each other in order to yield a well-rounded picture of the metacognition phenomenon under investigation. Mixed method research is defined as an "approach to research the social, behavioral, and health sciences in which the investigator gathers both quantitative and qualitative data, integrates the two and then draws interpretation based on the combined strengths of both sets of data to understand research problems" (Creswell, 2015, p 24).

The mixed method varies in the order by which data is collected. Some research necessates the collection of quantitative data that will lead to shape the form in which the qualitative data will be collected. Others may allow one method to dominate and then supported by the second. The research approach in this investigation would allow for the

collection of quantitative data independently of the qualitative data and in no justified order. The quantitative questionnaire research would allow to answer the first research question on awareness and uses of metacognition in secondary school science teachers; whereas the qualitative research method would answer the third research question independently of the data collected quantitatively. The qualitative method relies on observations, interviews and document analysis collected from teachers during and after professional development sessions on improving their metacognitive skills.

The quantitative and qualitative elements can work together to integrate inductive and deductive approaches which would strengthen the research (Cohen et al., 2018). One approach only cannot efficiently answer the research questions, having answers from both qualitative and quantitative approaches would add to the knowledge of the topic minimizing the limitations of any of the methods if used alone and eliminating any bias. Therefore, the quantitative study would serve in identifying teachers' awareness to metacognition and factors influencing their perceptions of metacognition using a closed ended data gathered from questionnaires. On the other hand, the qual data collected from interviews, observations and documents will allow the theme of how developing the planning, monitoring and evaluating (PME) skills in secondary school science teachers would influence metacognition awareness and skills in classrooms. Results from both studies will be compared to create a matrix that correlates the factors identified in the quantitative study to the themes emerging from the qualitative study.

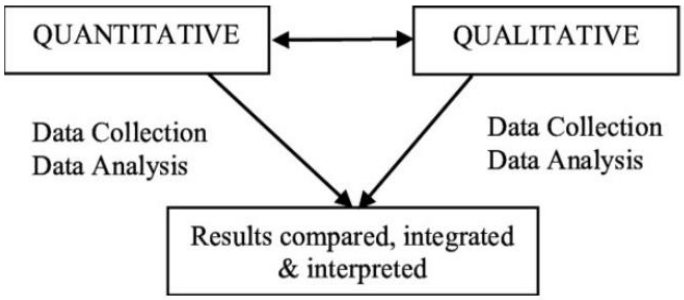
The qualitative approach should address many aspects in order to be effective resulting in the delivery of practical and intellectual goals that meet specific needs and tries to explain causal phenomena developed within certain contextual situations (Creswell, 1998; Cohen et al., 2018). For example, the observations within classroom settings of the instructional strategies and pedagogical resources and document analysis will help develop any emerging factors influencing teachers' metacognitions. The interviews with teachers will help identify their perception of using metacognition after the professional development sessions. While qualitative research tries to answer the 'how' and 'why', quantitative study can inform the 'what' and the correlations through survey (Cohen et al., 2018, p. 304). The survey will be used in this research to analyze factors and awareness of metacognition in science secondary school teachers in general.

The qualitative and quantitative approach provides a lens to compare results from two databases that will be conducted simultaneously, independently and in parallel with each other (Cohen et al., 2018). The quantitative approach will investigate the awareness of metacognition knowledge and skills in secondary school science teachers through survey as well as the factors that influence their metacognition, whereas the qualitative approach will explore the impact of developing the planning, monitoring and evaluating skills in secondary school science teachers on their instructional pedagogy, performance and competence through interviews, observations and document analysis. This allows for obtaining complete understanding of metacognition in teachers when comparing the closed ended survey's results to open ended questions from the qualitative study. The convergent mixed method is defined as "a mixed method design in which the researcher collects and analyses two separate

databases—quantitative and qualitative—and then merges the two databases for the purpose of comparing or combining the results" (Creswell &Clark, 2017).

Figure 10

Visualization of the Mixed-Methods Concurrent Triangulation Strategy



Note. (Atf et al., 2013)

Kuhn in 1962 introduced the 'paradigms' into the scholars' community clarifying how approaches to methodology in research is informed by the way a researcher looks into a phenomenon or a knowledge (Cohen et al., 2018). The positivists believe that there is one reality that need to be discovered by the researcher (Mertens, 2019). Post-positivists consider accepting natural science related to human knowledge; they agree that the social context influences the action being investigated. Post-positivists supported quantitative studies that correlate to existing natural phenomena. Researchers in the post-positivist approach rely on empirical evidence and its commitment to testing theories through rigorous methods. By using these methods, researchers are able to generate knowledge supported by evidence that help make accurate predictions and inform decision-making (Creswell &Clark, 2017).

On the other hand, constructivists adopt an interpretive approach to try to explore phenomena in relation to social science and therefore, support qualitative studies that require the emergence of new experiences according to the phenomenon under exploration (Cohen et al., 2018; Sahin & Öztürk, 2019). Unlike the post-positivist approach, constructivism is based on the assumption that reality is socially constructed through language, culture, and historical context, rather than existing independently of human perception. Overall, the constructivist approach is characterized by its focus on subjective experience, the social construction of reality, and the process of meaning-making. By studying these aspects of human experience, researchers can generate theories that are grounded in the perspectives and experiences of participants to generate broader patterns and understandings (Creswell & Clark, 2017).

The mixed method research considers both quantitative and qualitative approaches. Therefore, instead of using only one approach, the convergence of both qualitative and quantitative research known as “mixed methodology” elicited a war of paradigms. Pragmatism emerged to be defined as “a philosophy of research focused on consequences of research, the problem, and what works in real-world practice” (Creswell, 2015, p.205). This outlines the importance of the research outcome rather than any previous knowledge or circumstances within legitimate standards. Pragmatism is based on the idea that the value of an idea or theory is determined by its practical usefulness and the consequences of its application. This perspective focuses on the problem at hand using a variety of methods to address it. Pragmatism is a pluralistic approach that is oriented towards what works in real-world practice (Creswell & Clark, 2017). Therefore, a researcher would use the research question to illuminate his choice of the method or methods to be followed that best answer the topic

investigated. While some experts in the field of educational research argue that "quantitative methods are incompatible with qualitative methods" (Fraenkel, Wallen & Hyun, 2019, p.506); others believe in using whatever combination if methods to fully answer the problem under investigation (Krathwohl, 1998). Within the pragmatism framework, a researcher can move back and forth between inductive and deductive reasoning in order to generate new hypotheses or theories based on abductive reasoning in order to explain the emerging expected or unexpected observations and facts based on the contextual situations during the research approach. This will allow for plausible explanations of phenomenon observed during practical implementation in real life situations (Patokorpi, 2006).

Both inductive and deductive reasoning will be implemented to investigate multiple views on metacognition in teachers (Cohen et al., 2018). This pluralism rectifies any errors or limitations in a single approach. Factors influencing metacognition in teachers emerging from questionnaire would be compared to factors emerging from interviews with teachers involved in the professional development sessions. This adds accuracy to the information of data gathered and reduces bias (Cohen et al., 2018). This is further expressed in Maarouf's (2019) article identifying "three new terminologies in pragmatism approach for mixed methods: "the reality cycle, the double-faced knowledge, and the necessary bias principle" (Maarouf, 2019, p. 2). This approach does not see quantitative and qualitative approaches as mutually exclusive, but rather as complementary methods where combining the strengths of both approaches allows for obtaining a more complete picture of the research problem. Moreover, this can help researchers develop more effective solutions or interventions (Christensen et al., 2015; Creswell, 2015; Maarouf, 2019). Teachers' perceptions to use and awareness to

metacognition will be deduced through quantitative method using a questionnaire; whereas exploring how PD sessions influence the use of metacognition skills by teachers as they plan their instructions, deliver them and evaluate the success of the lesson requires an inductive approach through using observations, document analysis and semi-structured interviews as elements of the qualitative approach in this research.

The pragmatic philosophical position will lead this research to be able to explore "how and why interventions function in real-world settings" (Albright et al., 2013) which directly relates to this research approach where intervention and raising PME skills in science teachers would be investigated within classroom settings as teachers design and deliver their instructions. Pragmatism is typically associated with mixed method approach where it allows the use of multiple methods to inform the problem under investigation in real-world practice and oriented towards "what works" (Creswell & Clark, 2017). It enables a more comprehensive understanding and deeper insight of the phenomenon within contextual complexity. Pragmatism allows for eclectic design to answer the research questions through both deductive and inductive methods allowing for multiple views and accepting any emerging situations according to 'what works' and to the fitness of data collected in multiple views (Cohen et al., 2018; Creswell & Clark, 2017). Researching metacognition in teachers through the pragmatic lens would allow for any emerging factor that could influence metacognition in teachers to be revealed in quantitative data analysis. The questionnaire will help accept the external realities of teachers through investigating their awareness and use of metacognition. The researcher will be able to find explanations to answers. The questions added to the inventory which are related to the demographic factors will help explore the

effect of age, education, experience, habits and beliefs of teachers. This is further confirmed in Howe's (1998) perspective of pragmatism where he claims that truth and experience are intertwined in pragmatism. The opportunity to observe the influence of metacognition of teachers as they design and deliver their instruction within identified setting through analysis of qualitative data add further in-depth to how participants interpret their experience and relate to their practices in reality. Metacognition is a human experience influenced by many situational factors within real world practice and is subjected to the experience of the participants and their views. Pragmatism helps the researcher use whatever works to make a decision and follow an approach that illuminates the research questions. This again enables not only asking the "what" and "why" but also the "how" as well (Fraenkel, Wallen &Hyun, 2019).

Since the purpose of the study is to explore the secondary science teachers' awareness and use of metacognition and the professional development of metacognition skills, real-life situations is required to see how this work and its impact on teachers. This can not be achieved if the researcher does not observe and interpret how teachers perceive their metacognition awareness and use. The researcher also needs to explore how metacognition skills in teachers are implemented in real life settings as teachers plan and deliver their instructions within their classrooms.

3.3 Research Methods

In this section, the method followed to answer the research questions is discussed and analyzed to explain how the method was conducted. It discusses the research design where the

choice of the site that fits the contextual needs of the research are detailed alongside the population and sample choice. This is followed with discussion of the instruments used and the analysis tools were found adequate for data processing. Finally, the validity, reliability of tools and the 5 ethical principles are discussed. The table below summarizes the method of this study in all its elements.

Table 1

A Summary of the Research Methods

Main Purpose	- investigating the secondary science teachers' perceptions to awareness and use of metacognition - exploring the development of teachers' metacognitive skills in (PME) after in-service professional development sessions in secondary school in Dubai.		
Approach	Mixed Method		
Strategy	Parallel Convergent (concurrent)		
Research Questions	1-What perceptions do science teachers have regarding awareness and use of metacognition in Dubai private secondary schools?	2- What demographic differences do science teachers have regarding their metacognition in science school teachers in Dubai private secondary schools?	3- How do science teachers develop metacognitive skills for planning, monitoring and evaluating (PME) of instructional strategies based on in-service metacognitive professional development sessions in Dubai private secondary schools?
Approach	Quantitative	Quantitative	Qualitative
Population	Secondary Science teachers in Dubai Private Schools (~1058 teacher)	Secondary Science teachers in Dubai Private Schools (~1058 teacher)	Secondary Science Teachers in one of the Private Educational

			Institutes (5 schools ; ~50 teachers)
Participants	10% population Or 214 science secondary school	10% population Or 214 science secondary school	Science Teachers who would volunteer in in-service PD sessions
Site	Private Schools in Dubai	Private Schools in Dubai	5 private schools in Dubai
Sampling	Convenience	Convenience	Convenience
Instrument	Modified close ended Questionnaire	Modified close ended Questionnaire	-Planning: document analysis -Monitoring: Observation -Evaluation: Semi structured Interviews
Data Analysis	Descriptive and inferential analysis of survey	Inferential/ Factor analysis of survey themes	from Coding and thematic analysis
	Complementary and triangulation: All data will be triangulated, compared, analyzed to complement the argument in the results.		

To answer the above research questions a concurrent mixed method was followed where both quantitative and qualitative approaches ran at the same time without preference (Creswell & Clark, 2017) through the convergent mixed method as explained above. According to the above scenario, a two-fold mixed method research is dominating where the quantitative approach is nested within a predominantly qualitative design (Merriem & Tisdell 2015).

3.4 Research Context and Site

The research site is where research is conducted and data are collected (Fraenkel, Wallen & Hyun, 2019). The proper choice of the sitedefine it first helps control bias of the

researcher and obtain efficient sampling (Arcury & Quandt, 1999). Moreover, concurrent mixed method allows for different sampling choices according to the needs of each of the two approaches: quantitative and qualitative (Christensen et al., 2015). Therefore, gaining access to the representative sample for the study is a crucial factor in conducting research. It is important to have a sample that accurately represents the population being studied in order to draw valid conclusions and make accurate predictions (Cohen et al., 2018).

This research occurs in Dubai where there are more than 500 private schools following different curricula: American common core and NGSS, British curriculum, Indian curriculum (CBSE), International Baccalaureate curriculum and others (KHDA, 2023; OpenData). All these schools have to commit to high competence and attainment in science benchmarked to standardized tests such as PISA, TIMMS, MAP, IGCSE or any other form of external international standardized tests. Therefore, science teachers are directly involved in raising attainment in schools and play crucial role in school's ranking during inspection of Dubai School Inspection Bureau (DSIB). The secondary teachers registered in private schools in Dubai up to August 2021 are about 5474 in UAE varying in nationalities from Indians, British, Arabs, Filipinos, Pakistanis and others (Nassir, 2018). This research investigates the science secondary school teachers' awareness of metacognition knowledge and skill and use of metacognition (RQ1 & RQ2) through a questionnaire in the quantitative approach, so the site is generalized to be all private schools in Dubai where science secondary school teachers are the potential participants. The quantitative approach will rely on internet communications through emailing secondary school teachers in private schools in Dubai. All curricula emphasize on Science or STEAM as core subjects; therefore, identifying potential candidates

in private schools is not a challenge in this research part. UAE's educational reform system have been targeted for improvement since 2005 (Dickson et al., 2015) including technology use (KHDA). Therefore, accessing the emails of principals of private schools in Dubai did not pose a problem especially that the KHDA school inspection reports have contact information for each school. The questionnaire was sent using google forms for the ease of access by any teacher.

Moreover, side-by-side, this research explores the influence of training the science secondary school teachers to use PME skills on their instructional strategies in a qualitative study through interviews, observations and document analysis (RQ3). Therefore, the site is limited to possible accessibility of researcher. The professional development sessions were limited to one school, for convenience, belonging to an educational institute that encompasses different school branches. For RQ3 the academic group, which has 5 different school branches was addressed. The training and interviews were on one of the schools' campuses and the observations for the participating teachers ran in their classroom settings as they deliver their pedagogical instructions (More information about the schools in Appendix A).

3.5 Population, Sampling and Participant Selection

The Ministry of Education (MOE) open statistics center reveals 5289 secondary school teachers (1809 males and 3480 females) Dubai private schools for the year of 2020 (MOE, 2022) as the most recent available statistics. Since no data were available for subject teachers numbers in particular; each school is expected to have at least 5 departments Arabic language department, Second Language department, Mathematics Department, Science department and

a fifth department which would include the physical education, social studies and other non-core subjects. So the number is estimated as1058 science secondary school teachers which would be the population identified for the quantitative study. Since the quantitative study relies only on the questionnaire, the digital communication will be enough through sending emails with consent letter and with the questionnaire for the school principals where they can forward it to their science secondary school teachers after their approval (See Appendix B).

According to the table of sample size at 90% confidence level with confidence interval (5%), any population size of about 1000 requires sample size of 214 according to Bartlett et al (as cited by Cohen et al., 2018, p.207). To obtain at least this number of participants, convenience sampling method will be used which allows choosing any potential secondary science teacher available and has access to the questionnaire. Convenient random sampling will ensure proper presentation of the population of the secondary science teachers in Dubai private schools. Conclusions derived from such sample sizes would provide accurate representation of the larger group of Dubai science secondary teachers in Dubai private schools (Fraenkel, Wallen & Hyun, 2019); however, would be limited to certain demographic and other characteristics of the sample studied. Therefore, the questions on demographic information were added to the questionnaire. The targeted population could be accessible through internet communication in the quantitative approach as it relies solely on questionnaires.

Sampling for the second qualitative fold of this research would differ not in the targeted population but in the accessibility and availability for the study (Fraenkel, Wallen &

Hyun, 2019). Although the population is the same –secondary science teachers in Dubai Private schools- yet sampling will be limited to a private schools in Dubai due to convenience and possible accessibility within the timeframe of this research. To answer RQ3, the participants will be those who volunteer for the in-service professional development (PD) programme from the science department in five schools of choice. A plan of the programme with all necessary details: times, presentations, activities…etc…will be shared with the principals of these schools for approval before sharing it with the science secondary teachers. This group of schools was chosen as the researcher works in one of them and can access the school easily and plan the PD programme without any interruption to school systems. Therefore, convenience sampling techniques will be applied as it allows the researcher to choose any participant who can apply to the category of being a science secondary teacher in these private schools in Dubai. The teachers who volunteer for the training will be given consent letters and will be aware of the aim of the training. All communications will be transparent and will allow flexibility during the PD sessions. Some teachers who would be involved in the training could be observed in their classrooms before and after the training programme after their approval and sharing with them all ethical protocols. The teachers would be selected for convenience after volunteering in the programme (Johnson & Christensen, 2014). Throughout the research convenience sampling is used as a non-random systematic sampling technique since a convenience sample is "a group of individuals who (conveniently) are available for study" (Fraenkel, Wallen &Hyun, 2019, p.98).

One of the challenges of sampling is the external validity and ability to create a generalization within the population (Fraenkel, Wallen &Hyun, 2019). The ability to replicate

the study within similar sampling techniques increases validity of the sampling used to collect data and allows for generalization of results. In their study, Hong and colleagues (2019) emphasize on the justification of the sampling strategy, choice of samples that represent diversity of characteristics of participants, and the relevance of the sample that fits the purpose of the research as the main components that add validity to sampling and population generalization.

3.7 Data Collection Instruments

Instrumentation is defined as the "whole process of preparing to collect data" (Fraenkel, Wallen &Hyun, 2019, p.111). The instruments used should be reliable, providing consistent results, to allow for valid conclusions with objectivity and absence of any subjective judgements. Mixed method research allows for the use of multiple varied methods to justify the methodology of the undertaken research (Cohen et al., 2018; Fraenkel, Wallen & Hyun, 2019). In their handbook, Teddlie and Tashakkori (2010) define the methodology followed in mixed methods research as "the broad inquiry logic that guides the selection of specific methods and that is informed by conceptual positions common to mixed methods practitioners" (Teddlie & Tashakkori 2010, p. 5). Using quantitative and qualitative data collection instruments adds depth and breadth to the knowledge in the topic under research, requires prolonged timeframe and effort, and combines the strengths of both quantitative and qualitative approaches (Creswell & Clark, 2017; Timans, Wouters & Heilbron, 2019).

The mixed method is used in this research to answer the research questions. In the first fold, a quantitative approach is used to answer RQ1: "What perceptions do science teachers

have regarding awareness and use of metacognition in Dubai private secondary schools?" and RQ2 : "What demographic differences do science teachers have regarding their metacognition in science teachers in Dubai private secondary schools?". These two questions will use a questionnaire adopted from two published and validated questionnaires and modified to fit the needs of this research. The questionnaire was be subjected to validation and evidence of reliability through statistical survey analysis in a pilot study. The pilot study was conducted in two schools and answers to questionnaire were collected from 19 participating teachers.

The second fold has a qualitative approach to answer the third research question: "How do science teachers develop metacognitive skills for planning, monitoring and evaluating (PME) of instructional strategies based on in-service metacognitive professional development sessions in Dubai private secondary schools?" The intervention through professional development sessions followed by thematic analysis of observation, field notes, lesson plans and answers to semi-structured interview questions helped answer this research question. All these qualitative methods help through triangulation in forming a bigger picture of building awareness and use of metacognition in teachers in a practical setting. In the final step, data collected from the qualitative and quantitative study both completed the picture through integrated results and an overall conclusion could be drawn.

Table 2

A Summary of the Instruments and Data Analysis Used

	Research Questions	Instrument	Data Analysis
RQ 1	What perceptions do science teachers have regarding awareness and use of metacognition in Dubai private secondary schools?	Quantitative: Questionnaire based on MAIT and TMI	-Descriptive statistics - Excel and Jamovi
RQ 2	What demographic differences do science teachers have regarding their metacognition in science teachers in Dubai private secondary schools?	Quantitative: Questionnaire	-Descriptive statistics
RQ 3	How do science teachers develop metacognitive skills for planning, monitoring and evaluating (PME) of instructional strategies based on in-service metacognitive professional development sessions in Dubai private secondary schools?	Qualitative: -Observation -Field notes -Document analysis -Interview	- thematic analysis

3.7.1 Questionnaire

A questionnaire is a quick, easy and widely used instrument to collect information from sample population in order to help in standardization and generalization. They provide numerical straightforward answers that can be analysed statistically, and open-ended questions can add to the final judgement of the researcher (Cohen et al., 2018). After defining the purpose of the questionnaire and deciding on the targeted population and sampling for answering RQ1 and RQ2, the researcher needed to identify the items to be included in the questionnaire. The items needed not only to identify awareness of metacognition knowledge in its three domains and metacognition use of the PME skills, but they also had to be addressing

teachers themselves rather than learners. Another aspect of possible demographic factors was added to try to find patterns and trends in attitudes (Creswell & Clark, 2017).

The quantitative approach is based on a questionnaire that is modified from two validated questionnaires: (1) Jiang and colleagues' Teaching Metacognitive Inventory (TMI) (2016) which is made of 28 items and would help answer RQ1 and RQ2 and (2) Balcikanli's Metacognitive Awareness Inventory for Teachers (MAIT) (2011) which constitutes 24 items and would answer RQ1. In his study, Balcikanli (2011) included the reliability analysis of the MAIT for the themes which varied from 0.79 to 0.85 indicating a high reliability to be used in future research. The TMI was described as having satisfactory reliability with Cronbach's alpha coefficient for the 6 themes varying from 0.771 to 0.839 (Jiang et al., 2016).

This research questionnaire is made of the 24 items extracted from the MAIT questionnaire to serve RQ1 and 2 and 12 items extracted from the TMI questionnaire to serve RQ2. Those questions were chosen as they directly relate to the main purpose of the study and they fit into the context of this research. No modifications were done to the questions themselves; only few questions were omitted from each in order to fit the size and time taken to fill in the questionnaire. According to Revilla and Ochoa (2017), the ideal questionnaire duration for any questionnaire is the one that takes between 10 to 20 minutes to fill. In their study, the researchers considered that this length is appropriate without any significance for the role of the sociodemographic factors of participants.

The questionnaire is a self-report close ended inventory that measures 3 variables which are the metacognition knowledge, the metacognition skills and the factors influencing

metacognition variable. Each variable has 3 domains containing different items or statements measured on a numerical rating scale of 1 to 5in the Likert-type response format where (1) refers to strongly disagree and (5) refers to strongly agree. Each of the variables below measures different items and is directly related to the conceptual framework suggested for this research.

Table 3

The Main Variables of the Questionnaire and Their Resource

MAIT themes		**TMI extracted themes** add column for items
1- Declarative knowledge	4-Planning	1-Experience
2-Procedural Knowledge	5- Monitoring	2-Knowledge about pedagogy
3- Conditional Knowledge	6- Evaluating	3- Reflection

Note. Each of the variables above constitutes of 4 items. (More Details in Appendix C)

First Variable with the domains (1-2-3) were extracted from the MAIT to measure the teachers' awareness of metacognition knowledge in its three domains: declarative, procedural and conditional. The MAIT extracted second variable (4-5-6) measure teachers' use of the metacognitive skills (both of which answer RQ1). TMI variable (1-2-3) measure some of the factors influencing teacher's metacognition in order to answer RQ2. The questionnaire will also include a part for demographic information such as the gender, age, nationality and years of teaching experience. This part has been added by the researcher to add to the context of this research and collect data on possible demographic variances within the teachers' populations in Dubai. The questions were shared by two experts in the field for verification and validation

of the context and applicability of the questionnaire. Then, the questionnaire required piloting for validation.

The quality of the instrument is crucial for the validity and reliability of the data collected (Fraenkel, Wallen &Hyun, 2019). Therefore, a pilot study within the school of the researcher allowed testing the validity of the questionnaire and revealed if any refinement was required before conducting the research on a bigger scale across the private schools in Dubai (Cohen et al., 2018). Statistical tools can justify the reliability of the results through Cronbach alpha coefficient. If Cronbach alpha is above 0.7 then this is an indication of reliability of questionnaire and its ability to be repeated and replicated to be used with many participants (Creswell & Clark, 2017). Further more, Kaiser-Mayer-Olkin (KMO) coefiicient can show validity of the quaestinnaire alongside Barlett sphericity test which reveals the strength among the factors within the variables (MacCallum et al., 2002).

3.7.2 Document Analysis

Document analysis is an instrument that would allow the researcher to indirectly study human behavior through analyzing their written communication (Fraenkel, Wallen &Hyun 2019). Metacognition is not directly measured or observed in teachers. This is why instructional and pedagogical resources were collected from teachers before and after the professional development programme. This allowed for coding of common categories that show how teachers are using metacognition and if their awareness and use of metacognition is evident or has changed after the training programme. The choice of pedagogical resources, instructional strategies, and use of metacognition prompts will all be indicative tool of how

teachers responded to the PD programme. This will help answer the planning phase of teacher's instructional strategies in the last research question and will lead to creating themes and evidence of the whole process of building planning in the PME skills in teachers within real-world application. This strategy allows for comparing attitudes and ability of teachers to change after professional development sessions. It will allow comparing trends over time and how teachers perceive trainings and respond to PD sessions.

According to Fraenkel, Wallen and Hyun (2019), document analysis serves five main objectives which are obtaining descriptive information, formulating themes, validating other research findings, providing relative frequencies of information used to solve educational problems, and finally testing hypothesis. The researcher would use questions related to the research and literature review; these questions can help detecting categories for analysis and generating coding units (Fraenkel, Wallen & Hyun, 2019). This allows an overlap of analysis and interpretation of data (Alhojailan & Ibrahim, 2012). Here the researcher is the instrument for data analysis and is responsible for making judgements and taking proper decisions. Through this process: coding, theming, decontextualizing and recontextualizing the data are required (Braun & Clarke, 2006; Nowel et al., 2017). This is further confirmed by Taylor and Ussher (2001) who stated "themes do not just lay about waiting to be discovered, they do not simply emerge, but must be actively sought out" (as cited by Xu & Zammit, 2020). This involves separating data and then relating them to the context or framework of the research. For document analysis, a rubric with specific checklist will be created with side notes to compare and contrast lesson plans, instructional strategies chosen and evidence of use of metacognition among the secondary science teachers who volunteered for lesson observations

and providing lesson plans. This is a crucial part in qualitative research but at the same time very challenging part due to authenticity of each document and less chances of checking for bias (Morgan, 2022).

The researcher must exercise critical thinking skills and subjectivity to interpret the data and provide informed decisions. It is important for the researcher to maintain transparency, rigor and reflexibility. This ensures reliability, validity and trustworthiness of the data analysis in qualitative research and eliminates bias (Cohen et al., 2018; Nowel et al., 2017). Writing lesson plans is a school routine and these documents were not solely prepared for this investigation which adds reliability and validity of the documents used. Teachers were not affected by the researcher and did not have to be involved in preparing these plans only for the research use. This routine ensured trustworthiness of document analysis due to objectivity while preparing the documents by the teachers and disconnecting the researcher from prejudgment or prejudice.

3.7.3 Observations

Observation techniques help evaluate cognitive as well as non-cognitive aspects of the observed individual. Observation involves more visual senses to systematically watch and record behaviors, actions, and expressions within different contextual and social situations (Pandey & Pandey, 2021). Observations add the opportunity to collect data from in-situ where the social situation is supporting the data collection rather than just self-reporting data (Cohen et al., 2018). Therefore, observations highly dependent on the researcher's skills to observe, focus and capture simple details that might emerge in the scene (Kawulich, 2005).

Observing teachers deliver their instructions using metacognitive prompts will allow the researcher to evaluate the effect of the PME training programme on the teacher's performance. This is an opportunity to strengthen the research with face validity and rich contextual information within real world view (Cohen et al 2018). By directly observing the teachers, the researcher is able to gather information about what teachers think and do, without relying on self-reporting or interpretation by others (Pandey & Pandey, 2021) which were the main elements of the quantitative part of this research.

Only teachers who volunteered into the professional development programme and accept to be observed will be involved in this process for contextual purposes and relating to human experience. At least three teachers should be involved in this process. The researcher would be able to observe how the teacher is developing the metacognition knowledge and monitoring the delivery of the instructional pedagogy within classroom setting. Within this setting the stance of complete observer will be applied where the observer will only observe without any interference or prior judgement (Merriem & Tisdell, 2015). During the observation, data will be collected in the form of field notes, reflective memos and referring to a checklist of the tasks, behaviors to be observed, and process involved throughout the lesson and during the data collection process (Cohen et al., 2018). These observations help also determine the influence of the socio-situational contexts depicted in the classroom during the delivery of the lessons and the response of teachers to these circumstaces in real-time application.

During observation, a checklist is prepared as guidelines for the observer during the lesson. Moreover, prompts and questions will be prepared to try to find answers during observation. These questions determine all phases of metacognition skills and mainly monitoring phase. Some were marked as present or absent such as the use of metacognitive prompts, the ability of the teacher to adjust to emerging situations during the lesson and others were notes on certain aspects such as what strategies the teacher is using in class (see Appendix E for more information).

To conclude, observations do not occur haphazardly but are systemized allowing the researcher to prepare a checklist of what is needed to be observed and how field interviews will be documented. The observation should be recorded immediately and subjected to checks for validity, reliability and precision in order to warranty trustworthiness of this tool (Merriem & Tisdell, 2015; Pandey & Pandey, 2021). Consistency and repeatability of the observations can increase reliability of the observation tool. Accuracy and truthfulness of the observation add to the validity of data collected from observations. Standardizing the observation procedure to avoid bias and subjective interpretation increase the objectivity in data. Being aware of the social, cultural, and environmental factors add to the contextual understanding of the study. Finally, documenting clearly the procedures, settings and details add to transparency to the research. All these elements contribute to trustworthiness of the data analysis from this tool (Alhojailan & Ibrahim, 2012; Cohen et al., 2018; Merriem & Tisdell, 2015). The researcher did not have any input or interference with the teachers under observation to avoid bias and ensure trustworthiness. Triangulation of data and using all information will ensure validity of analysis.

3.7.4 Interviews

According to Pandey and Pandey (2021) “Interview is a two-way method which permits an exchange of ideas and information” p. 59. The qualitative approach will be based on semi-structured interviews of teachers involved in the in-service professional development programme before and after the training sessions. The semi-strucured interview combined pre-determined open questions prompted to explore teachers’ PME skills with an opportunity to extend the questions to further explore certain answers or themes extracted from the teachers’ responses during the interview. Interviewing teachers would provide deep understandings of their perceptions to metacognition awareness use of metacognition to answer RQ3 and as well as it would allow explore if training teachers to use their evaluation skills would influence their awareness and use of metacognition in their instructional pedagogies in classrooms. The questions would be mainly based on the variables and items of the questionnaire and the training programme in order to compare and complete the data analysis from both quantitative and qualitative methods. The semi-structured interview allows flexibility and ability to adjust any question according to the participants’ answer. Probing questions can emerge from new situations or ideas that stimulate the interviewee (Merriem & Tisdell, 2015). The semi-structured interviews mainly addressed the strategies teachers use to plan and prepare their instructional methods and pedagogical resources; the ways and frequency at which they respond to their students’ needs during teaching and learning within the class context and their ability to adpt changes during the lesson. Then, teachers were asked to reflect on the success of their practices and on criteria they refer to in order to determine the efficiency of their

practices. Finally teachers were asked about their perceptions towards the PD sessions that they had participated in during this research.

For trustworthiness the questions will be shared with experts in the field for checking and the interviews will be recorded to add to the trustworthiness and to avoid any bias during transcription of data. Recording will only be possible after sharing informed consent letter with the interviewees and subjected to their approval. The interviewees will be aware of the aim of the interview and the topic of metacognition and all ethical principles will be precedent. Informed consent letters protect participants from being vulnerable to sharing personal experiences that rise the potential of misuse (Fraenkel, Wallen &Hyun, 2019). (Refer to Appendix D for more details). The researcher did share the transcribed interview with the participants to ensure objectivity and avoid any bias in interpretation of questions.

3.7.4 Data Analysis

Data mining is identified as the process of analyzing data and extracting information from recognizing patterns and finding relationships (Romero & Ventura, 2020). Primary data collected by the researcher from quantitative approach needs to be analyzed using statistical methods in order to reduce complexity and find similarities and differences that would lead to generalizations. Qualitative data collected require looking for patterns and transforming information collected in order to identify themes.

Descriptive and inferential statistics: Descriptive and inferential statistical analysis for the quantitative approach in RQ1 and RQ2 will be used. The Excel as well as Jamovi online

software will be used for the analysis of the survey. It will reveal the correlations among the variables in the different themes followed by factor analysis. The inventory will be validated using the sampling adequacy measured by Kaiser-Mayer-Olkin (KMO). Statistical conclusions obtained from Microsoft office Exceland Jamovi can validate the data collected. Cronbach's alpha coefficient will be calculated using Jamovi to test the reliability and internal consistency of the inventory in the context of the research. Descriptive statistics will show the averages, standard deviations and frequencies of all variables and items within variables; whereas further analysis using ANOVA, posthoc and correlations will be in the inferential statistical analysis part which would test the null hypothesis and check for significance between the different items within the variables and the data obtained (Fraenkel &Wallen, 2018). These statistical analysis allow for understanding the perceptions of teachers to awareness and use of metacognition knowledge, skills and experience. ANOVA, T-tests and correlations allow for identification of relationships among groups and variables to see how metacognition variables vary among teachers and what factors influence their metacognition.

Thematic analysis: Interviews will be transcribed and coded which would help in thematic analysis (Cohen et al., 2018; Creswell &Clark, 2017). The transcription will be shared with the participant for trustworthiness and bias check. Document analysis would serve select categories and patterns observed during practice (Merriem et Tisdell, 2015). Notes from the observations and the observation checklist would add themes and evidence to the analysis. Content analysis adds value to the interviews and observations through offering the chance of comparing data from before and after the PD training of in-service science secondary teachers (Fraenkel et al., 2019). These data help identify how teachers decide on

their pedagogical resources, what strategies they have chosen for instructions and how they reflect on their practices. These are main elements of metacognition skills that can be evaluated and monitored by the secondary science teachers in Dubai private schools.

This research relies on methodological triangulation where data from different methods add credibility and validity for the research findings (Noble & Heale, 2019). Triangulation of data from document analysis of lesson plans, observations of the lesson delivery and interviewa after the lesson with the participants allowed for capturing a full image of how metacognition skills are developing in teachers. This triangulation of qualitative tools adds trustworthiness and reliability to data and analysis. The statistical analysis of the survey, which are checked for validity and reliability through statistical calculations, would help classify themes and teachers' knowledge, PME skills, experience influence, pedagogical knowledge and ability to do reflections. These will be compared to themes emerging from the interviews, observations and document analysis. The results from the two types of data will be compared to see how they converge, diverge or relate to the complete understanding of the teachers' metacognition and to refer to the conceptual framework of the research (Creswell &Clark, 2017). Flow chart presenting this research design in appendix F.

3.8 Ethical Considerations

The five principles of ethical considerations alongside BUiDs protocol for ethics in research will be taken into account throughout this mixed method approach. These were identified by many researchers in the field and will be referred to in all phases (Christensen et al., 2015; Cohen et al., 2018; Creswell &Clark, 2017). The ethics form will be shared with

BUiD “Research Ethics Committee” for approval before conducting any of the research work. Informed consent letters that include the purpose, the plan and emphasis of anonomosity of participants and transparency in communication will be shared in all phases: for the survey, before interviews, observations and while collecting documents for analysis. All participants will be given pseudo-names to refer to during the qualitative data collection and data transcription will be shared with them for transparency, validation and bias check. The privacy of the site, participants and all data collected will be ensured in the consent letter and orally during the training and interviews. The participants will be only those who volunteer without causing them any ethical harm or pressure where they can withdraw at any phase. All of these abide by the identified ethical principles in the research field such as the AERA Code of Ethics (2011) which focuses on adhering to professional standards during research work in order to ensure complete confidentiality, anonomity and privacy of all participants and of data collected which will be intended to serve this research only. These all are included within the BUiD protocol for research.

During the research work, the researcher ensured to hide the schools and teachers’ names. They were given numbers to refer to during the reading checks and validation with experts in the field. All stakeholder including principals, teachers and students in classrooms were addressed anonymously during observations and interviews. Names were hidden in all documents during the document analysis process. All documents were password protected in the computer of the researcher and any discussion of the findings will be solely used for this thesis. Transcribing interviews was done by the researcher alone and through a website protected by personal email ID. Any further publications might use emerging results only

without reference to schools, teachers or any oersonnel involved in the process of data collection. The researcher will abide to all BUiD ethical considerations and will secure data to ensure transparency and avoid bias.

3.8 Limitation of the Study

There are many possible limitations that could emerge from this study such as time constraints to conduct the research without interrupting the teaching and learning system within the schools of choice in the qualitative part of this research. For qualitative research, it is a challenge to encourage secondary science teachers to volunteer and dedicate their time for the training sessions and for the observations. Although convenience sampling is suggested in the method, if any challenges arise, the researcher would consider snow-balling and purposive sampling for accommodating the maximum number of secondary science teachers to be involved in the programme through the help of the interested school principals.

School privacy protocols would hinder the accessibility to school campuses and classrooms, and this will limit the choices to the school where the researcher already works at. The contextual settings of the research is limited to private secondary section of the schools in Dubai. It would have been a deeper and broader approach if the other Emirates in United Arab Emirates where involved in the study.

3.9 Pilot Study

Reliability, trustworthiness and validity are all main elements for the success of the research work. As discussed earlier, reliabity and trustworthiness in the qualitative method

depends upon checks from experts in the field and validation of all instruments used. Moreover, triangulation of data adds to the validity to data and results. However, the quantitative research depends on statistical analysis for validation. Therefore, a pilot study for the questionnaire was conducted to validate the overall as well as the variables and items' strength. Only pilot study would reveal if the questionnaire requires changes and alterations.

3.9.1 Questionnaire in the Pilot Study

Validity and Reliability of the questionnaire was obtained through a pilot study that included answers for 19 secondary science teachers (N=19, M=4.1; SD=0.4). The mean level of awareness and use of metacognition was 4.1 ± 0.4 according to Likert Scale and therefore teachers in the pilot study had strong awareness and use of metacognition. To validate the reliability of the results and the tool used, Cronbach alpha was calculated. It was 0.937. this is a very high and indicates excellent internal consistency among the items in the questionnaire.

The each variable was checked for reliability through calculating the Cronbach alpha coefficient. All values were above 0.800 indicating strong reliability and irems are correlated with KMO value of 0.6 suggests a marginal acceptance of sample size; therefore a larger population size will be required for factor analysis. Moreover, the Barlett's test test (Chi-square = 3438, df = 561, $p < 0.001$) show strong correlation among the items within variable.

Table 4

Reliability Analysis for Pilot Study

Variable	Mean	SD	Cronbach's alpha	Number of items
Metacognition Knowledge	4.40	0.63	0.892	12
Metacognition Skills	4.17	0.43	0.861	10
Metacognition Experience	3.79	0.65	0.881	12

Note. All items within variables had values ranging from 0.833 to 0.932.

Chapter 4: Data Analysis and Results

4.1 Overview

In this chapter the analysis and results of data collected are presented according to the research questions addressed. Since the methodology approach is convergent parallel mixed method, the quantitative data were collected separately from the qualitative approach. Both data collection methods ran at the same time during the research period. Multiple phases of data collection were followed to answer the following three research questions: wo

RQ1: What perceptions do science teachers have regarding awareness and use of metacognition in Dubai private secondary schools?

RQ2: What demographic differences do science teachers have regarding their metacognition in science schoolteachers in Dubai private secondary schools?

RQ3: How do science teachers develop metacognitive skills for planning, monitoring and evaluating (PME) of instructional strategies based on in-service metacognitive professional development sessions in Dubai private secondary schools?

Data for Research questions 1 and 2 were obtained from a questionnaire. The survey answers are presented in this chapter through descriptive and inferential statistical analysis. The data obtained to answer the third research question were from different resources to allow for triangulation and secure trustworthiness of data collected. Combined thematic analysis

from Professional development sessions and field notes, lesson plan document analysis, observations and semi-structured interviews helped answer research question 3.

4.2 Analysis of The Quantitative Data Results from the Survey

The first two research questions required the use of a questionnaire and therefore quantitative data was used for analysis. Statistical analysis was used to analyze the answers of 84 participants who are teachers from private schools in Dubai representing science secondary schools and the questionnaire was divided into four variables: Demographic information, teachers' metacognition knowledge, metacognition skills and metacognition experience. The data collected were from a questionnaire answered by 84 teachers.

4.2.1 Analysis of Research Question 1

RQ1: What perceptions do science teachers have regarding awareness and use of metacognition in Dubai private secondary schools?

Before starting with the analysis of data, it is important to check the validity and reliability of the data collected. To test the reliability of the questionnaire, the Cronbach alpha is calculated especially that the items within the questionnaire do not have right or wrong answers (Frankel et al 2019). To ensure that the grouping of factors and suitability of data for factor analysis Kaiser-Meyer-Olkin (KMO) and Barlette test are examined. Once the KMO measure is greater than 0.7, then the variables compared are acceptable, and if Barlette test is statistically significant with value less than 0.5, then the data are suitable for factorization and analysis (Cohen et al., 2018, Frankel et al., 2019). Further to the pilot test (presented in the

methodology), the overall Cronbach alpha was calculated using the formula on Excel sheet. The Result shows that data is strongly reliable since α= 0.947 (Table 4.1). Additionally, Cronbach alpha was calculated for each variable within the survey to confirm reliability and proceed with factor analysis. The results also show strong reliability with α= 0.79 for the first variable which is Metacognition as Knowledge, and 0.94 for Metacognition as skills variable and 0.71 for Metacognition as experience variable (Table 4.2). These values are all high (above 0.85), indicating that the items within each of these scales (Knowledge, Skills, Experience) are highly reliable and consistent.

Table 5

Cronbach's Alpha Calculation for the Survey

Cronbach's Alpha is calculated using the following formula: $$\alpha = \frac{(K)}{(K-1)} \frac{Sy^2 - Sum\ Si^2}{Sy^2}$$ ***Where:*** **α** = Cronbach's Alpha **K** = the number of items in the scale **Si** = the sum of the item scores for the each item **S** = the sum of the total scores for all items	α= (35/34){(350.56-28.03)/350.56}= 0.947 This indicates a strong reliability of data. Note: The calculations were done using Excel.

Table 6

Cronbach's Alpha Calculation for the Variables and Exploratory Factor Analysis

Means	*Cronbach's Alpha*	Uniqueness
Metacognition as Skills	0.916	0.494
Metacognition as Knowledge	0.909	0.114
Metacognition as Experience	0.852	0.370

Bartlett's test would indicate if the variables are related and suitable for factor analysis. Since $P < 0.01$ for all three categories, this suggests that there are significant relationships between variables, indicating that factor analysis is appropriate for this data.Now that reliability is confirmed, exploratory factor analysis was followed for the variables and then for the items within each variable (Table 4.2). The factor analysis (Table 4.3) indicates that awareness and use of Metacognition as Knowledge is the strongest factor for teachers as compared to the other two variables. Metacognition as Skills variable is moderately associated with some variability in teachers' perceptions and needs to be further investigated as some items in the survey within this variable might not be significant.

Table 7

Reliability Test and Exploratory Factor Analysis

	Metacognition as Knowledge	**Metacognition as Skills**	**Metacognition as Experience**
Cronbach's α	0.909	0.916	0.852
Bartlett's test	P<0.01	P<0.01	P<0.01
KMO Exploratory Factor Analysis	KMO values between 0.76-0.93	KMO values between 0.74-0.90	KMO values between 0.65-0.84

	Factor		
	1	2	Uniqueness
A	0.836		0.432
B	0.602		0.420
C	0.794		0.453
D	0.551		0.438
E	0.547		0.626
F		0.667	0.415
G		0.775	0.349
H	0.598		0.342
I	0.665		0.436
J		0.663	0.434
K		0.924	0.226

	Factor	
	1	Uniqueness
A	0.531	0.718
B	0.768	0.410
C	0.685	0.531
D	0.789	0.377
E	0.856	0.267
F	0.871	0.242
G	0.576	0.668
H	0.756	0.428
I	0.740	0.452
J	0.668	0.553

	Factor		
	1	2	Uniqueness
A		0.635	0.485
B		0.615	0.616
C		0.875	0.283
D		0.544	0.604
E	0.543		0.720
F	0.662		0.577
G		0.312	0.820
H	0.485		0.759
I	0.765		0.332
J	0.797		0.327
K	0.882		0.269
L	0.800		0.357

The above analysis shows strong reliability for each variable. The factor analysis shows how the items in each variable domain are related. In metacognition as knowledge, items related to declarative knowledge (items A-B-C-D) are highly related followed by items of procedural knowledge (items F-G-H) and finally the items related to conditional knowledge. As for metacognition as Skills, all items are strongly related. The metacognition as experience shows variation in factor analysis with thoughts being the strongest (items I-J-K-L), followed by feelings (A-B-C-D). Awareness to pedagogical strategies had the least correlations especially item G (I know that group discussion do not apply when time is short for teaching). Moreover, factors H, G and E reflect uniqueness; this might be due to the fact that it relies on the level of self-awareness of teachers.

4.2.1.1 Overall Analysis of Survey on Metacognition. To know the overall perception of secondary science teachers on their awareness and use of metacognition in their classrooms, the data from survey were collected for 3 variables: Metacognition as knowledge, metacognition as skills and metacognition as experience. Using Likert scale with 5 being strongly agree and 1 strongly disagree, the data is presented in the tables below through descriptive statistical analysis of the survey. 5 is the highest positive attitude of awareness and use for each statement within the metacognition domains in the science secondary school teachers. The teachers had to rate each item as strongly agree (5); agree (4), unsure (3), disagree (2) and strongly disagree (1).

Within the descriptive statistical analysis used, higher mean scores suggest a relatively positive perception or competency in awareness and use in metacognistion , while standard deviations indicates the variability or consistency in responses across all teachers for each item within each variable. The survey conveys strong perceptions in secondary science teachers for awareness and use of metacognition (N=84, M=3.94, SD=0.89). The minimum was M=2.73 and the maximum was M=4.76.

4.2.1.2 Analysis of the Metacognition Variables. The overall average of each of the variables (Knowledge, Skills and Experience) were calculated alongside the standard deviation value to show how data are distributed around the mean for a population sample of 84 science secondary teachers in private schools in Dubai. The teachers had highest perceptions to Metacognition as Knowledge (N=84, M=4.2, SD=0.8) followed by Skills (M=3.8, SD=0.9) and finally the experience (M=3.7, SD=0.9).

Table 8

Teachers' Awareness and Use of Metacognition Knowledge, Skills and Experience

Dependent Variables	Count	Sum	Mean	SD
Metacognition as knowledge	84	354.3	4.2	0.8
Metacognition as Skills	84	323.7	3.8	0.9
Metacognition as Experience	84	315.5	3.7	0.9
Overall Perception to Metacognition	84	330.6	3.9	0.8

Furthermore, the Spearman ranking correlation which is highly used in psychological education research is used to determine the correlation between each two variables (De Winter, Gosling & Potter 2016). The estimated Spearman correlation coefficient is calculated using the number of paired ranks (n) in the data set and di is the difference between the paired ranks. Moreover, the hypotheses Ho and H_A were referred to while computing the correlation coefficient. The higher the value towards 1, the more correlated are the variables. The mean rank of each variable were paired against each other.

Table 9

Spearman Correlation Coefficient for Teachers' Awareness and Use of Metacognition Knowledge, Skills and Experience

Variables	Spearman Correlation Coefficient (rs)	P value	significance
Knowledge -Skills	rs = 0.71862	p (2-tailed) = 0	Significant Association
Experience - Knowledge	rs = 0.65389	p (2-tailed) = 0	Significant Association
Skills- Experience	rs =0.54642	p (2-tailed) = 0	Significant Association

The association between the each of the two variables above would be considered statistically significant. Knowledge and skills showing the highest moderately strong positive correlation with r_s=0.71862, which indicates that as metacognition knowledge increases in teachers, their tendency for metacognition skills also increases. Following is also a moderately strong association between Metacognition as Experience and Metacognition as Knowledge with r_s= 0.65389 and finally a moderate positive correlation of r_s= 0.54642 for skills and experience. Therefore, the increase in awareness and use of metacognition in one variable leads to increase in the other variable.

4.2.1.3 Analysis of the Metacognition as Knowledge Variable. Anlysis of the domains and items with the variable of " Metacognition as Knowledge" show that the degree of teachers' perceptions towards metacognition as knowledge in its three domains are very high in almost all items of this variable. The mean score of all items of this variable ranged between 3.9 and 4.5. The total mean score was 4.2 ± 0.8 of the whole variable.

Table 10

Teachers' Awareness and Use of Metacognition Knowledge

Metacognition as Knowledge			
Domains	**Statement**	**Mean**	**SD**
Declarative Knowledge	I am aware of the strengths and weaknesses in my teaching]	4.5	0.5
	[I know what skills are most important in order to be a good teacher]	4.4	0.7
	[I have control of how well I teach]	4.3	0.7
	[I know what I am expected to teach]	4.4	0.6

Procedural	[I try to use teaching techniques that worked in the past]	4.5	0.6
Knowledge	[I have a specific reason for choosing each teaching technique I use in class]	3.9	0.9
	[I am aware of what teaching technique I use while I am teaching]	4.0	0.9
	[I use helpful teaching techniques automatically]	4.0	0.9
Conditional	[I use my strength to compensate my weaknesses in teaching]	4.4	0.7
Knowledge	[I can motivate myself to teach when I really need to teach]	4.2	0.9
	[I use different teaching techniques depending on the situation]	4.1	1.1
	[I know when each teaching technique I use will be effective]	4.0	0.9

All domains of metacognition as knowledge – Declarative, Procedural and Conditional- generally show a high degree of agreement with the statements related to awareness and use of metacognitive knowledge in teaching. Most items have an average around 4.0 or higher indicating a positive attitude towards awareness and use of metacognition as knowledge in all its domains. This indicates a higher degree of agreement among participants regarding their awareness, skills, expectations, and strategies related to teaching. However, procedural knowledge seems to have slightly lower mean scores compared to that of declarative and conditional knowledge. Participants might be less certain about reasons for choosing a specific teaching technique. A summary of these domains and an average of all statements within each domain are shown in the table below:

Table 11

The Average of the Domains of the Variable Metacognition as Knowledge

Domains within the variable of Metacognition as Knowledge	Mean	SD
Declarative Knowledge	4.4	0.1
Procedural Knowledge	4.1	0.2
Conditional Knowledge	4.2	0.2

To further confirm if the different mean values are by chance or due to the different agreement levels of teachers, ANOVA test is performed. ANOVA was used to compare responses of the teachers in the different domains within the variable of metacognition as knowledge.

H_o= There is no difference in between declarative, procedural or conditional knowledge in metacognition among the secondary science teachers in private schools in Dubai.

H_A= The awareness and use of declarative, procedural or conditional knowledge in teachers differ among the secondary science teachers in private schools in Dubai.

Table 12

ANOVA of The Domains within the Metacognition as Knowledge Variable

ANOVA: Single Factor						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Declarative	84	370.75	4.41369	0.276346		
procedural	84	343.25	4.08631	0.464599		
Conditional	84	348.75	4.151786	0.510569		
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	5.041667	2	2.520833	6.042676	0.002738	3.032065
Within Groups	103.8757	249	0.417172			
Total	108.9174	251				

Since F calculated (6.04) > F critical (3.03) and P=0.002 < 0.05, then we fail to accept the null hypothesis "there is no difference in teachers' perception to domains in Metacognition as Knowledge". The participating teachers' perceptions to awareness and use vary according to type of knowledge addressed. To test whether all domains are statistically significant multiple post hoc Tukey comparisons tests are conducted.

Table 13

Tukey-HSD Results within the Domains of Metacognition as Knowledge

	Tukey HSD results		
Treatment Pairs	**Tukey HSD Q statistic**	**Tukey HSD p-value**	**Tukey HSD inference**
Declarative vs Conditional knowledge	4.6455	0.0033351	P< 0.01
Declarative vs Procedural Knowledge	3.7164	0.0246664	P < 0.05
Conditional vs Procedural Knowledge	0.9291	0.7684772	insignificant

The data in table 4.9 shows significant different among Declarative knowledge and conditional knowledge as well as among Declarative knowledge and procedural knowledge at level of confidence of 95%; however, it shows insignificance between conditional and procedural knowledge. This means teachers are aware of information related to the topics and instructional strategies to use in classrooms but not on how and when to use these instructional strategies.

4.2.1.4 Analysis of the Metacognition as Skills Variable. Planning, Monitoring and Evaluating are three domains within the variable of Metacognition as Skills.

Table 14

Teachers' Awareness and Use of Metacognition Skills

Metacognition as Skills			
Domains	**Statement**	**Mean**	**SD**
Planning	1-I pace myself while I am teaching in order to have enough time]	3.9	0.9
	[I set my specific teaching goals before I start teaching]	3.9	0.7
	[I ask myself questions about teaching materials I am going to use]	4.1	0.6
	[I organize my time to best accomplish my teaching goals]	3.9	0.8
Monitoring	[I ask myself periodically if I meet my teaching goals while I am teaching]	3.5	0.9
	[I find myself assessing how useful my teaching techniques are while I am teaching]	3.7	0.8
	[I check regularly to what extent my students comprehend the topic while teaching]	4.0	0.7
	[I ask myself questions about how well I am doing while I am teaching]	3.7	0.9
Evaluating	[I ask myself how well I have accomplished my teaching goals once I am finished]	3.7	0.7
	[I ask myself if I could have used different techniques after each teaching experience]	3.8	0.7

Table 4.10 reflects high attitudes towards teachers' perceptions to awareness and uses of metacognition as skills in its three domains: planning, monitoring and evaluating. The means of the statements vary from 3.5 to 4.1 which are moderately high degree of positive attitudes among teachers regarding their engagement in planning their instructions and

pedagogical resources, monitoring their teaching, and evaluating the success of the teaching and learning experiences in the classrooms.

The item 3 in Planning (mean 4.1 ± 0.8) and item 3 in Monitoring (mean 4.0 ± 0.7) received mean scores closer to 4.0 or above, indicating a higher degree of agreement among science teachers regarding their engagement in monitoring students' comprehension and asking questions about teaching materials before using them, which reflects a more robust engagement with metacognitive strategies in these areas. The least was item 1 in monitoring (I ask myself periodically if I meet my teaching goals while I am teaching) which indicates a struggle in teachers to find the time during the lesson to reflect on their delivery of the instruction.

Table 15

The Average of the Domains of the Variable Metacognition as Skills

Domains within the variable of Metacognition as Skills	Mean	SD
Planning	4.0	0.1
Monitoring	3.7	0.2
Evaluating	3.8	0.2

Table 4.11 shows the mean of all domains within the variable of metacognition as skills. It is highest for planning and least for monitoring. In order to check statistically the significance of this data and confirm if the variation in readings with the different dependent

variables (planning, monitoring and evaluating) is due to chance or to teachers' awareness ANOVA single factor is performed using Excel.

H_o= There is no difference in between planning, monitoring or evaluating skills in metacognition among the secondary science teachers in private schools in Dubai.

H_A= The awareness and use of planning, monitoring or evaluating skills in teachers differ among the secondary science teachers in private schools in Dubai.

Table 4.12

ANOVA of the Domains within the Metacognition as Skills Variable

ANOVA Single Factor						
Groups	***Count***	***Sum***	***Average***	***Variance***		
Planning	84	339.05	4.03631	0.533636		
Monitoring	84	312.75	3.723214	0.54822		
Evaluating	84	320.5	3.815476	0.78783		
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	4.348631	2	2.174315	3.488794	0.032039	3.032065
Within Groups	155.1839	249	0.623228			
Total	159.5325	251				

The ANOVA results F = 3.48 > F(3.03) aand p< 0.05 show statistical significance in daya and therefore, fails to accept the null hypothesis. Since the ANOVA result shows that the data collected are due to variations in teachers' perceptions to awareness and use of metacognition skills at p< 0.05, a post-hoc Tukey HSD test is performed to compare each pair of variables. The post-hoc will enable see if teachers' perceptions to planning differ from monitoring; if perceptions to planning differ from evaluating and finally if their perceptions to monitoring is distinct from their perceptions to evaluating.

Table 16

Tukey-HSD Results within the Domains of Metacognition as Skills

Tukey HSD results Treatment Pairs	Tukey HSD Q statistic	Tukey HSD p-value	Tukey HSD inference
Planning vs Monitoring	3.7014	0.025	P< 0.05
Planning vs Evaluating	2.5620	0.0168	P < 0.05
Monitoring vs Evaluating	1.139	0.683	insignificant

Results show that both pairs (planning vs monitoring) and (planning vs evaluating) are significantly different at level of confidence 0.05 but insignificant for monitoring and evaluating. There seems to be a gap in skills used to monitor the delivery of the lesson and then reflect on its success. This insignificance can be due to limitations discussed in the conclusion.

4.2.1.5 Analysis of the Metacognition as Experience Variable. The survey variable for factors influencing metacognition is called "Metacognition as Experience" and has three domains: Feelings, Awareness and Thoughts. The mean of the answers of 84 secondary science teachers is presented for each statement within each domain for this variable alongside the standard deviation to show how values are scattered around the mean. Using Likert scale, 5 is the most agree and 1 is the least.

Table 17

Teachers' Awareness and Uuse of Metacognition Experience

Metacognition as Experience			
Domains	**Statement**	**Mean**	**SD**
Feelings	[I always worry about students feeling tedious in my classroom]	3.9	0.9
	[I worried that I cannot control the pace of teaching]	3.2	1.1
	[When my classroom teaching fails, I feel anxious]	3.6	1.1
	[When I successfully complete the classroom teaching task, I feel very relaxed]	4.0	0.8
Awareness	[I clearly know demonstration can make abstract knowledge concrete]	4.1	0.7
	[I know exactly what method can inspire students to think]	3.9	0.8
	[I know that group discussion do not apply when time is short for teaching]	3.5	1.0
	[I know that interaction with students can make them concentrate]	4.2	0.7
Thoughts	[I re-evaluate appropriateness of my teaching after each lesson]	3.7	1.0
	[I reflect on whether my teaching design is appropriate after each lesson]	3.6	1.0
	[I ask myself if I have considered other possible methods after each lesson]	3.4	1.0
	[I reflect on whether my teaching performance is proper after each lesson]	3.5	1.0

These domains gauge to teachers' emotions, level of self-awareness and reflective thoughts in relation to their teaching practices and their impact on the learning experience in students. The means and standard deviations calculated suggest an average level of awareness in teachers in response to their teaching contexts. The mean of the statements related to metacognition as experience which is an indicative tool for factors affecting metacognition vary between 3.2 and 4.2 within an error range between ± 0.7 and 1.0. Therefore, the data

portrays a moderately high level of self-awareness of instructional methods and reflection with some concerns related to teaching effectiveness and engagement. The lowest was item 2 (3.2) (I worried that I cannot control the pace of teaching) which reflects the response of teachers to negative feedback or frustration in the lesson which might affect their motivation.

Table 4.15

The Average of the Domains of the Variable Metacognition as Experience

Domains within the variable of Metacognition as Experience	Mean	SD
Feelings	3.7	0.1
Awareness	3.9	0.3
Thoughts	3.6	0.1

The mean scores suggest a generally high level of awareness, moderately positive feelings and a slightly lower level of thoughtful engagement within metacognition as experience. The standard deviation (SD) levels reflect slight variability in these domains among teachers' responses.

In order to check the statistical significance of this data and confirm if the variation in teachers' perceptions to the different dependent variables in metacognition as experience (feelings, awareness and thoughts) is due to chance or to teachers' awareness ANOVA single factor is performed using Excel.

H_o= There is no difference in between feelings, awareness to pedagogical skill and thoughts experiences in metacognition among the secondary science teachers in private schools in Dubai.

H_A= The awareness and use of feelings, awareness to pedagogical skill and thoughts as experience in teachers differ among the secondary science teachers in private schools in Dubai.

Table 18

ANOVA of the Domains within the Metacognition as Experience Variable

ANOVA: Single Factor						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Feelings	84	309.75	3.6875	0.656438		
Awareness	84	333.25	3.967262	0.314427		
Thoughts	84	303.5	3.613095	0.893682		
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	5.858631	2	2.929315	4.713179	0.009792	3.032065
Within Groups	154.7574	249	0.621516			
Total	160.6161	251				

With F = 4.71 > F(3.03) and Since p< 0.05, then the null hypothesis is rejected and the data show difference according to teachers' perceptions towards factors influencing metacognition. Since ANOVA reveals significance in data collected, Tukey HSD in post hoc can be calculated to compare pairs of domains.

Table 19

Tukey HSD Results within the Domains of Metacognition as Skills

Tukey HSD results			
Treatment Pairs	**Tukey HSD Q statistic**	**Tukey HSD p-value**	**Tukey HSD inference**
Feelings vs Awareness	3.2524	0.057	P= 0.05
Feelings vs Thoughts	0.8650	0.0168	P < 0.05
Awareness vs Thoughts	4.1174	0.683	insignificant

Perceptions of teachers towards their feelings and thoughts seem to be statistically significant. This reflects high motivation attitudes in teachers. However, despite having high perceptions towards their awarenessof pedagogical strategies; they still vary in how they think and apply them. Although others are insignificant, teachers' feelings towards their teaching and their awareness of the strategies seem to be slightly significant considering P is 0.05.

To answer the second research question: What demographic differences do science teachers have regarding their metacognition in science schoolteachers in Dubai private secondary schools? Data from the first section of the questionnaire is interpreted. These data points include information on gender, nationality, level of education and years of experience.

4.2.2 Analysis of Research Question 2

RQ2: What demographic differences do science teachers have regarding their metacognition in science schoolteachers in Dubai private secondary schools? The first part of the questionnaire covers questions related to demographic factors and could answer the second research question. The descriptive statistical analysis is presented in Table 4.20 below.

Table 20

Demographic Description from the Survey

Demographic Variables		Frequency	Percentage	Mean	SD
Gender	Males	24	29.0	3.75	0.62
	Females	60	71.0	3.80	0.59
Age	20-25	4	4.7		
	26- 30	13	15.5		
	31-35	29	34.5		
	36-40	23	27.4		

	41 and above	15	17.8		
Nationality	Arabs	17	20.2	3.9	0.7
	British & Irish	28	33.4	3.9	0.6
	Indian	21	25.0	4.0	0.6
	Others	18	21.4	4.0	0.7
Years of Experience	1-2	1	1.2		
	3-4	12	14.3		
	5-6	15	17.8		
	7-8	35	41.7		
	9 and above	21	25.0		
Qualifications	Bachelor degree	83	98.8		
	Masters	41	48.8		
	PhD / Doctorate	6	7.1		
	Teaching Diploma	29	34.5		
	PGCSE	30	35.7		

These demographics provide a snapshot of the sample of teachers who responded to the questionnaire and represent the secondary science teachers in private schools in Dubai. They reveal distributions across gender, age groups, nationalities, years of teaching and qualifications. Majority of the sample comprises females, with a significant representation of teachers aged between 31-35 years. The distribution across nationalities is fairly diverse, with British/Irish and Indian individuals being the most prominent. In terms of teaching experience, a notable percentage falls within the 7-8 years of experience range, and the qualifications primarily consist of Bachelor's degrees, with a substantial number holding Masters degrees and teaching diplomas as well.

4.2.2.1 Perceptions of Metacognition According to Gender. The descriptive statistical analysis of the results of the survey for comparing metacognition for male (N=24, M= 3.75, SD=0.62) and female genders (N=60, M=3.80, SD=0.62) are shown in table 4.21 below which are captions from computed Jamovi statistical tool kit. The survey yielded results

from 60 females and 24 males. The perceptions of participating teachers to awareness and use of metacognition seem to be of similar strength for males (M= 3.75) and females (M=3.80). However, statistics show that participating female teachers are three time more in number than the male teachers.

Table 21

Descriptive Analysis of Perceptions to Metacognition According to Gender

Perceptions of participating Male teachers				
				If item dropped
	Mean	SD	Item-rest correlation	Cronbach's α
Male-Declarative	4.26	0.895	0.917	0.960
Male-Procedural	4.02	0.923	0.921	0.960
Male-Conditional	4.13	0.988	0.919	0.960
Male-Knowledge	4.12	0.897	0.957	0.959
male-planning	3.93	0.806	0.877	0.962
Male-Monitoring	3.60	0.864	0.768	0.964
Male-Skills	3.73	0.800	0.874	0.962
Male-Evaluating	3.67	0.903	0.791	0.964
Male-Feelings	3.53	1.048	0.502	0.973
Male-Awareness	3.87	0.827	0.791	0.964
Male-Thughts	3.68	1.014	0.807	0.964
Male-Experience	3.69	0.812	0.850	0.962

Perceptions of participating Female teachers				
				If item dropped
	Mean	SD	Item-rest correlation	Cronbach's α
Female-Declarative	4.44	0.525	0.660	0.945
Female-Procedural	4.09	0.685	0.844	0.939
Female-Conditional	4.13	0.700	0.841	0.939
Female-Knowledge	4.21	0.572	0.895	0.939
Female-Planning	3.96	0.785	0.823	0.939
Female-Monitoring	3.81	0.794	0.809	0.940
Female-Evaluating	3.83	0.942	0.672	0.946
Female-Skills	3.86	0.735	0.904	0.937
Female-Feelings	3.74	0.752	0.475	0.951
Female-Awareness	3.98	0.565	0.664	0.945
Female-Thoughts	3.56	0.963	0.771	0.942
Female-Experience	3.75	0.608	0.849	0.939

The Independent Samples T-test for gender perceptions to awareness and use of metacognition show that is no statistical significance between male teachers (M=3.75, SD=0.62) and female teachers (M=3.8, SD=0.62) on their' awareness and use of metacognition knowledge, skills and experience in all the domains. In all aspects of metacognition examined, the differences observed between males and females show statistical insignificance as indicated by the p-values at significance level of 0.5; t=0.331, p=0.744. This suggests no significant gender bias in metacognition within samples studied.

To see if there is significant difference among domains within the variables between males and females, 2 sample Independent Unpaired T-test for the variables. Among 60 females and 24 males with degree of freedom 82, the compared results are shown below.

Ho= There is no effect to gender on teachers' perceptions on all variables and domains in metacognition

HA= Teachers' perceptions on all variables and domains in metacognition vary according to gender of the teacher.

Table 22

Unpaired T-test for Comparing Variable Domains in Males and Females

		N=60 Female	N=24 Males	T-test p	Statistical Significance
Metacognition as knowledge	**1- Declarative knowledge**	4.4 ± 0.5	4.3 ± 0.9	0.24	insignificant
	2- Procedural knowledge	4.1 ± 0.6	4.0 ± 0.9	0.68	insignificant
	3- Conditional knowledge	4.1 ± 0.7	4.1 ± 0.9	0.98	insignificant
Metacognition as Skills	**1- Planning Skills**	3.9 ± 0.8	3.9 ± 0.8	0.85	insignificant
	2- Monitoring Skills	3.8 ± 0.8	3.6 ± 0.8	0.29	insignificant
	3- Evaluation Skills	3.8 ± 0.7	3.7 ± 0.9	0.44	insignificant
Metacognition as Experience	**1- Feelings**	3.7 ± 0.7	3.5 ± 1.0	0.29	insignificant
	2- Awareness	4.0 ± 0.5	3.9 ± 0.8	0.48	insignificant
	3- Thoughts	3.6 ± 0.9	3.7 ± 0.8	0.61	insignificant

Results show that perceptiona of teachers are high to metacognition knowledge, skills and experience irrespective of gender. We fail to reject the null hypothesis for all items.

4.2.2.2 Perceptions of Metacognition According to Nationality. Furthermore, the data from different nationalities are analyzed to describe the perceptions of teachers in each nationality and then to compare the nationalities amongst each other. Teachers from Arab countries (N=17; M=3.9; SD=0.7) and from England and Ireland (N=28; M=3.9; SD=0.6) had similar perceptions to awareness and use of metacognition. Teachers from India (N=25; M=4.0; SD=0.6) and other countries had slightly higher perceptions: 4.0.

Analysis of Nationalities' perceptions for Metacognition as Knowledge and its Domains

The following descriptive analysis of perception of teachers to Metacognition as knowledge and its domains according to nationality are taken as screenshots from Jamovi (Tables 4.20-4.21 and 4.23).

Table 23

Descriptive Analysis of Knowledge Domains for British And Irish Teachers

	English-Declarative	English- Procedural	English- Conditional	English- Overall Knowledge
N	28	28	28	28
Mean	4.33	4.04	4.13	4.15
Median	4.30	4.15	4.30	4.30
Standard deviation	0.479	0.661	0.700	0.555
Minimum	3.50	2.50	2.50	2.90
Maximum	5.00	5.00	5.00	4.90

Table 24

Descriptive Analysis of Knowledge Domains for Indian Teachers

	India- Declarative Knowledge	India- Procedural Knowledge	India- Conditional Knowledge (2)	India- Overall Knowledge
N	21	21	21	21
Mean	4.50	4.22	4.17	4.28
Median	4.50	4.30	4.30	4.20
Standard deviation	0.500	0.582	0.737	0.511
Minimum	3.30	3.00	2.50	3.20
Maximum	5.00	5.00	5.00	5.00

Table 25

Descriptive Analysis of Knowledge Domains for Arab Teachers

	Arab-Declarative	Arab- Procedural	Arab- Conditional	Arab- Overall Knowledge
N	17	17	17	17
Mean	4.45	4.08	4.13	4.21
Median	4.80	4.30	4.30	4.30
Standard deviation	0.624	0.698	0.824	0.690
Minimum	3.30	2.50	2.50	2.90
Maximum	5.00	5.00	5.00	5.00

Perceptions of Metacognition as Knowledge According to Nationality was compared across all nationalilities and their knowledge domains through ANOVA.

H_o= There is no difference among teachers of different nationalities and their perceptions to metacognitive declarative knowledge.

H_A= The perception of teachers to metacognitive declarative knowledge differs according to their nationality.

Table 26

ANOVA Test for Declarative Knowledge among Teachers of Different Nationalities

One-Way ANOVA						
Groups	*Count*	*Sum*	*Average*	*Variance*		
India-Declarative	21	94.5	4.5	0.25		
British/Irish-Declarative	28	121.3	4.332143	0.229669		
Arab-Declarative	17	75.7	4.452941	0.388897		
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.368242	2	0.184121	0.665749	0.517466	3.142809
Within Groups	17.42342	63	0.276562			
Total	17.79167	65				

The results fail to reject the null hypothesis with F calculated (0.66) < Fcritical (3.14) and P> 0.05. Therefore, nationality does not play a role in determining the declarative knowledge in science secondary teachers.

H_o= There is no difference among teachers of different nationalities and their perceptions to metacognitive Procedural knowledge.

H_A= The perception of teachers to metacognitive declarative knowledge differs according to their nationality.

Table 27

ANOVA Test for Procedural Knowledge Among Teachers of Different Nationalities

One-Way ANOVA						
Groups	*Count*	*Sum*	*Average*	*Variance*		
India-Procedural	21	88.6	4.219048	0.338619		
British/Irish-Procedural	28	113.1	4.039286	0.436548		
Arab-Procedural	17	69.3	4.076471	0.486912		
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.407821	2	0.20391	0.487532	0.616438	3.142809
Within Groups	26.34975	63	0.41825			
Total	26.75758	65				

The results here also fail to reject the null hypothesis with F calculated (0.48) < Fcritical (3.14) and P> 0.05. Therefore, nationality does not play a role in determining the declarative knowledge in science secondary teachers.

H_o= There is no difference among teachers of different nationalities and their perceptions to metacognitive Conditional knowledge.

H_A= The perception of teachers to metacognitive conditional knowledge differs according to their nationality.

Table 4.26

ANOVA Test for Conditional Knowledge among Teachers of Different Nationalities

One-Way ANOVA Summary						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Indian Conditional	21	87.5	4.166667	0.543333		
British/Irish Conditional	28	115.6	4.128571	0.489524		
Arab Conditional	17	70.2	4.129412	0.679706		
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.020442	2	0.010221	0.018419	0.981755	3.142809
Within Groups	34.9591	63	0.554906			
Total	34.97955	65				

The results here also fail to reject the null hypothesis with F calculated (0.48) < Fcritical (3.14) and P> 0.05. Therefore, nationality does not play a role in determining the conditional knowledge in science secondary teachers.

Analysis of Nationalities' perceptions for Metacognition as Skills and its Domains The tables below show the descriptive statistical analysis of the domains within the skills variable for the three main nationalities identified in the survey: Indians, Arabs and British-Irish teachers.

Table 28

Descriptive Analysis of Metacognition as Skills And Its Domains for Indian Teachers

	India-Planning	India-Monitoring	India-evaluating	India-Skills
N	21	21	21	21
Mean	3.98	3.90	3.64	3.87
Median	4.00	4.00	4.00	3.80
Standard deviation	0.677	0.667	0.910	0.634
Minimum	2.00	2.00	2.00	2.40
Maximum	5.00	5.00	5.00	5.00

Table 29

Descriptive Analysis of Metacognition as Skills and its Domains for British-Irish Teachers

	British-Irish-Planning	British-Irish-Monitoring	British-Irish-Evaluating	British-Irish-Overall Skills
N	28	28	28	28
Mean	4.22	3.77	3.84	3.86
Median	4.30	3.80	4.00	3.85
Standard deviation	0.554	0.741	0.903	0.644
Minimum	3.00	2.50	2.00	2.60
Maximum	5.00	5.00	5.00	5.00

Table 30

Descriptive Analysis of Metacognition as Skills and its Domains for Arab Teachers

	Arabs-Planning	Arabs-Monitoring	Arabs-Evaluating	Arabs-Overall skills
N	17	17	17	17
Mean	3.58	3.69	3.88	3.79
Median	4.00	4.00	4.00	4.10
Standard deviation	1.10	0.875	0.857	0.781
Minimum	0.500	2.30	2.00	2.40
Maximum	5.00	5.00	5.00	5.00

The data for perceptions to domains within variable of metacognition as skills differ among the different nationalities of the secondary science teachers. Therefore, ANOVA is conducted to test whether these data are different are due to the demographic characteristic of nationality or due to chance.

H_o= There is no difference among teachers of different nationalities and their perceptions to metacognitive planning skills, monitoring skills or evaluating skills.

H_A= The perceptions of teachers to metacognitive skills differ according to their nationality.

Table 31

ANOVA Test for Planning among Teachers of Different Nationalities

Anova: Single Factor				
Groups	*Count*	*Sum*	*Average*	*Variance*
India-Planning	22	87.2142	3.964286	0.436224
English-Planning	28	117.75	4.205357	0.305804
Arab-Planning	18	64.0588	3.558824	1.12154

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	4.58200326	2	2.291002	4.081701	0.021386	3.138142
Within Groups	36.48358718	65	0.561286			
Total	41.06559044	67				

The results for perceptions of planning as metacognitive skills and nationality of teachers reject the null hypothesis and accepts the alternate hypothesis with F calculated (4.08) > Fcritical (3.13) and P< 0.05. Therefore, nationality does play a role in determining the planning skills in science secondary teachers. Therefore, post hoc can be done to check the statistical significance between each pair of nationalities..

Table 32

Post hoc Test for Planning among Teachers of Different Nationalities

Tukey HSD results Treatment Pairs	**Tukey HSD Q statistic**	**Tukey HSD p-value**	**Tukey HSD inference**
India vs British	1.5172	0.533	insignificant
India vs Arab	2.2921	0.2447	insignificant
British vs Arab	38566	0.022	P<0.05

Only planning skills between Arab teachers and British teacher show significant differences in their perceptions to planning as metacognition (p<0.05). Reasons for this will be discussed later in chapter 5.

Table 33

ANOVA Test for Monitoring among Teachers of Different Nationalities

Anova: Single Factor						
Groups	*Count*	*Sum*	*Average*	*Variance*		
India-Monitoring	21	81.8	3.8952	0.445476		
British Irish-Monitoring	28	105.6	3.7714	0.548783		
Arab-Monitoring	17	62.7	3.688235	0.766103		
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.4182620	2	0.209131	0.366139	0.694872	3.142809
Within Groups	35.984313	63	0.57118			
Total	36.402575	65				

The results here also fail to reject the null hypothesis with F calculated (0.36) < Fcritical (3.14) and P> 0.05. Therefore, nationality does not play a role in determining the monitoring skills in science secondary teachers.

Table 34

ANOVA Test for Evaluating among Teachers of Different Nationalities

Anova: Single Factor						
Groups	*Count*	*Sum*	*Average*	*Variance*		
India-evaluating	21	76.5	3.642857	0.828571429		
English-Evaluation	28	107.5	3.839286	0.815806878		
Arab-Evaluating	17	66	3.882353	0.735294118		
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.6673828	2	0.333691	0.41742139	0.6605517	3.1428085
Within Groups	50.362920	63	0.799411			
Total	51.030303	65				

Since F calculated (0.41) < Fcritical (3.14) and P> 0.05 then, the null hypothesis is accepted. Nationality does not play a role in determining the evaluating skills in science secondary teachers.

From all above analysis, it seems that planning skills plays a major role in difference in participating teachers' perceptions due to nationalities unlike the other metacognition skills of monitoring and evaluating.

Analysis of Nationalities' perceptions for Metacognition as Experience and its Domains

Table 35

Descriptive Analysis of Metacognition as Experience and its Domains for Indian Teachers

	India- Feelings	India- Awarenes	India- Thoughts	India- Overall Experience
N	21	21	21	21
Mean	3.75	4.08	3.68	3.81
Median	3.80	4.00	4.00	3.90
Standard deviation	0.499	0.537	0.921	0.526
Minimum	2.80	2.80	1.80	2.70
Maximum	4.80	5.00	5.00	4.80

Table 36

Descriptive Analysis of Domains of Metacognition As Experience for British-Irish Teachers

	British-Irish Feelings	British-Irish Awareness	British-Irish Thoughts	British-Irish Overall experience
N	28	28	28	28
Mean	3.42	3.81	3.42	3.54
Median	3.40	3.80	3.40	3.40
Standard deviation	0.863	0.574	0.797	0.457
Minimum	2.00	3.00	2.00	2.50
Maximum	5.00	5.00	5.00	4.60

Table 37

Descriptive Analysis of Metacognition as Experience and its Domains for Arab Teachers

	Arab- Feelings	Arab Awareness	Arab- Thoughts	Arab- Overall Experience
N	17	17	17	17
Mean	4.07	4.02	3.65	3.91
Median	4.30	4.00	4.00	4.00
Standard deviation	0.741	0.417	1.03	0.622
Minimum	3.00	3.00	2.00	2.70
Maximum	5.00	4.50	5.00	4.70

Further Statistical Analysis of Nationalities' perceptions for Metacognition as Experience and its Domains

H_o= There is no difference among teachers of different nationalities and their perceptions to metacognitive feelings experience, awareness experience or thoughts experience.

H_A= The perceptions of teachers to metacognitive experience differ according to their nationality.

Table 38

ANOVA Test for Feelings among Teachers of Different Nationalities

Anova: Single Factor						
Groups	*Count*	*Sum*	*Average*	*Variance*		
India-Feelings	21	78.7	3.747619	0.248619		
English-Feelings	28	95.9	3.425	0.744907		
Arab-Feelings	17	69.2	4.070588	0.548456		
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	4.4974	2	2.2487	4.183916	0.019674	3.14280
Within Groups	33.860	63	0.537463			
Total	38.357	65				

Since p< 0.05, then perceptions of feelings as metacognitive experience and nationality of teachers reject the null hypothesis and accepts the alternate hypothesis with F calculated (4.18) > Fcritical (3.14) and P< 0.05. Therefore, nationality does play a role in determining the feelings in science secondary teachers. Following, post hoc can be done.

Table 39

Post hoc Test for Feelings Among Teachers of Different Nationalities

Tukey HSD results Treatment Pairs	**Tukey HSD Q statistic**	**Tukey HSD p-value**	**Tukey HSD inference**
India vs British	2.1599	0.2869	insignificant
India vs Arab	1.9096	0.37429	insignificant
British vs Arab	4.0504	0.0154	P<0.05

Factors such as feelings within Metacognition as experience aer not significant for Indians and British-Irish or Indians; however, it is statistically significant with p<0.05 when comparing British with Arab teachers.

Table 40

ANOVA Test for Awareness Among Teachers of Different Nationalities

Groups	Count	Sum	Average	Variance		
India-Awareness	21	85.6	4.07619	0.287905		
English-Awareness	28	106.7	3.810714	0.329881		
Arab-Awareness	17	68.3	4.017647	0.174044		
Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.955262	2	0.4776	1.724439	0.186581	3.1428
Within Groups	17.44959	63	0.2769			
Total	18.40485	65				

Since F 1.72< F(3.14) and p>0.05, then the null hypothesis is accepted and any changes in teachers' perceptions to awareness of pedagogical strategies is not due to nationality but rather due to chance. This is due to statistical insignificance among the different nationalities.

Table 41

ANOVA Test for Thoughts Among Teachers of Different Nationalities

Groups	*Count*	*Sum*	*Average*	*Variance*		
India-Thoughts	21	77.3	3.680952	0.847619		
English-Thoughts	28	95.8	3.421429	0.63582		
Arab-Thoughts	17	62	3.647059	1.067647		
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.973426	2	0.4867	0.5988	0.552533	3.1428
Within Groups	51.20188	63	0.8127			
Total	52.1753	65				

In both Awareness and Thoughts the perceptions of teachers are not related to nationality differences and the results fail to reject the null hypothesis.

4.2.2.3 Perceptions of Metacognition According to Educational Level. All teachers in Dubai should have a bachelor's degree to be able to teach. Therefore, the degrees of teachers were given numbers as follows:

Table 42

Educational Level

Degree	Scale	Justification	Number of participants
Bachelor Degree	1	Not exposed to educational pedagogies	9
Teaching License	2	Had to sit for pedagogy exam as per ministry of education in UAE	4
PGCSE or Teaching Diploma	3	Are exposed to educational studies	27
Masters	4	Higher level of education	33
PhD or Doctorate	5	Highest level in education	11

To see if data is validated for this division, cronbach α is calculated. The higher the value of cronbach, the more the data are reliable. The Cronbach alpha value is 0.938 indicating dtrong reliability of data related to educational levels in teachers. The reliability test was done to validate the scale system followed for educational level.

Table 43

Analysis for Perceptions of Teachers of Educational Level

Metacognition as Knowledge	Metacognition as Skills	Metacognition as Experience

Proportions - Education Level

Level	Count	Proportion
1	34	0.0947
2	14	0.0400
3	113	0.3196
4	144	0.4059
5	50	0.1398

χ^2 Goodness of Fit

χ^2	df	p
172	4	< .001

Proportions - Education Level

Level	Count	Proportion
1	28	0.0853
2	12	0.0380
3	106	0.3262
4	132	0.4081
5	46	0.1424

χ^2 Goodness of Fit

χ^2	df	p
165	4	< .001

Proportions - Education Level

Level	Count	Proportion
1	31	0.0978
2	13	0.0415
3	102	0.3219
4	126	0.3989
5	44	0.1399

χ^2 Goodness of Fit

χ^2	df	p
148	4	< .001

Overall, this analysis attempts to group the metacognition domains into factors where the strongest factor seems to represent a variable of knowledge-related items within the survey, following are items related to planning, monitoring, evaluating which represent the metacognition as skills domain, finally are the items representing a mix of emotional and cognitive factors (feelings, awareness, thoughts) which belong to the metacognition as experience variable. Since data was verified for teachers' degrees scale and their awareness and use of Metacognition, the following descriptive data show how the higher the educational background of the teachers is, the higher the Metacognition as knowledge, skills or experience as seen in the figure below.

Table 44

Descriptive Analysis of Teachers' Perceptions According to Educational Level

	Education Level	N	Mean	SD	SE
Declarative Knowledge	1	9	4.16	0.525	0.1749
	2	4	3.83	0.538	0.2689
	3	27	4.40	0.477	0.0918
	4	33	4.54	0.537	0.0934
	5	11	4.64	0.338	0.1020
Procedural Knowledge	1	9	3.60	0.765	0.2550
	2	4	3.33	0.768	0.3838
	3	27	4.09	0.582	0.1120
	4	33	4.25	0.669	0.1164
	5	11	4.40	0.486	0.1465
Conditional Knowledge	1	9	3.46	0.704	0.2346
	2	4	3.50	0.707	0.3536
	3	27	4.13	0.653	0.1257
	4	33	4.36	0.680	0.1183
	5	11	4.53	0.488	0.1471
Overall Knowledge	1	9	3.73	0.581	0.1936
	2	4	3.55	0.656	0.3279
	3	27	4.20	0.488	0.0940
	4	33	4.36	0.582	0.1013
	5	11	4.51	0.378	0.1140

	Education Level	N	Mean	SD	SE
Planning	1	9	3.34	0.721	0.2404
	2	4	3.27	0.881	0.4404
	3	27	3.98	0.627	0.1206
	4	33	4.17	0.701	0.1221
	5	11	4.25	0.570	0.1718
Monitoring	1	9	2.88	0.504	0.1681
	2	4	2.70	0.572	0.2858
	3	27	3.91	0.746	0.1436
	4	33	3.91	0.678	0.1181
	5	11	4.19	0.365	0.1099
Evaluating	1	9	2.94	0.808	0.2693
	2	4	3.50	1.000	0.5000
	3	27	3.87	0.884	0.1700
	4	33	3.92	0.867	0.1509
	5	11	4.18	0.603	0.1818
Skills	1	9	3.07	0.555	0.1848
	2	4	3.08	0.665	0.3326
	3	27	3.91	0.616	0.1186
	4	33	4.00	0.662	0.1153
	5	11	4.19	0.435	0.1310

	Education Level	N	Mean	SD	SE
Feelings	1	9	3.48	0.890	0.2966
	2	4	3.15	0.947	0.4735
	3	27	3.75	0.755	0.1453
	4	33	3.80	0.863	0.1502
	5	11	3.71	0.686	0.2069
Awareness	1	9	3.80	0.661	0.2205
	2	4	3.63	0.946	0.4732
	3	27	3.96	0.505	0.0971
	4	33	4.04	0.587	0.1022
	5	11	4.17	0.307	0.0925
Thoughts	1	9	3.03	0.835	0.2784
	2	4	3.00	1.414	0.7071
	3	27	3.64	0.799	0.1538
	4	33	3.66	1.010	0.1758
	5	11	4.18	0.731	0.2203
Experience	1	9	3.43	0.612	0.2041
	2	4	3.27	1.097	0.5483
	3	27	3.77	0.490	0.0943
	4	33	3.82	0.630	0.1097
	5	11	4.02	0.490	0.1476

The table shows that participating teachers with higher educational qualifications (Masters, PhD or Doctorate) tend to rate more positively in perceptions to awareness and use of metacognition compared to those with lower qualifications (Bachelor's, Teaching License).

The overall ratings in the survey increase as the educational level progresses from Bachelor's to PhD or Doctorate.

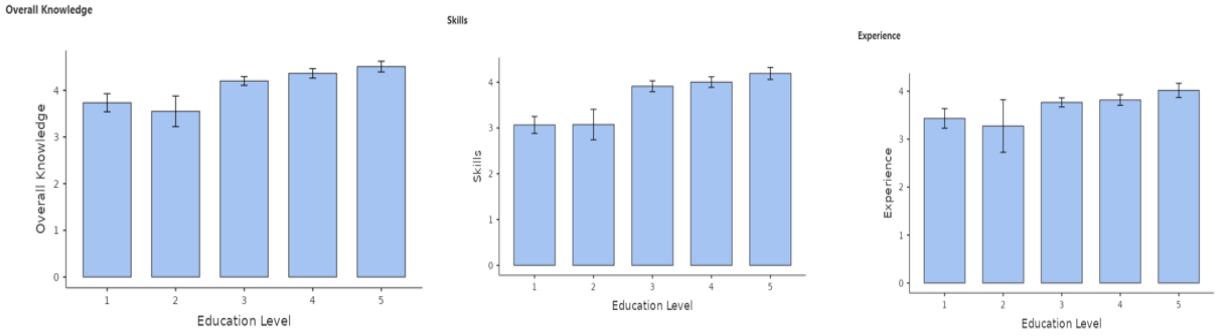
Table 45

Rating from Bachelor's to PhD or Doctorate

Degree	Scale	Number of participants	Mean	SD
Bachelor Degree	1	9	3.41	0.53
Teaching License	2	4	3.30	0.80
PGCSE or Teaching Diploma	3	27	3.96	0.52
Masters	4	33	4.06	0.62
PhD or Doctorate	5	11	4.24	0.43

Figure 11

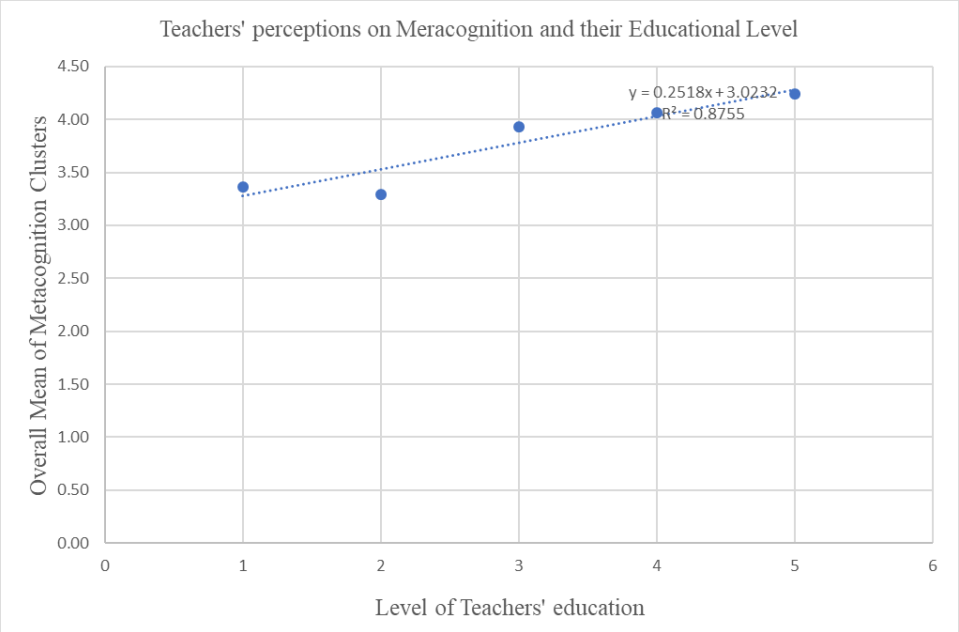
The Mean of each Metacognition Variable in Relation to Educational Level of Teachers



This figure represents increasing awareness and use of metacognition as knowledge, skills and experience with the increase in education level where error bars represent how data points are scattered around the means.

Figure 12

Teachers' Perceptions on Metacognition and their Educational Level



There is a a strong correlation between the level of education of teachers and their perceptions to the awareness and use of metacognition with R^2= 0.87. This indicates that the higher the educational level of the teachers, the higher is their perception to metacognition as knowledge and skills. Even feelings which represent teachers' motivations, and their awareness of the pedagogical strategies are more profound in teachers with higher levels of education.

4.3 Analysis of the Qualitative Data Results

To answer the third research question: "How do science teachers develop metacognitive skills for planning, monitoring and evaluating (PME) of instructional strategies

based on in-service metacognitive professional development sessions in Dubai private secondary school?" Results were collected from observations in professional development sessions, document analysis of lesson plans and semi-structured interview. It is a challenging part to do qualitative analysis which would lead eventually to the concept of thematic analysis (Cohen et al., 2018; Lester, Cho & Lochmiller, 2020). In thematic analysis, langauge-based data are used to look for patterns. In their book, Clark and Braun (2016; 2019a; 2019b), they identified the steps followed for thematic analysis which were used in this part of the research (Braun, Clarke &Hayfield, 2022). Since the interviews and observations were limited to 5 teachers, the researcher felt that familiarization with the content will be easier and more authentic if it was through self-analysis and not referring to N-vivo but rather do checks for validity during the process using the software. The first step was familiarization with all documents in hand, followed by coding through identifying statements, highlighting key terms, and identifying patterns. Once the step was over, the researcher used software for coding reliability and avoiding the bias factor. The relevant codes would help generate a broader theme which reflects a deeper understanding of the researcher in a reflexive approach. The themes generated from document analysis are reviewed and checked for any missing information or unnecessary addition. This method of thematic analysis "includes the possibility of using both inductive and deductive (or conventional and directed) coding approaches, or a combination of the two" (Braun, Clarke &Hayfield, 2022, p. 40). Once themes are defined and named, the writing up can start.

In the first section, data was collected during professional development sessions.

4.3.1 Data Analysis from Professional Development Sessions

Three PD sessions were planned and conducted in one of the schools in Dubai.

PD session	Title	Participant
First PD Session	Introduction to "Teaching With and Teaching For" Metacognition	55
Second PD Session	Using Data to Plan lesson Instruction- Prompts to metacognition planning skills for teachers	16
Third PD Session	Designing a lesson plan using planning metacognition skills	16

The first PD session included all science teachers (n=55) from 5 different schools. 55 teachers were involved in the training. These PD sessions help change teachers' beliefs, perceptions and practices in their instructions in a way that will improve their students' learning (Haug& Mork, 2021).

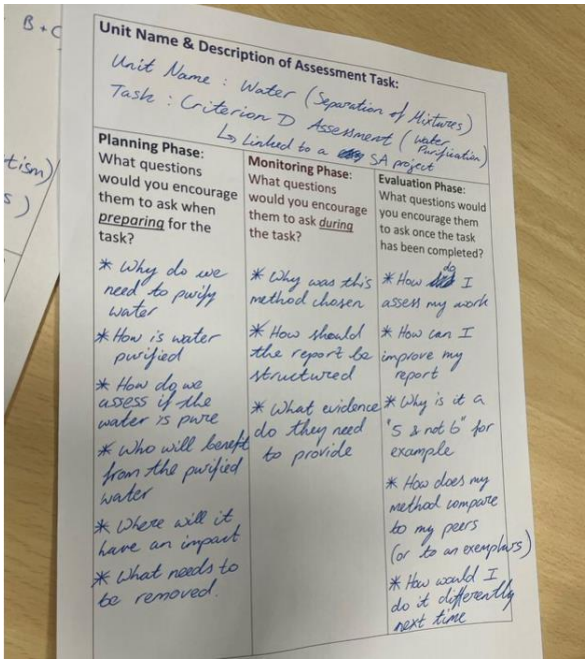
The first training PD session introduced the meaning of metacognition. Teachers were introduced to how to teach "With Metacognition" and teach "For Metacognition". This allowed teacher to consider what they know and how they use PME while designing their lesson plans. At the same time, they would start considering how to raise students' awareness and use of their own metacognition (O'Hara, Pritchard & Pitta, 2019). A poster was developed by the end of the training to include PME prompts for students and for teachers. This poster was then shared with all schools to be a part of the school policy and to be presented in each staffroom. The A3 poster included questions for "teaching with and for metacognition"; these questions were addressed in one part to teachers as they plan, monitor and evaluate their instructions and another part included questions for students to plan, monitor and evaluate

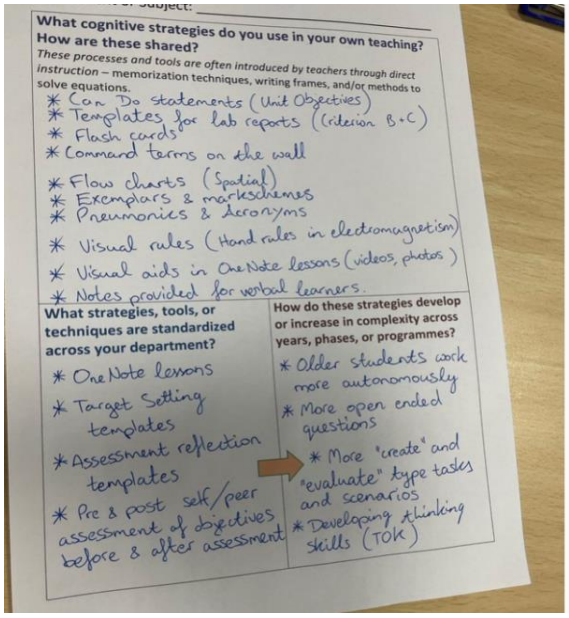
their tasks during the lesson (refer to Poster in Appendix G). During the session all teachers were involved in brainstorming the importance of metacognition in their planning and lessons.

In the second PD session, 16 teachers were involved in creating and evaluating lesson plans that fit their students and include metacognitive prompts. This session focused on how to plan lessons while monitoring the skills of planning: choice of tasks, strategies to be used and how to be implemented. In this session, the teachers were trained to use metacognitive prompts involving regulation of planning instructional strategies and activities that suit their own students. For this session, teachers were taught how to involve triangulation of their students' data from standardized testing (cognitive ability test –CAT4), International School Assessment (ISA- academic ability standardized test) and their own observations in order to identify the tasks that suite their students' profiles (a sample of the PowerPoint shared with teachers is in Appendix H). This enables them choose tasks that fit the profile of their students and the instructional strategy that best meets their learning style.

Figure 13

A Sample of Teachers' Planning Session: Using Metacognition to Plan





In the last PD session, the teachers were placed in four groups according to science subject taught to design lesson plans using their metacognitive knowledge and skills gained from the previous two sessions. The teachers were given one class-students' data to help them think about the adequate instructional strategies that suit the profile of this class and choose the suitable tasks for the lesson.

Table 46

Science Teachers Group

Group 1	Biology teachers	4 teachers	"How is life organized?""
Group 2	Chemistry teachers	4 teachers	"'How do we use matter"
Group 3	Physics teachers	4 teachers	"Electromagnetism"
Group 4	General Science teachers	4 teachers	"Atoms, Elements and Compounds"

During the planning first PD session, the Biology teachers planned a lesson “How is life organized?”. During the planning session, One teacher in the group said “never knew that CAT4 can give me all these details”. Another teacher mentioned that she has never thought of reasons for a task she finds “nice” and shares with students. She added “now I have to think why, when and how to implement each task.” A third teacher indicated that she has always chosen tasks that are re-enforced by resources such as videos and reading articles to suite all learners styles but has never thought of the process of encouraging students to reflect on the choice of the task resource. Within the chemistry teachers, two teachers felt confident that they know how to use data well to design instruction. Another teacher said: “I never knew how ISA data can be used.”.

While planning a lesson on electromagnetism, one teacher stated during the session: “I never knew how to vary strategies according to data. I use metacognitive prompts but mainly for evaluation. Now, I have to start thinking differently”. Another teacher added: “I should question myself during planning phase, the same way I question the students.”

Figure 14

A Sample of Task Chosen by the Biology teachers and Feedback by the Researcher

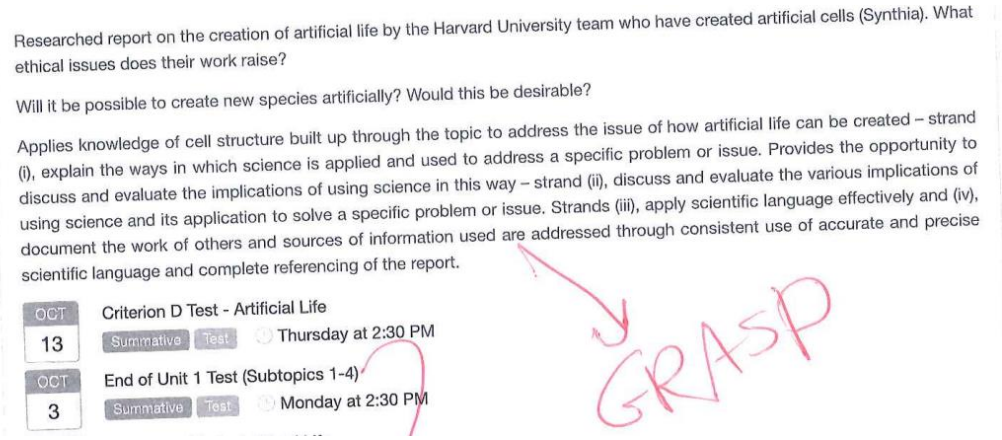
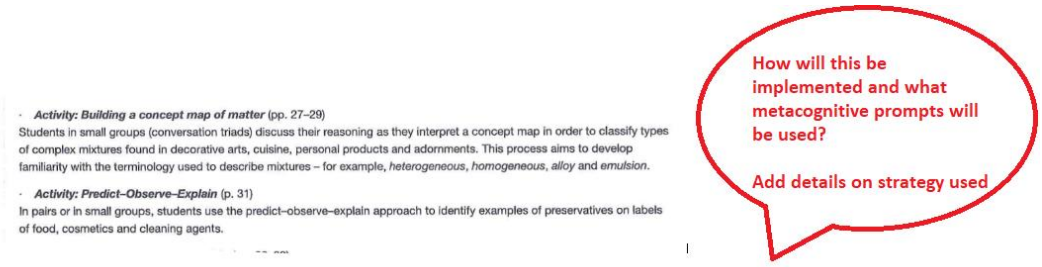


Figure 15

A Sample of Task Chosen by the Chemistry Teachers and Feedback During the PD Session



These PD sessions allowed for collaboration and exchange of instructional strategies and ideas which are considered key features of efficient PD sessions. Through planning teachers used metacognitive prompts to choose their tasks and decide on suitable instructional strategies that can guide their students while solving the tasks. Using the cognitive ability with situational collaborative discussion in the setting of these PD sessions re-enforce the reference to the Neo-Piaget theory for cognitive ability in relation to emerging contextual situations. During these sessions, teachers were trained on planning instructional strategies in the PME cycle of metacognition skills.

4.3.2 Document Analysis from Lesson Observations, Field Notes and Lesson Plans

Metacognition skills are planning, monitoring and evaluating. Monitoring can only be observed while teachers are delivering their lesson plans within their classrooms. The context and situational settings during the delivery of the lesson can be indicative tool of monitoring skills in teachers. For the monitoring of instructional strategies of the science teachers, lesson observations and document analysis of lesson plans were used. Five teachers agreed to be

observed after the PD sessions. The Researcher took field notes on how teachers are monitoring the implementation of their planned instructional strategies through using some keynote checks. Observing the teachers in real life situation- within their classrooms- adds "contextual situatedness" as evidence in qualitative research (Mirhosseini & Mirhosseini, 2020, p.61).

Below are presentation of field notes and evidence from the lesson plan submitted by teacher for the lesson under observation. During the observation as a complete observer stance, notes were taken according to the following observation inventory:

Observation Inventory

- Choice of Instructional Strategies
- Choice of pedagogical resources
- Use of metacognitive prompts
- Response to emerging contextual effects
- Response to different needs of students
- Evidence of metacognition knowledge in teacher
- Evidence of metacognition awareness in teacher
- Evidence of Use of metacognition skill by teacher

The five teachers observed participated in the PD sessions and volunteered to be involved in these observations. They will be referred to as Teacher A, B, C, D and E for anonymity and privacy of participants. The teachers had also prepared lesson plans for the

lessons observed. All documents provided by the teachers were saved securely and used solely for analysis in this research. The researcher used the lesson plans and observed the delivery of the teacher of the lesson plan in order to explore the awareness and use of metacognition of teachers in how they teach with and for metacognition. More of these lesson plan samples are in Appendix I.

Table 47

A Brief of the Participating Teachers

Participant	Lesson Observed	Year level	General Notes
Teacher A	Chemistry	Year 12	Teacher from Serbia Has a PHD 6 years of teaching experience; 2 within Dubai
Teacher B	Biology	Year 10	Teacher from India Has teaching diploma 6 years of teaching in Dubai
Teacher C	General Science	Year 9	Teacher from India Has a BSc in Biology 5 years of teaching of which 4 years in Dubai
Teacher D	Biology	Year 12	Teacher from Ireland Has a Master's Degree 8 years of experience in Dubai
Teacher E	Physics	Year 10	Teacher from India Has engineering degree + teaching diploma 6 years of teaching experience

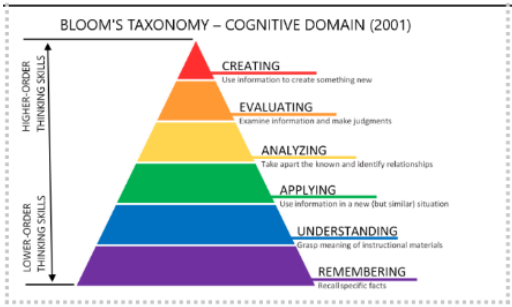
4.3.2 .1 Choice of Instructional Strategies. The choice of instructional strategy reflects the teacher's awareness of the profile of the students. Teachers need to use metacognition planning skills in cognition regulation and metacognition procedural knowledge as discussed earlier in order to be able to choose and apply adequate instructional

strategies. The main themes emerging from observing the choice of strategies for these teachers was the “identifying the different learning strategies” and making them explicitly used in classrooms. Teachers reflect awareness of metacognition when they choose strategies that promote self-awareness, self-regulation, reflection and adaptive learning. These promote critical thinking in students (Nobutoshi, 2023).

Only three teachers used different instructional strategies during the delivery of their lessons. Those are teachers A, D and E. The main strategies referred to during instructions were Bloom’s taxonomy, Marzano’s intelligences and E-cycle. Teacher A chose 4 different instructional strategies within his lesson through referring to Marzano’s intelligences. The lesson had different elements such as a video used as a short starter, a main task and a plenary including multiple checkpoints (progress checks of different types) during the lesson. Teacher D chose two different instructional strategies focused on Bloom’s taxonomy and learning style. The lesson had a starter- a questionnaire- followed by two small tasks and a plenary which is checking the answers to questionnaire filled during the starter. Teacher E chose the E- cycle as instructional strategy. The teacher had paused the lesson and adjusted the teaching strategy during the lesson when she felt that the students are struggling to gain the expected learning experience from the activity.

Figure 16

Sample of the Use of Bloom's Taxonomy taken from Teacher D's Lesson Plan



Learning Objective & Big Idea (Lesson Focus): To understand how to process quantitative data using statistical analysis for students IA.

Learning Outcomes (Blooms):

- **Construct** appropriate data tables
- **Calculate** the mean and standard deviations using Excel
- **Create** appropriate graphs with process data, error bars and an appropriate line of best fit
- **State** that error bars are a graphical representation of the variability of data and **comment** on their significance based on overlap, size and value
- **Analyze** the data and the trend and **deduce** which additional statistical tests must be done to further assess the data and express this in mathematical form
- **Describe** the trend observed in graphs
- **Comment** on the precision and accuracy of the data

On the other hand, both teachers B and C chose only one instructional strategy. Despite using one instructional strategy, teacher B referred to Bloom's taxonomy depending on the academic achievement levels of the students. The lesson used charts and cues as a starter. It was followed by one main task. The teacher used questioning and peer assessment during the task as progress checks. Teacher C failed to justify the choice of the instructional strategy used in the lesson which relied solely on modelling and general questioning. This part can give evidence of planning metacognition skills and the delivery of this instruction can be evidence of how teachers monitor their instruction during the lesson.

4.3.2.2 Choice of Pedagogical Resources. The main observation here was that all teachers rely mainly on different webpages and internet resources to choose their pedagogical material. The emerging theme here was “availability of all types of resources” and “choice of resources”. All teachers agreed that websites and internet has loads of resources but very few justified the reasons and methods used to choose from these resources.

Three teachers A, D and E used literacy stations which include reading from articles and textbooks. All teachers referred to videos, animations or other visual resources during the lesson. Only one teacher- Teacher E – had lab equipment and construction material for hands on activity. She was the only teacher to include a clear rubric for the task. Students had to choose one task from two tasks presented to them. Her resource focused on the metacognition evaluation skills of students. On the other hand, teacher A had included rich resources for the students that meet all learners learning styles: webpages, an e-book, a textbook and articles. The resources had animations, figures, videos and reading texts. Both teachers A and D used many metacognitive prompts in their tasks to teach for metacognition. Moreover, teacher B relied on “Forms” to collect answers from students and check their progress during the lesson. This again is a way for teachers to monitor and evaluate the success of the learning experience in their classrooms. If teachers reflect on students ‘answers, then the teacher has good monitoring metacognition skills in teaching with metacognition (Loibl et al., 2020).

Although resources varied and were rich in almost all of the lessons, the clarity on why or how resources were chosen were clearly reflected in teachers And D and to a lower extent in teacher E. The choice of pedagogical resources by teachers reflects teacher’s awareness of

metacognition when they choose resources that encourage students to understand and control their cognition processes (Karlen et al., 2023).

Figure 17

Caption from Teacher a Lesson Plan

SEN/ALPHA/Emirati Provision/Accommodations:	**Resources:**
Emirati students (Hoor Kamkar)– Seated in front for better attention. *Provided one to one attention whenever required.* *SEN (Anton Bennour-Wave 2)- Help sheet will be provided for the tasks.* *Anton has been paired with Shaurya for support and they often discuss the tasks together.* *Positive reinforcement with tangible, quick rewards.* *One-to-One support wherever needed.* Help sheet available for lower ability students.	Visual: • https://www.youtube.com/watch?v=n0uABIIfj44 • https://youtu.be/_q2RHIrgaXE • https://study.com/academy/lesson/cellular-respiration-lesson-for-kids-definition-steps.html Textual: • https://www.bbc.co.uk/bitesize/guides/zm6rd2p/revision/2 • https://flexbooks.ck12.org/cbook/ck-12-biology-flexbook-2.0/section/2.30/primary/lesson/anaerobic-and-aerobic-respiration-bio/ Links for Practice: https://www.footprints-science.co.uk/index.php?quiz=Anaerobic_respiration

Note. This caption shows how resources were differentiated according to students learning style. Students were also grouped according to ability.

4.3.2.3 The Use of Metacognitive Prompts The use of metacognitive prompts includes strategies that enhance metacognition monitoring skills. Intervention can yield positive outcomes when considering teaching the different strategies (Gutierrez, 2022). Therefore, observing teachers and how they use metacognition prompts not only with their students but also while monitoring their lesson can be indicative tool of teacher's awareness and use of metacognition. The practice of using metacognitive prompts can be indicative of teachers being aware of their students' needs and ways and as an indirect way of reflecting on the learning experience occurring within classroom.

Teacher A provided students a chance of self-reflection and peer assessment via answering written metacognitive questions during and after the task; such as:

"What are some challenges you are facing in solving the equation? How will you try to solve them?

What strategy can you use to solve this?

Have you achieved the correct answer?

To what extent have you used the provided resources?"

The teacher also used evaluative questions and monitoring questions during the activity. He used oral communication with each student and provided feedback. Example:

"How can you solve this?

Think of a simpler way to find a practical solution. How can you improve your method?"

While teacher A used written and oral metacognitive prompts, Teacher B used only oral metacognitive questions to ask students while working in pairs and provided some written feedback on student's work.

"What clues can you use to find the answer?

Can you read this resource! It will help you find the proper answer.

Is this a significant answer? How does it relate to real life?"

Sample of the provided written feedback:

"The answer is too vague, can you use the clues in the graph to add necessary details to the process?

"What do you think is missing in this answer? Think about velocity!"

Teachers C and D focused on metacognition in students but no cues of applying metacognition on their own teaching strategies. Teacher D was satisfied with general questioning during a "teacher centered" talk to generalize her metacognitive prompts. Teacher C has used a self-reflection inventory with the students. Both teachers did not adjust teaching to students' arising needs during the learning experience in the classroom.

Figure 18

Caption from the Lesson Plan Provided by Teacher D

Students work their way through the processing tasks using raw data that they are provided with. Students will be guided towards data to use based on their level and the complexity of the data. Throughout activities students will be assessing their understanding of each learning objective after completing a task by ranking their understanding from 1-3 (1 very confident, 2 some confidence, 3 not confident).

Note. This caption shows evidence of raising metacognition in students

Teacher E use of her own metacognitive skills was strongly evident as the teacher did adjust in the task and in the questions according to students' needs during attempting the task. The teacher moved off the lesson plan when it was needed.

Figure 19

Caption from the Lesson Plan Provided by Teacher E

The lesson will have two main tasks.
Task 1 will be 10-minute-long. Students will be asked to define the term anaerobic respiration by recalling the discussions from last lessons. They will be provided with links to look up and write their response.
Task 2 will be a group task involving active collaboration. 5 different stations will be set up in class. Students will be asked to move around the room. They will get 10 minutes to complete a station and then will move on to the next station. Once they finish a station, they will discuss and write the ATL sills used during the task on a post-it notes and will stick it on the progress check sheet stuck in the room.

Note. This figure reflects the teacher's awareness of use of metacognitive prompts

Summary of notes from observing the different teachers using metacognitive prompts

Table 48

Metacognitive Prompts Feedback

	The Use of Metacognitive Prompts
Teacher A	Questions that the teacher has included in the task with metacognitive cues in a part called "Self-reflections": "What are some challenges you are facing in solving the equation? How will you tackle them? What strategy can you use to solve this? Have you achieved the correct answer?

	To what extent have you used the provided resources?"
	Oral questions that teacher has asked during monitoring of students:
	"How can you solve this?
	Think of a simpler way to find a practical solution. How can you improve your method?"
Teacher B	Oral cues used by teacher to question students (individually) while checking on their work:
	"What clues can you use to find the answer?
	Can you read this resource! It will help you find the proper answer.
	Is this a significant answer? How does it relate to real life?"
	Written Feedback while students were working on their task:
	"The answer is too vague, can you use the clues in the graph to add necessary details to the process?
	"What do you think is missing in this answer? Think about velocity!"
Teacher C	The teacher provided full class feedback and general metacognitive questions to monitor the modelling process and to evaluate their models.
	"Look at your model, can you compare it to the provided sample?"
	"Try to find the error in this model?'
	"How can you evaluate your model as compared to the model on my desk"
	"Write one strength in building your model and one weakness you could have avoided while building your model?"

Teacher D	The teacher focused on "Approaches to Learning Skills" as a way to raise metacognition in students. She had a checklist of skills related to planning, monitoring and evaluating the task in hand.
Teacher E	The teacher moved around and asked each student various questions related to the metacognition skills: planning, monitoring and evaluating. Students had to answer orally and write few notes of teacher feedback. "Which task will you choose? Why?" "What strategy/ies will you need to solve the task?" "How long do you need to solve the task?" "How are you using your thinking skills to find answers?" "Are you able to gather information from different resources and choose those that are adequate?" 'Use the rubric to evaluate your answer once you are done".

4.3.2.4 Response to Emerging Contextual Effects. The teacher's response to emerging contextual effects is a high indicative tool of teacher's own use of metacognition skills of monitoring the delivery of instruction. The teacher's ability to adjust the lesson plan and respond to students' needs during the lesson increases efficiency of the teaching and learning. In a study by Michelle and colleagues (2021), teachers face a challenge when thinking of how contextual factors could influence their pedagogical practices. They are in need for policy changes that allows for flexible curriculum, support programs and less administrative work. Practical solutions such as time management training, collaborative platforms and tech tools would help teachers respond to these needs (Michelle et al., 2021). All teachers observed seem to have followed the lesson plan. Teachers A and D were engaged in monitoring skills through looking into students' work and adjusting their questioning

according to arising situational work presented by students. Only teacher E provided strong evidence of response to contextual needs when she paused the lesson and had to re-adjust the whole setting of class and task expectations in response to the students' emerging needs in the classroom. She decided to pause the learning, change instruction and use cues and questions to re-enforce previously taught concepts to help students bridge an emerging gap from their understanding in order to be able to proceed with the tasks that were on hand.

Summary of notes from observing the response of teachers to emerging contextual effects

Table 49

Response to Emerging Contextual Effects

	Response to emerging contextual effects
Teacher A	The teacher grouped the students according to the results of the starter as a response to the readiness of each student.
Teachers B & C	No evidence of change of change in the planned lesson. The lesson plan was not interrupted or altered.
Teacher D	One group was struggling to work on the main task and achieve the target. The teacher gave more attention and further scaffolding material to this group.
Teacher E	The teacher had to pause and re-adjust instruction once few students felt confused on the main target of the task. The teacher went off task and added a small video and discussion that she found was needed in order to bridge a gap in the main concept of the lesson to students. This was not included within the lesson plan.

4.3.2.5 Response to Different Needs of Students. The teachers were trained on how to triangulate data in grouping their students and setting expectations of work delivered by each group of students. Student grouping was evident in almost all teachers and in their lesson

plans except for teacher C. Teacher C failed to provide evidence of reflecting on students' ability to vary instructions or prompts accordingly during the lesson.

Figure 20

Caption from Teacher E-Lesson Plan

Differentiation:

- This entire group is HL
- Students with low/average CAT4 Spatial (e.g. Netra, Sanya, Adham, Ayushman) may struggle with this unit as it relies on ability to recognize patterns and apply systems of rules. This will be alleviated by continuously checking in with them.
- Optional additional IB Questions to practice for students who want to
- Since the beginning of the year many students have writing on the desks with markers – they enjoy the visual aspect & find it easier to draw molecules which would be tedious to draw using a trackpad.
- Extension & support options are available on every task.

Note. The figure has evidence of how differentiation was implemented to meet all needs of students.

Another example can be found in Figure 4.8 on grouping students and differentiation by learning style.

Summary of notes from observing the response of teachers to different needs of students

Table 50

Response to Different Needs of Students

Response to different needs of students

Teachers A, B, D and E	All teachers had different resources that fit all student profiles according to CAT4: spatial learners had videos, charts, simulations or lab, verbal students had literacy stations and reading articles, low verbal students were given key terms vocabulary list. Additionally, teacher A, the teacher provided different scaffolding material according to the needs of each group while working on their chosen task.
Teacher C	No evidence of differentiation of task according to students' abilities except during the questioning part in the plenary of the lesson.

4.3.2.5 Evidence of Metacognition Knowledge in Teachers. Metacognition knowledge in teachers will be evident through observing what tasks the teachers has chosen, what instructional strategies the teacher has selected and what skills the teachers are referring to during the delivery of the lesson. These refer to the procedural, declarative and conditional knowledge of cognition (Schraw & Dennison 1994).

Some teachers had added many resources which do not reflect proper awareness of what resources to select and what resources would be unnecessary for the students. It looked like they chose any resource they found which is related to the lesson. For example teacher B included general commentary on choice of resources (Figure 4.12 below).

Figure 21

Caption from Teacher B- General Commentary

The station on Literacy, helps students enhance their reading comprehension skills.
The station on graph, makes students utilize their mathematical knowledge.
The practical activity station also provides students to do mathematical calculations using the data generated.

Others such as Teachers A and D justified the choice of the resources and/or strategies that students could follow while solving or selecting their tasks in classroom.

Figure 22

Caption from Teacher a as Evidence of her knowledge of why and how to Choose Tasks

> Studying periodic trends is a rather useful strategy for Data Analysis/Science enthusiasts. Students have hands-on opportunity to analyze data, produce graphs, and present their findings to the rest of the class.
> Cross curricular links: Mathematics, Data/Computer Science

Figure 23

Caption from Teacher D as Evidence of Her knowledge of why and how to Choose Tasks

> Target setting- Students will set targets after completing all tasks on an element of statistical analysis they feel could be revisited. They will use a new set of data for homework to practice the skill they are not fully confident in.

Summary of notes from observing the evidence of metacognition knowledge in teacher

Table 51

Evidence of Metacognition Knowledge in Teacher

	Evidence of metacognition knowledge in teacher
Teacher A	The choice of tasks and grouping of students reflect awareness of metacognition knowledge.
Teachers B and C	The choice of tasks appeared to be random and according to availability of resources rather than in-depth thought of why, how and when to place the task.

Teacher D and E	There is evidence of metacognition knowledge in teacher in the choice and reasons for each task presented in the lesson. The teachers focused on the strategies the students will be using while solving each task.

4.3.2.6 Evidence of Metacognition Awareness and use of Metacognition Skills in Teachers.

Not only students need to use metacognition, but teachers also tend to use metacognition in order to reflect on the delivery of their lessons and the success or failure of their instructional strategies used to deliver their pedagogical resources. When teachers use metacognition this could help them enhance their self-reflections on what worked well in their teaching methods, add flexibility and adaptability to teaching methods, and improve instructional strategies (Drigas &Mitsea, 2020; Duman & Semerci, 2019).

Table 52

Evidence of Metacognition Awareness and Skill in Teacher

	Evidence of metacognition awareness and use of metacognition skills in teacher
Teacher A	- The teacher used metacognitive prompts with the students through questioning and allowing for self- and peer reflections. - The choice of tasks reflected awareness in planning skills - The strategies used to lead the teaching process reflected evidence of metacognition skills of monitoring. While one group was struggling the teacher had to improvise and go beyond the written lesson plan to lead the students and help them find solution to the problem in hand.
Teachers B and C	No evidence of metacognitive skills of self-monitoring and evaluation. The teachers have followed the lesson plan in its exact details.
Teachers D and E	Strong evidence of metacognition skills while teaching. Teacher E stopped the lesson and reflected on their struggle in one aspect of the lesson and re-formatted the lesson plan

<table>
<tr>
<td></td>
<td>Starter: 5 minutes
Students will be asked to write a tweet recalling what they have learnt about respiration in the previous lessons.

Main Activities:
The lesson will have two main tasks.
Task 1 will be 10-minute-long. Students will be asked to define the term anaerobic respiration by recalling the discussions from last lessons. They will be provided with links to look up and write their response.
Task 2 will be a group task involving active collaboration. 5 different stations will be set up in class. Students will be asked to move around the room. They will get 10 minutes to complete a station and then will move on to the next station. Once they finish a station, they will discuss and write the ATL sills used during the task on a post-it notes and will stick it on the progress check sheet stuck in the room.</td>
<td>Progress check sheet will be put up on the board and the students will be asked to stick the post it notes in the completion status once they complete a station.
Progress check
<table>
<tr><th>Stations</th><th>Points</th><th>Completion status</th></tr>
<tr><td>1: Understanding</td><td>4</td><td></td></tr>
<tr><td>2: Graph</td><td>4+2</td><td></td></tr>
<tr><td>3: Literacy</td><td>4*2</td><td></td></tr>
<tr><td>4: Video</td><td>4</td><td></td></tr>
<tr><td>5: Activity</td><td>4</td><td></td></tr>
</table>
Teacher will be moving around asking questions and checking the progress.</td>
</tr>
</table>

4.3.3 Thematic Analysis from Interviews

Five teachers agreed to be interviewed after attending the professional development sessions and getting observed in one of their lessons. The semi- structured interviews had questions derived and adjusted from the questionnaire and literature review. Therefore, the questions were divided into 6 main domains: Planning, Monitoring, Evaluating, Motivation, Instructions, and Reflection.

4.3.3.1 Questions Related to Planning. The first three questions were related to planning. All teachers agreed that they set goals for learning in each lesson. For most of them, planning comes as an obligation set by school. One teacher admitted that planning and setting goals occur for the learning experience in each lesson but not for the teaching experience in each lesson. He was aware that teaching requires deeper thought of “metacognition for” teaching by the teacher.

Almost all teachers admitted that they rely on internet resources to prepare their lessons and plan accordingly. They all agreed on the importance of literacy in their science lessons; however, their readiness to unexpected emerging situations in their classrooms varied.

They responded differently to how they face and respond to these emerging contexts during instructional delivery. While few said they are ready for unexpected situations, others seem to plan and go for the plan whatever happens and then, they would reflect on these situations after the lesson.

Table 53

Samples of Teachers' Responses to Questions Related to Planning

Planning	Setting Goals, Resources, Contextual effects
Key terms	Obligation, internet, amend
Question 1	**Do you set specific teaching goal for each and every lesson?** "It's an obligation. Even if it is not an obligation, I feel it is professionally, yes important; for me, when I'm doing the lesson, or whatever activities are there, …, there needs to be a focus". "You can do it for each and every lesson: I mean specific learning goal but not teaching. Teaching a specific lesson-No, no. But you do for the learning! "So I have a learning objective for the whole lesson but not Each and every task. …. No, not all of them and then I have learning outcomes for each and every task specifically."
Question 2	**How do you choose your resources and class instructions?** ".... when it comes to choosing resources for every single lesson, I have prepared a set of websites and also textbooks and everything else that I combined. And for each concept that I teach in the class, I choose different parts from the textbook, one of the four textbooks that I use, I choose YouTube video" "So when it comes to resources, frankly speaking, for me, the most important resources to see they are two kinds: textbook and internet web pages"

Question 3	"I tried to pick my resources that are short player. So timing is very important. I really love to share videos. I will have to research for various resources, I have to choose: this will fit my student, this will not fit my students." "we share resources as teachers, unless it is a new concept". **Are you prepared for unexpected situations?** "Yes. Because of that, it happened to me. Twice, I think, one of the first time years that I was here in Dubai, and we had cage to inspection, which was a fantastic lesson plan, which was being used by all the classes, yeah, mines. My class just couldn't do it. So I stopped the lesson midway. And I said, Okay, this is not working, let's go back and revise the skills and the concepts". "It's more like trial and error. So if it's failed, then would plan a second lesson" "So sometimes you amend your planning according to situations." "Yes, most of the time" While planning "I need to leave certain space for flexibility in the lesson itself, so that I can modify my instruction accordingly."

.

4.3.3.2 Questions Related to Planning Questions Related to Monitoring. The second set of five questions were related to teachers monitoring their delivery of the lesson instruction within their classrooms. These questions refer to the feelings of teachers as they complete the lesson successfully or with some failure elements. All teachers expressed a sense of pride and happiness once a lesson is accomplished with success. One teacher considered

this as an important aspect in her teaching goals; another referred to mutual feeling of happiness that extends from teacher to students and vice versa once a lesson is properly delivered. Despite the opposite is true for teachers, no one indicated that she we gauge to the needs of the students during the lesson. However, two teachers reflected to using metacognitive prompts with students to evaluate the lesson's failure or success.

Teachers appear to rely on observing students during the tasks and checking their work through what they called "Progress Checks" in order to evaluate their students' learning and the success of the teaching strategy implemented during the lesson.

Table 54

Samples of Teachers' Responses to Questions Related to Monitoring

Monitoring	Feelings, success and fail, impact of techniques used, evaluating students
Key terms	Happy, frustration, improve, feelings, reflecting, metacognition, progress checks
Question 1	"**What is your feeling when you successfully complete the classroom teaching class?"** "I feel accomplished, I feel happy about it" Feeling that it is completed successfully is "important for me" "I feel very proud, of course... the students feel that they've been engaged, and then they know what to do...." "we're both on our mutual terms".
Question 2	

	“**What is your feeling when your teaching fails?** “It was frustrated, It was a frustration because obviously, that lesson plan was created, keeping in mind what the students already know...” “when I feel that the class is not doing as well, or like as anticipated, I asked the students like what's going wrong? Where do you need help?”
Question 3	**How and to what extent do you consider the students’ feelings and pace of the classroom?** “I won't reflect upon every single lesson definitely. But usually I would reflect on the lessons that didn't really go according to the plan.” “I would see how they coping with tasks” “because you need to see in that lesson, how much of the student progress or understand, okay,…" “Even after one lesson, it doesn't work, then I would go back. And I would write again, I would reflect I would write my approach to that particular lesson...”
Questions **4-5**	“…..So I stopped the lesson midway. And I said, Okay, this is not working, let's go back and revise the skills and the concepts”... **Do you think the instructional strategies you used during the lesson are useful for better understanding of the student? How do you evaluate your students’ strengths and weaknesses during the lesson?** “to make them feel discouraged,” “Yes, most of the time, because there would always be some questions being asked, right.” “I take notes or I keep them”

	"Most of the times, yes, I am pretty aware about how the lesson goes. ... And we do also implement a lot of progress checks during the lessons" "I'm walking around and I'm seeing that the students who aren't doing the task"

4.3.3.3 Questions Related to Evaluation. Three questions were asked to explore metacognitive evaluation skills in teachers. These questions focused on how often teachers practice reflections on their teaching and their awareness and regulation of their strengths and weaknesses in their teaching. Four teachers indicated that reflection is not a possible process after each lesson. It is an ongoing process but not necessarily happening after each lesson due to time constraints. One teacher referred to students' behavior as a major factor in indication of success or failure of the lesson.

Table 55

Samples of Teachers' Responses to Questions Related to Evaluating

Evaluating	Reflecting on the lesson after delivery of instruction, checking applicability of the technique used.
Key terms	Not regularly, briefly, reflect, time, Challenge, students' ability, behavior, skill
Question 1	**Do you reflect on if you have achieved your goals and on the teaching method that you have used after each lesson?** "So usually, I won't reflect upon every single lesson definitely. But usually the lessons that I would reflect on the lessons that didn't really go according to the plan." "after each lesson: that I won't say it is done very regularly." "After each lesson, I reflect briefly to know how to plan for the next one"

	"I wouldn't say I sit down and do it"... it would be more a sort of organic thought if it went well or no. "
Questions 2-3	**Are you aware of these methods, your weaknesses and strengths? Do you apply them in teaching and learning? Do you check the applicability of your teaching methods?**
	"you don't use this knowledge to research for an activity, you find that activity, and then you see if it fits or not"
	"I use some of which I received in teacher training sessions and PD sessions"
	"There are lots of challenges: if you try to combine the students according to their ability, similar ability, there will be a huge gap in terms of accomplishment at the end of the lesson. If you combine students in terms of like mix stability, then there is a different gap in terms of collaboration..."
	"students' behavior plays a major role..."

4.3.3.4 Questions Related to Motivation, Instruction and Overall Experience. The last set of questions addressed teachers' motivation to plan their lessons, their awareness of the instructional strategies and an overall feeling towards their experience in this research-based participation. Almost all teachers (four teachers) related their motivation of planning lessons to the success of their students and to increasing their attainment. One teacher considered that giving attention to planning lessons that suit the students' needs and planning with metacognition skills add to the integrity of teaching as a whole. For this teacher, planning with metacognition is a must to see the impact on students. This teacher added that students' impact is realized in better attainment and in reflection of happiness and good behavior in classroom. Another teacher considered planning with metacognition is a part of her job where she needs to "know her students better" in order to be able to cater to their needs and plan accordingly.

She would even monitor the learning of the students during the lesson to see how to adjust her planning.

Teachers have also associated the choice of teaching strategies to the success of their lessons in classrooms. They reflect on the successfully accomplished lesson and adopt the strategies that they have followed. Very few – mainly two teachers- named the instructional strategies that they usually use. Others were very general in their answers and did not name or indicate instructional strategies that they refer to while planning and delivering their lessons. One teacher correlated good class management and student behavior to proper strategies implemented during the class instruction. Finally teachers were asked to reflect on their journey in this study. Two teachers stated directly that the PD sessions for raising awareness and use of metacognition in their practices improved their teaching and learning in classrooms. One teacher even took a step further and started a research action plan on two theories that he felt are interconnected and relate directly to metacognition and these are "Dewey's inquiry cycle with the Kolb's experiential learning cycle". Another teacher felt in need for such PD sessions to get introduced to more theories and teaching methods.

Table 56

Samples of Teachers' Responses to Questions Related to Experience

Factors	**Motivations, Awareness of Instructional Strategies, Reflection**
Key terms	**Integrity, happy, instruction theories, Dewey and Kolb's theories, behavior, attainment**

Question 1	**What makes you determined to prepare adequate resources for your students?**
	" I call this integrity”
	“I know that my students make the biggest difference when I do things which are not noticed.”
	“I give students a feedback on the formative assessment prior to the summative assessment, their scores goes, go higher. So all these approaches that I do in the class simply lead to that end goal... this makes me happy”
	“I feel that part of my job is basically supporting them to know better.” them here refers to students.
	“I want my students to do well,”
Questions 2-3	**Are you aware of the different instructional strategies? How or where did you access them?**
	“strategies are associated either with like the behaviorism, or like masochism, all of the electronic learning theory theories. And basically, with experiments, it's more like skills based. And it's also associated with like Bloom's taxonomy."
	“ the success of different instructions in the classroom setting itself - that this through practice and also through observation I start to pick my teaching methods”
	“we do associate this with the learning theories on how like we kind of maintain the behavior, manage the class and keep the kids engaged as well.”
Questions 4-5	**What are your thoughts on the PD sessions and the whole process? Did it impact your teaching experience? Anything to add?**
	The workshop helped improving the progress of the students in the class. (two teachers)

> "After the workshop, I went ahead and I compare Dewey's inquiry cycle with the Kolb's experiential learning cycle."
>
> "proper training on how to reflect on your subject matter, what are the indicators of success besides like the outcome of the students"
>
> "So we do have to research and we have to restructure and we're always in the process of like reflecting adjusting, reflecting, adjusting..... this will help you improve the teaching and learning classroom"
>
> It is a " challenge to evaluating yourself, definitely you can. But whether you actually have time to do it or not, is the reality of the situation."

4.3.4 Emerging Themes from the Qualitative Data

Considering all the codes and evidence from the interviews, PD sessions, lesson observations and lesson plans the following theme can be deduced.

4.3.4.1 Criteria for Lesson Planning. Lesson planning is considered the first step required within metacognition skills in the planning, monitoring , evaluating model. When asking teachers about their planning and whether they set goals for each lesson, all teachers agreed that it is a required routine in their school. One teacher added that it is an "obligation". All teachers need to have specific objectives and set goals for the students' learning outcomes for each lesson. It is within the framework set by the teaching and learning team within the school. Lesson planning seems to be an identified procedure in teachers' metacognition skills.

Despite having planning as a crucial element in teachers readiness for classrooms, one limitation for teacher's planning that arose from the interview is time; while one teachers said "I think I have time to prepare for every lesson"; another teacher confessed that planning is

time consuming since a teacher has to “prepare suitable tasks for their lessons that meet the specified learning objectives... this leads to have task-based learning objectives”.

From this theme there emerges many sub-themes which would be discussed in the conclusion; such as:

- Data driven decision making
- Inclusion policy
- Differentiation

4.3.4.2 Pedagogy Effect in Selecting Resources and Instructional Strategies. While planning, teachers need to select resources and tailor them to the needs of their students as one of the teachers said: “I choose resources based on the year group and the class profile” and another teacher added: ″I apply strategies based on assessments and the activity's suitability for assessment types. This indicates that teachers not only research, choose and prepare resources, but also, they adapt them to the context of their instructional setting. One teacher mentioned how he tries to “pick resources that are short, precise and time-efficient". For them all these are factors the impact the effectiveness of the instructions within classrooms and lead to better pedagogical impact for them. Teachers consider that planning adequate resources increases the effectiveness of the teaching and the satisfaction feelings as one teacher confirmed:

> “I prepare resources to help students do well and feel a sense of achievement; so even if I find the task unfamiliar, I create new resources to teach myself."

Therefore, resources' selection and adaptation increase motivation and positive attitudes within teachers. Teachers do not need to tailor their resources only; they need to think of their instructional strategies as well. All five teachers referred to using diverse teaching strategies; one teacher that she aims at "Using think-pair-share, short video clips from movies, images to engage students in discussions". Two teachers were even able to relate instructional strategies to theories. One of them said: "We use learning theories associated with arts, behavioral management, and Bloom's taxonomy", and the other said: he had "devoted one unit in my DP program designed according to the combination of Dewey's inquiry cycle and Kolb's experiential learning cycle". A third teacher mentioned the need to research and develop her teaching instruction to promote critical thinking in classrooms.

Within the planning skills in the PME model, teachers find it challenging to find adequate resources. They even indicated their need for training sessions and guidelines to help them better choose and adapt their resources as one teacher pointed out: "Resources are researched through blogs or search engines since there are no guidebooks". They all agreed that lots of research work is required to identify and use the appropriate instructional skills.

Emerging themes could be added to this main theme such as:

- Adaptability
- Professional Development
- Effective teaching and proper choice of Instructional strategies
- Motivation

4.3.4.3 Enhancing Teaching Practice. In the monitoring phase of the PME model, most teachers related the in-class eveluation of the success of the lesson to students' response and progress. For them, when students acknowledge that they have acquired the new skill or concept, or when students show progress measured through the use of different progress check methods; then teachers deduce that the lesson is going on successfully and are able to proceed with their lesson plan. Questioning is another way teachers monitor the progress of the lesson and the success of the lesson. Teachers often link the success of a lesson to how students react and improve in class. This is reflected when one teacher said : "I monitor strengths and weaknesses during the lesson by asking students questions"; moreover, another teacher answered that "reflection happens when asking students what they liked and didn't like". Students' reflections help teachers estimate the success of the tasks and instruction.

> "We use the Progress Tracker to rank how students felt about tasks... assess their perception of every task"

It appears that owning self-monitoring skills during the lesson and according to the contextual situations happen spontaneously and naturally. It involves spontaneous form of assessing how the lesson is running as one of the teachers emphasized: "I don't necessarily stop to evaluate during the lesson. I observe students' engagement and reflect organically". This organic reflection appears to be a challenge to teachers and setting criteria to monitor the lesson and modify according to the lesson context is something that teachers require training on.

Enhancing lesson practice generated many themes:

- Students are the prime indicators of success of the instructional strategies use
- Autonomy and Organic Reflections of teachers

4.3.4.4 The Post-Lesson Evaluation and Teachers' Reflection. The final step in applying metacognition skills is evaluation. Checking how teachers reflect on the success of their lesson post instruction is one of the targets explored in the interviews. These yielded the theme of post-lesson evaluation and teachers' reflections. In this theme, almost all teachers agreed that some sort of reflection happens after the lesson is delivered; however, at different paces. Some consider reflections after each lesson; others reflect only if the lesson did not proceed in the way it was supposed to:

> "Usually, when I reflect upon lessons, it's the ones that didn't really go according to plan"

Another teacher considered results and data generated from the students' progress checks during the lesson are means to reflect on the success of the lesson delivered. Therefore, while performance can be a measure of evaluation, feelings and instructional methods used are other forms of reflection criteria identified by the teachers.

The themes emerging from reflection questions are

- Criteria for reflection
- Time management

4.3.4.5 Teachers' Motivation for Effective Learning. All teachers agreed that they reflect on their lessons but at different pace and time intervals. This act impacts their feelings and motivation. Many of them related motivation to effective learning and diligent work ethics:

> "Knowing what students like and dislike makes teaching easier and more effective"

> "Always reflections help improve" the teaching experience

> "I know that my students make the biggest difference when I do things which are not noticed... I call this integrity"

> "students do well, and it gives me a sense of achievement"

From teachers' answers, successful teaching experience after the lesson promotes their sense of accomplishment and satisfaction reflected in the success and progress of their students. Big evidence of the role of motivation in refining teachers' instructional strategies and promoting their growth is what teachers say after the reflection process. Engaging in reflective practices allows teachers to assess their strengths and weaknesses and identify areas for growth, act with integrity, and fetch for methods to enhance students' success. They consider these as fundamental elements in teaching experience for effective pedagogy. One teacher said: "If it fails, it's more of a reflection process, identifying missing gaps and trial and error". This shows how teachers build on their motivation after a successful or unsuccessful

experience. Another teacher added that despite frustration, she knew she had to revise the skills in teaching to improve her lesson in future.

> "Felt frustrated when the lesson failed... Stopped and revised skills when frustration didn't help".

The following themes emerge from questions related to motivation:

- Effective teaching
- Drive to Impact Learning
- Sense of achievement
- Feelings lead the motivation in teachers

4.3.4.6 Professional Development and Factors Impacting Teacher's Awareness and Use of Metacognition. All teachers rely on their pedagogical skills to improve the use of metacognition. These skills are acquired either from their own experience

"Always reflecting helps to improve"

or from research work:

> "I need to research to answer student queries, to be able to support and aid their progress" ..... "I need to know more about strategies to use while teaching"

or from the PD sessions.

"Workshops in the school, especially the one about planning phase and inquiry learning, left a solid impression on me"

or from their own post-graduate studies

"Took courses on improving students' progress and learned about equity in teaching from Harvard Graduate School of Education"

"We use learning theories associated with arts, behavioral management, and Bloom's taxonomy"

Teachers acknowledge the need for continuous improvement and further readings to improve the teaching and learning experience in classrooms which is coupled by improving their metacognitive skills. However, they find it challenging to find the proper time within their packed schedule in school. They even asked for more PD sessions that can identify criteria for the success of the lesson while using adequate metacognitive skills.

From this approach, the following themes have emerged:

- Professional Development for teachers' use of metacognition
- Criteria for successful metacognition skills
- Videotaping
- Time constraints

Table 57

Summary of Themes, Codes And Evidence from Teachers' Interviews

Themes	Codes	Evidence
Lesson planning	– Specific objectives – Setting goals – Learning outcomes – Task-based learning objectives – Planning time	"Each lesson has objectives. I think I have enough time to prepare for every lesson." "It's an obligation to set specific teaching goals for each lesson." "I have learning objectives for the whole lesson and specific outcomes for each task."
Pedagogy for resource selection and instructional strategies	- Criteria for resource selection - Adapting resources to Students - Researching for subject specific - Adaptation of Strategies to Class Needs - Creating New - Resources for Effective Teaching - Student Success - Sense of Achievement - Diverse teaching strategies - Inquiry Learning - Research and development	"I tried to pick resources that are short, precise, and time-efficient." "I choose resources based on the year group and the class profile." "Resources are researched through blogs or search engines since there are no guidebooks." "I apply strategies based on assessments and the activity's suitability for assessment types." "If I find the task unfamiliar, I create new resources to teach myself." "I prepare resources to help students do well and feel a sense of achievement." "Devoted one unit in my DP program designed according to the combination of Dewey's inquiry cycle and Kolb's experiential learning cycle"

		"We use learning theories associated with arts, behavioral management, and Bloom's taxonomy." "Researched online, explored lesson plans, utilized resources like Project Zero for critical thinking skills". "Learning outcomes are based on teaching techniques and skill development"
Enhancing Teaching Practice	- In-Lesson Evaluation - Real-time observation - Organic Reflection - Monitoring student progress - Providing Individual Attention	"I observe students' engagement and reflect organically during the lesson" "I will make sure that [student] keeps further away from the other student and he will be the first one when I start giving one-on-one time" "I monitor strengths and weaknesses during the lesson by asking students questions" "I evaluate by asking students where they need help or what challenges they face" "We use the Progress Tracker to rank how students felt about tasks... assess their perception of every task"
Post-Lesson Evaluation and Teacher's Reflection	- Informal reflection - Reflecting on Teaching Methodologies - Evaluation and adaptation	"I reflect informally after the lesson, thinking about what went well and what didn't" "I reflect on what worked well or didn't, keeping progress checks and awareness of lesson outcomes" "Usually, when I reflect upon lessons, it's the ones that didn't really go according to plan" "Reflection happens when students' feedback is considered... It's important to

		reflect, especially at the beginning of new skill sets or assessments”
Motivation	- Effective teaching - Drive to Impact Learning - Sense of achievement - Student Success	“Knowing what students like and dislike makes teaching easier and more effective” “I know that my students make the biggest difference when I do things which are not noticed... I call this integrity” “If the lesson goes well, I feel a sense of achievement and flexibility in altering plans” “students do well, and it gives me a sense of achievement” “If it fails, it's more of a reflection process, identifying missing gaps and trial and error” “Felt frustrated when the lesson failed... Stopped and revised skills when frustration didn't help”
Factors impacting teachers’ metacognition awareness and use	- Importance of evaluation - Research needed - Classroom observations - Knowledge of pedagogy - Time constraints - Need for improvement - Video-taping lessons - PD Sessions - Indicators for success	“Evaluating practices is essential, but time is a challenge in allocating for such tasks” “Always reflecting helps to improve, but finding time for it is challenging” “Never make them feel discouraged or that they can't do it... They need to be resilient”

	“Videotaping and reflecting on classes would be beneficial, but it's time-consuming to review the entire lesson”
	“I need to research to answer student queries, to be able to support and aid their progress”..... “I need to know more about strategies to use while teaching”
	“We use learning theories associated with arts, behavioral management, and Bloom's taxonomy”
	"Proper training on reflection, success indicators besides outcomes would help improve teaching."
	“Took courses on improving students' progress and learned about equity in teaching from Harvard Graduate School of Education”
	“Workshops in the school, especially the one about planning phase and inquiry learning, left a solid impression on me”

Chapter 5: Discussion, Conclusion and Recommendation

The main twofold purpose of this study was to examine the awareness and use of science teachers' metacognition in private secondary schools in Dubai, investigate the demographic factors that might influence teachers' perceptions to awareness and uses of metacognition, and explore the development of metacognitive PME skills in science teachers. This chapter presents discussion of the main findings, conclusion, recommendations and limitations. . Through convergent parallel approach, quantitative and qualitative data were collected to complement the findings and form an overall conclusion. Quantitative data were collected from the questionnaire answered by 84 secondary science teachers in different private schools in Dubai and results of the survey helped answer the first two research questions. Additionally, PD sessions in one of the private schools in Dubai followed by lesson observations, interviews and document analysis helped answer the third research question. Additionally, findings from both approaches helped yield some common themes and generalizations.

- (RQ1): What perceptions do science teachers have regarding awareness and use of metacognition in Dubai private secondary schools?

- (RQ2): What demographic differences do science teachers have regarding their metacognition in science schoolteachers in Dubai private secondary schools?

- (RQ3): How do science teachers develop metacognitive skills for planning, monitoring and evaluating (PME) of instructional strategies based on in-service metacognitive professional development sessions in Dubai private secondary schools?

5.1 Discussion

In this section, the results from questions one, two and three are discussed. In the first section results from first research question discuss the significance in the difference in metacognition awareness and use as knowledge, skills, and experience among secondary science teachers in Dubai private schools. In this section, results show significance difference in planning ability in teachers yet a struggle in monitoring phase during delivery of the lesson and real-time reflections due to curriculum and time constraints. It concludes at a recommendation for the importance of professional development sessions for teachers. In the second section, the results to second research question are discussed. Results reveal the significance in the difference of aearenwss and use of metacognition according to different demographic factors such as gender, nationality, years of experience and degrees obtained. Results mainly show a contextual effect on development of metacognition in teachers.

In the third section, results from the third research question -which mainly covers qualitative thematic analysis- are presented. In this section, it is possible to draw two main conclusions: Data Driven Decision making in the planning phase and Continuous Professional Development for domains of metacognition skills.

Finally, combined results from all collected data from the three research questions lead to the following themes: :

- “Teaching “For” rather than “With” Metacognition”
- Empowering teachers with adequate Instructional Strategies

- Metacognition as a policy for inclusive education
- Contextual teaching and learning (CTL) model to enhance teacher's metacognition
- Gains from teaching with metacognition.

5.1.1 Discussion of Question One Results

Analysis of the survey revealed relatively strong positive overall perceptions of awareness and use of metacognition in secondary science teachers in Dubai private schools (N= 85, M=3.9, SD=0.8). The 85 participating teachers according to likert scale averaged 3.9 indicating a high positive perception to awareness and use of metacognition. In particular, they possess relatively higher perceptions of metacognition knowledge (M=4.2, SD=0.9), followed by metacognition skills (M=3.8, SD=0.8) and finally metacognition experience (M=3.7, SD=0.8) i.e. factors affecting metacognition. These results were statistically significant between variables and almost significant within variables with few statistical insignificance as shown in the table below.

Table 58

Summary of Statistical Analysis of Teachers' Perception among and within Variables

Between Clusters			Within Clusters	
Knowledge vs Skills	Significant	Knowledge	Declarative vs Conditional knowledge	Significant
Knowledge vs Experience	Significant		Conditional vs Procedural Knowledge	Insignificant
Skills vs Experience	Insignificant		Declarative vs Procedural Knowledge	Significant
		Skills	Planning vs Monitoring	Significant
			Planning vs Evaluation	Significant
			Monitoring vs Evaluation	Insignificant
		Experience	Feelings vs Awareness	Significant
			Feelings vs Thoughts	Significant
			Awareness vs Thoughts	Insignificant

In this research, the perceptions of the secondary science teachers as confirmed in the self-report questionnaire reflects high positive perception to metacognition knowledge with an average of 4.2 (M=4.2, SD=0.8) where the highest score being 4.5 for "identifying teacher's own strengths and weaknesses" and for "using techniques that worked in the past". This suggests that secondary science teachers possess a strong understanding of how they think and learn within the context of their teaching practices. The low SD value suggests consistency among the responses. The participating teachers have a strong ability to recognize their strengths and identify weaknesses which would enable them to select from strategies and teaching practices that were proven as successful in classrooms in the past. This confirms studies by Cromley and Kunze (2020) and Lai (2011) where teachers need to understand the metacognition theory which focuses on knowing one's own thinking as well as factors and

skills that influence one's own performance.. According to the conceptual framework, these elements will help teachers improve their performance in teaching and gain more confidence in their practices (Ozturk, 2018; Wray et al., 2022). In the theoretical framework and while discussing the timeline of development of the metacognition theory, Lai (2011), Moshman (2018) and Pennequin et al. (2020) related experience such as emotions, competence and situational effects.

The data clearly provides evidence that teachers have strong declarative knowledge; they are aware of their subject knowledge and are even able to choose ways and methods to transfer this awareness to their students through the use of their procedural knowledge.

Analysis for results for metacognition as skills are discussed here. The perceptions of the 84 participating teachers show significant high significant positive attitudes to awareness and use of metacognition skills which averaged 3.8. Teachers' perceptions to metacognition skills are also strong but to a lower degree (M= 3.8; SD=0.9) with highest is for planning (4.1) in "I ask myself questions about teaching materials I am going to use". Teachers' perceptions to experience, awareness of pedagogical methods and feelings were high but with least overall mean (M=3.7, SD=0.9), with the highest being "I know that interaction with students can make them concentrate" (4.2). The results indicate that secondary science teachers perceive themselves as having a strong grasp of metacognition skills. They have confidence in their ability to plan lessons effectively by engaging in self-questioning since the highest average was for own questioning on the success of the choice of their pedagogical resources and the success of instruction in class. Moreover, teachers strongly believe in the importance of

student-teacher interactions to facilitate the learning process and the focus of students. This refers to response to contextual factors as discussed in the theoretical framework for this study. Garcia and colleagues (2019), Moshman (2018) and Siegal and Castel (2019) disuss how the emerging situational and strategy-feedback to students are influenced mainly by metacognition ability pf teachers. Many studies refer to the importance of contextual factors in regulating the metacognition in teachers and influencing their pedagogical practices (Azevedo, 2022; Beneliyahu & Bernacki, 2015; Michelle et al., 2021). The strategies teachers plan to use for instruction aim at increasing students' concentration, motivation and achievement as agreed by teachers in this survey and in the literature review (Yuruk, Yilmaz & Bilici, 2019). Another study AZheng and Wang (2023) that teachers should intervene to help students perform better through tailoring their resources to meet their learning needs.

The perceptions of participating teachers to their metacognition skills is fairly positive with an average of 3.8 and to almost same extent their perceptions towards metacognition experience is 3.7. Despite this, there seems that teachers view their skill level and practical experience similarly due to statistical insignificance between metacognition skills and metacognition experience. The lack of significance between perceived skill level and practical experience suggests that teachers see these metacognition variables as interconnected and equally important in their practices. These data alongside the data collected from observations in the qualitative part of the study during lesson observations show that teachers are more aware of using metacognition as a skill with students rather than as a reflective skill for their own practice indicating that teachers lean more towards Teaching "For" rather than "With" metacognition. In their study, O'Hara, Pritchard, and Pitta (2019) described teaching with

metacognition as the ability of teachers to manage their own teaching process through not only planning, monitoring and evaluating their instructional strategies but also through adjusting them based on their students requirements and sociocultural context. Moreover, teaching for metacognition means designing instructions that cultivate and activate metacognition in sudents. Furthermore, there seems to be a direct correlation between the teachers' efficacy and their promotion of metacognition in a study by Karlen and colleagues (2023) who highlited the significance of teachers' combined proficiency in fostering metacognitive development.

In the variable of metacognition as experience teachers' perceptions towards metacognition feelings, awareness of pedagogical strategies and thoughts in teachersare investigated. Awareness of pedagogical methods was the highest (M=4.0, SD=0.8); followed by feelings and motivation (M=3.7, SD=1.0) and finally by thoughts (M=3.6; SD=1.1). This variable had the lowest average due to many factors that could impact metacognition perceptions in teachers. Many teachers pointed out that time can be one of the obstacles to evaluating and reflecting on their performances; therefore, decreasing the evaluation and reflection skill in metacognition as seen in the statement "I reflect on whether my teaching performance is proper after each lesson" which had an average of only 3.2. This confirms the need for teachers to equip them with adequate time to reflect and practice implementing their metacognition as discussed in the conceptual framework in this thesis (Quigley, Muijs &Stringer, 2018). Moreover, there is an emphasis on the need for prolonged time of planned PD sessions to help teachers build and use their metacognition skills (Sulaiman, 2021) .

Moreover, using spearman's correlation, the findings of this study reveal significant positive associations between teachers' awareness and use of metacognition knowledge, skills, and experience. These results suggest that any increase in awareness and use of metacognition in one domain would correspond to an increase in the other domain. These findings underscore the importance of incorporating metacognitive practices into instructional strategies to enhance teachers' effectiveness and facilitate students, cognitive development.

5.1.2 Discussion of Question Two Results

Research question two looks into the demographic variabless and their impact on teachers' perceptions to awareness and use of metacognition. These factors are gender, nationality, academic degrees, and years of experience.

Twenty-four male teachers and sixty female teachers participated in the survey. Both participating genders reflect relatively high positive feelings towards their awareness and use of metacognition. They had almost the same average where females scored 3.80 and males scored 3.75 as average. However, there was statistical insignificance in teachers' perceptions to metacognition with reference to gender difference. Therefore, gender did not have an impact on how teachers perceive their metacognition ability. Many studies also concluded that metacognitive skills are insignificantly different between males and females in students (Merchán et al., 2020; Özçakmak et al., 2021).

Data analysis from the survey for research question two refer to the demographic differences in secondary science teachers that might influence their perceptions to awareness

and use of metacognition. Nationality, educational background, years of experience as well as perceptions to metacognition are all interconnected factors that might play a role in influencing the teachers' understanding and utilization of metacognitive skills. As for the nationality, the teachers from the Arab world had the highest perceptions to awareness and use of metacognition (M=3.99, SD =0.7) as compared to teachers from India (M=3.96, SD=0.56) and finally from British or Irish countries (M= 3.85, SD=0.54). This might be due to the fact that the academic system in the Arabic countries has a different approach than the British or Indian system. In the Arab countries teachers are satisfied by bachelor's degree; however, teaching in UAE requires teachers to have teaching certificate. So most of the teachers from Arab countries such as Egypt, Syria, Jordan and Lebanon had bachelor's degree in a certain subject; however, they are required to obtain a diploma or master's in education to be eligible to enter into the teaching domain in UAE (MOE 2023). This relates to the importance of pedagogical knowledge in teachers for better metacognition skills. As discussed earlier in the theoretical framework metacognition in teachers becomes "more explicit, powerful and effective" with training and developing pesgogical practices (Kuhn, 2000; Pennequin et al., 2020; Pritchard, 2017).

While the perceptions towards awareness and use of metacognition in participating teachers coming from India was 3.96 and those coming from Ireland or UK was 3.8. The difference in their metacognition awareness and use was statistically insignificant. Both teachers from India and Ireland or UK have the options of starting with bachelor's in teaching and might enhance it with a postgraduate certificate in education (PGCE). This might explain the insignificance in the perceptions between teachers from India and United Kingdom or

Ireland. In a study by Bhat and Jan (2021), the development of teaching education system in UK and India was compared and revealed how both systems require phases of development. In India teachers are involved in practicum trainings that include in-class teaching sessions and in UK the teachers are prepared through introducing them to their responsibilities and the framework of the curriculum in general (Bhat & Jan, 2021). This again confirms the contextual effect in building metacognition in teachers as their readiness and affection are affected by culture and their study route.

Table 59

The Awareness and Use of Metacognition in Teachers According to Nationality

Nationality	N	Mean	SD	Statistical Significance	
Indian		3.96	0.56	Arab vs Indian	Insignificant
Irish/ British	28	3.85	0.54	Indian vs British/Irish	Insignificant
Arab	17	3.99	0.7	British vs Arab	Significant

Nationality shapes teachers ‘perceptions especially when considering the two main nationalities in the Dubai private schools: who answered the questionnaire British (N=28; f=34.5%). and Arabs (N=17; f=20.2%). This significance might be due to the different curricula taught in preparing teachers. British and Irish teachers follow a special educational pathway that allows not only knowledge in the science as their subject but also through including psychology and education pedagogy courses; whereas in Arab countries teachers have pure bachelor's degree in the subject; any information related to psychology or pedagogy are gained as additional certification or Diploma. This might explain the higher perception to metacognition in Arab teachers (M=3.99; SD=0.7) as compared to British or Irish (M=3.85; SD=0.54) and Indian teachers (M=3.96; SD=0.56).

In comparing degrees of teachers, most of Arab teachers had another teaching certification in addition to their bachelor's degree. From the 17 Arab teachers, 15 had at least masters degree tht is 88% of the Arab teachers had degrees higher than the bachelor level. This might also explain why Arab teachers had higher perceptions of their metacognition as compared to other nationalities. Additionally, a high positive correlation is demonstrated for the level of education as one contributing and significant factor in determining the level of teachers' perceptions of awareness and use of metacognition. Teachers who have a bachelor degree in their subjects and therefore, were not exposed to pedagogical learning theories in their studies had the least perceptions (3.41 ± 0.53) as compared to those who have higher level of studies and exposed to post graduate degrees in education. The perceptions of participating teachers who have masters is highly positive (M= 4.06 ± 0.62) and even higher for teachers with PhD or doctorate level (M=4.24 ±0.43). The results confirm that the higher the education especially beyond just subject knowledge (bachelor's degree) the higher the awareness and use of metacognition due to exposure to pedagogical approached required in teaching. This contributes to "the awareness of instructional strategies" as a main factor impacting teachers' metacognition as reflected in the conceptual framework in this study. Moreover, it is concluded that both individual and contextual factors are important while exploring metacognition in teachers. These were the results of the quantitative data obtained from research question two as well as from the qualitative data collected while answering research question.

Table 60

The Awareness and Use of Metacognition in Teachers according to Years of Experience

Years of Experience	N	F	Mean (M)	SD
1 to 2	1	1.2	3.8	
3 to 4	12	14.3	3.4	0.6
5 to 6	15	17.8	3.8	0.6
7 to 8	21	41.7	4.1	0.6
9+	35	25	4.1	0.6

One of the unexpected findings in this research is the ability of teachers to plan lessons with metacognition irrespective of gender. There seems to be statistical insignificance between males and females perceptions to metacognition awareness and use. Therefore, gender seems not to play a role in metacognition awareness and use of skills in students as well as in teachers. Moreover, the results show that there is no correlation between years of experience and awareness and use of metacognition by teachers. This can indicate that teachers need growth mindset in order to take the initiative and work on their own metacognition. It is their readiness and ability to plan instruction and respond to situational changes that shape their awareness and use of metacognition. This refers to motivation and autonomy which are influenced by metacognition (Fathima &Vimala, 2020; Lynch, 2021, Rusyati et al., 2021). According to the theoretical framework, these are main elements of the self-regulated learning theory (Lai, 2011; Schraw et al., 2006). Moreover, self-regulated learning theory considers the realistic situations that influence the development of metacognition (Duell, 1986; Hennessey, 1999; Siegel & Castel, 2019). A study by Sheffler and colleagues (2022) states that both metacognition and intrinsic as well as extrinsic motivation help learners build new skills and move from novice stages to experts. Therefore, teachers need these elements to be able to

improve their efficacy and instructions in classrooms as discussed in the conceptual and theoretical framework (Hayat et al., 2020; Nieto-Marquez et al., 2021; Schraw et al., 2006).

In conclusion, the above data reveal how awareness and use of metacognition do not rely on years of experience but rather on teachers' readiness and mindset. Readiness as seen in the certificates the teachers had obtained and mindset as reflected in the variations of the means of their awareness and use of metacognition irrespective of years of experience or gender. This is one of the recommendations in this study. Preparing teachers through professional development programmes and through including metacognition in their education as they prepare to become teachers. A study by Suman (2023) discusses how growth mindset helps cultivates motivation and metacognitive skills. Being reflective and incoprating training sessions and interventions into the curriculum help build resilience, motivation and metacognition skills. Another study by Soleas and Hong (2020) also confirms that training programs designed for teachers can help build their motivation and teaching strategies. They have also deduced that teachers' mind set and motivation directly correlates to the mind set and motivation of their students (Soleas& Hong, 2020).

5.1.3 Discussion of Question Three Results

Answers to the third research question came from qualitative data. Professional development sessions were followed by lesson observations and document analysis of lesson plans. Finally, there were interviews with teachers who were observed. The PD sessions focused on the Planning, Monitoring and Evaluation (PME) metacognition skills. These skills are not only necessary to students but also to teachers themselves in their cycle of preparing for their

lessons, delivering the lessons and reflecting on the success of the teaching and learning experience after the lesson delivery. Teachers responded positively to the PD sessions designed to raise awareness of the PME skills. Teachers collaborated to produce lesson plans adequate for their students. They have discussed the appropriateness of the tasks chosen and responded to feedback from the researcher. While teachers were developing their metacognition planning skills during the PD sessions, they were also able to explore their declarative, procedural and conditional metacognition knowledge. Teachers need to perceive, interpret, and make decisions about their classrooms. It reflects teachers' understanding of their subject, choice of their pedagogy and finding ways to connect with their students (Cromley & Kunze, 2020; Saks, Ilves, & Noppel, 2021; Lai, 2011).

During the lesson plan analysis, awareness of instructional strategies varied among teachers. As discussed in Chapter 2, instructional strategies do not only enhance metacognition in students but also require high levels of metacognition in teachers themselves (Jusnair 2021; Marzano 2009). Merrill identified the first five principles of instruction where he focusses on a cycle students use to solve tasks using real-world problems. The cycle involves students applying their skills to link new information to previously existing knowledge; followed by integrating their newly acquired knowledge into solving the problem (Badali et al., 2022; Merrill 2006, 2013). This process engages students in active learning and promotes high order thinking which are main elements of metacognition. For teachers to choose their pedagogy and plan their instruction, they require high levels of metacognition skills.

Lesson plans had strong evidence of using metacognition prompts with students in the design of the lesson; however, evidence for teachers' metacognition was evident to much lower extent. Although teachers referred to known strategies such as Bloom's, "think-pair-share" and many of the collaborative learning strategies, only two teachers stood out in their planning to show high metacognition skills in planning and in knowledge. They varied their instruction and used metacognition related strategies such as SOLO taxonomy, Dewey's inquiry cycle, Kolb's learning cycle, E-cycle and Marzano. These strategies chosen alongside the pedagogical resources are indicative tools of how much teachers can engage students, motivate them, offer scaffolding and improve their performance. Therefore, awareness of what strategy to use and what tasks to choose reflects the strength of awareness and use of metacognition in teachers. This meets the conceptual framework and related studies in literature that lead this research and are discussed in Chapter 2. Instructions that motivate students require effective PME skills in teachers (O'Hara, Pritchard& Pitta, 2019; Suleiman, 2021; Zohar &Lustove, 2018). Two teachers relied on solely one instructional strategy indicating lower metacognition skills of planning and identifying a potential area for improvement.

As for lesson observations followed by the interviews, the findings suggest a varying degree of metacognitions awareness and use in the science teachers. While some teachers exhibited robust integration of metacognitive strategies in the instructional planning and delivery of the lesson; others showed limited ability to use metacognition especially during planning and monitoring phases. The effective use of diverse instructional strategies, thoughtful selection and justification of the pedagogical resources as well as the consistent

application of metacognitive prompts in class were indicative tools of higher levels of metacognition skills implementation by teachers (Wall & Hall, 2016; Yildiz & Atman 2023). Only one teacher demonstrated strong metacognition monitoring skills through adjusting the lesson plan during delivery based on the students' emerging needs. The teacher posed and had to stop the instructions in order to bridge a gap identified during discussion. All other teachers adhered to their plan with minimal alterations observed in two others. This aligns with the call for policy changes that promotes for flexibility and adaptability in curriculum and training for proper time management skills as mentioned by a study by Michelle et al (2021). Moreover, teachers require constructive platforms to share resources and ideas. Again, through lesson observation three teachers were able to justify the choice of their tasks and instructional strategies based on the cognitive needs of their students. Others conveyed their choices to availability of resources rather than thoughtful consideration of the cognitive demands of their students.

The insights obtained from the semi-structured interviews with five teachers provide diverse understandings of their awareness and use of metacognition skills of planning, monitoring and evaluation; in addition to their views related to teaching practices and experience influence. While there is a general agreement on the importance of goal setting, the depth and flexibility of planning vary among teachers. Monitoring strategies primarily rely on post-lesson reflections and students' observations and achievements. This suggests potential areas for real-time adaptation and responsiveness to student needs. Moreover, reflection on teaching strategies and outcomes, although recognized as valuable, is not consistently practiced due to time constraints. The motivation to plan and employ effective teaching

strategies is driven by the desire for students' success. Teachers' motivation plays a pivotal role in sustaining teachers' commitment to improving their instructional strategies and teaching practices continuously. The positive impact of the PD sessions on enhancing awareness and use of metacognition skills was evident highlighting the importance of continuous professional development and its role in fostering reflective effective teaching practices (Makovec, 2018; Wafubwa, Csikos & Opoku-Sarkodie, 2021).

Teachers during the process of PD sessions, lesson planning, observations and interviews demonstrated a proactive approach to planning their lessons, selecting their resources and designing their instructional strategies. For them, there is an emphasis on setting clear objectives, providing a student-centered learning environment and adapting their lesson plans to cater to the diverse needs of the students. These same elements were referred to in the conceptual framework which listed instructional strategies, PME, and social contextual settings as elements that raise the awareness and use of metacognition in teachers. Therefore, the following themes emerged from analysis of the qualitative thematic analysis of the lesson plans, observations and interviews: (1) Data Driven Decision making in the planning phase and (2) Continuous Professional Development for domains of metacognition skills

5.1.3.1 Data Driven Decision Making During the Planning Phase. Metacognition planning skills were explored during the PD sessions, lesson observations, analysing lesson plans and teachers' interviews. In the PD session teachers were advised to refer to their data in order to plan their metacognitive prompts that suit their students. Planning adequate instructional strategies requires teachers first to triangulate their data: students' achievement,

cognitive ability, socio-economic factors and their own observations to add validity and reliability to their choice of their pedagogical resources (Eggleston, 2018). Data driven practices while planning enhance efficiency, objectivity, transparency and foster innovation as stated in Raffaghelli et al (2020) research. This is shown in the discussions of teachers during the PD sessions and choosing metacognitive prompts that suit their students. One teacher said: "what is a higher order thinking question for one student can be an easy question for another". This explains how developing PME metacognition skills in teachers refers to the Neo-Piagetian theory. The development of PME requires high order thinking to be able to transfer the acquired knowledge into practice according to the situational conditions (Case, 1987; Downing et al., 2009; Sevinc, 2019). The socio-cultural dimensions of the environment play a crucial role in the formation and development of the cognition (Kusmaryono et al., 2022). Therefore, teachers need to understand their students and the classroom environment as they plan their instructions. They have to prepare themselves for any emerging situations.

Lesson plans had evidence of differentiation which is according to data. Some teachers were not aware of the importance of using data while choosing their instructional strategies. They just used what they could find on the internet or school resources. This was evident in some of the lesson plans and during the observation of some teachers; such as the teacher who relied on one type of activity regardless of the weaknesses and strengths of her students. Proper planning skills gained from PD sessions can enhance teachers' confidence, knowledge, skills, efficacy and foster innovation in classrooms (Christian, Kelly & Bugallo, 2021; Raffaghelli et al., 2020). Understanding how each learner differ in their internal and external conditions, mechanisms of evaluating and responding to feedback and their adaptability help

conceptualize metacognition and plan the pedagogical instructions accordingly (Cohen, Paul & Edward, 2014).

Most of the teachers agreed that planning is time consuming and requires some guidance and availability of resources to choose from. They found it a challenge to differentiate through using different metacognitive prompts and acquire adaptability to respond to contextual factors during the lesson. Chew and Cerbin (2021) designed a framework of cognitive challenges for teachers to design plans for effective teaching and learning. In this framework, teachers need to consider student mindset, metacognition, self-regulation, students' prior knowledge and misconceptions in order to plan lessons that transfer knowledge effectively while raising students' attention and challenging their cognitive ability and working memory. This again agrees with the PME cycle in the framework and raising teachers' competence in the conceptual framework in this thesis. Teachers agreed in the interview on the importance of planning lessons for effective learning experience. They have put effort into planning lesson plans and providing evidence of differentiation and using metacognition to plan their tasks and choose from a variety of available tasks and strategies.

In conclusion, to enhance teaching efficacy and promote metacognition, there is a need for continuous professional development sessions that focus on explicit integration of metacognition strategies while planning instructions and during instruction delivery. This requires re-enforced self-monitoring skills and fostering a culture of reflective practices and collaborative learning support among teachers themselves. This will support the development and application of metacognition skills in science education.

5.1.3.2 Continuous Professional Development for Domains of Metacognition Skills.

This research provided evidence of how professional development can play a paradigm shift in training teachers to use metacognition skills. To see how secondary science teachers in one of Dubai private school chain develop metacognition skills for planning, monitoring and evaluating (PME), 55 teachers participated in the first PD session. Running these PD sessions meet the conclusion drawn in Tocco and colleagues research (2023) on the importance of building pedagogical metacognition in teachers to encourage reflecting on and acting upon one's teaching. For Tocco et al. (2023) intervention programs that explore teachers' reflective and reflexive practices in their teaching help teachers become more aware of pedagogical theories and enable them to identify their own weaknesses and strengths. This will allow them to set goals of proper instructional strategies that are research based. This confirms Borkowski and Muthukishna (1992) who argue that metacognitive theory has "considerable potential for aiding teachers as they strive to construct classroom environments that focus on strategic learning that is both flexible and creative" p. 479. This further aligns with the Neo-Piaget theory of contextual influence on the cognitive ability. The PD sessions helped in three domains. First, teachers collaborated in producing a "Metacognition Poster" with prompts that can help teach "with" and "for" metacognition skills. Then, planning skills were empowered in teachers through allowing them to reflect on how, why and when to select their instructional methodologies and pedagogical resources. This was a gap as the researcher observed during the PD sessions and while taking notes during discussions within the PD sessions.

Another study by Alder, Zion and Rimerman-Shmueli (2019) concluded that professional development sessions are important for teachers to help them use metacognitive

prompts while embracing inquiry-based learning so that they can engage their students and reflect on the learning process occurring in classrooms. All the teachers in the interviews agreed on the importance of the PD sessions, especially when they are research-based and rely on educational theories. These findings also meet the conclusion from research where PD sessions conducted on Mathematics teachers found that intervention and material offered during the intervention helped them advance in their zone of Proximal Teacher Development zone due to increasing their metacognition awareness (Potgieter & van der Walt, 2022).

5.1 Discussion of Integrated Results

Analysis of the results from quantitative data and qualitative data is used to complete the conclusion drawn for this research. Both data worked in parallel to understand the awareness and use of metacognition by secondary science teachers. From both approaches, it is possible to conclude the following integrated themes: (1) "Teaching "For" rather than "With" Metacognition", (2) Empowering teachers with adequate Instructional Strategies (3) Metacognition as a policy for inclusive education (4) Contextual teaching and learning (CTL) model to enhance teacher's metacognition (5) Gains from teaching with metacognition

5.2.1 Teaching "For" rather than "With" Metacognition

The results from both quantitative and qualitative data showed stronger evidence of teaching "for" rather than teaching "with" metacognition. There has been more emphasis on raising awareness and use of metacognition in classrooms. Metacognition is a part of schools' hidden policy. In Dubai, all schools are inspected by the Dubai School Inspection Bureau and

are rated according to a framework where teaching and learning is a prominent element of the framework. Within this framework, monitoring students' progress, reflection, and feedback are main elements to be inspected (KHDA). These elements are main components of metacognition skills. With all this in mind, schools and teachers are teaching students how to regulate their cognition and evaluate their work. This explain the focus on "teaching for" metacognition in classrooms.

Results from quantitative data as well as from qualitative data support this theme. In quantitative data, teachers with higher educational degrees have higher perceptions to metacognition. Teachers also had higher perceptions towards using the proper strategies and planning i.e teaching "for" metacognition rather than monitoring and reflections which are mainly teaching "with" metacognition.This is evident as well in qualitative data as reflected from the lesson observations and teachers' interviews. While metacognition use and awareness is being more prominent; still the emphasis is on teaching "for metacognition" rather than "with metacognition" in schools. Teaching for metacognition is defined as ways teachers design their lessons to develop and activate metacognition in their students (O'Hara et al., 2019). "Teaching with" metacognition refers to teachers "thinking about their own thinking regarding their teaching" (Hartman, 2001, p. 149).

Willson and colleagues (2023) described AMERT as a framework for metacognition which categorizes metacognition in teachers in levels starting from self-Awareness, into self-Monitor, followed by self-Evaluation, then self-Regulation and the highest level is self-Transfer of cognition (see table below). This framework was observed during the lesson

observations and in the lesson plan. This is one of the emerging unexpected themes in ways to measure levels of use of metacognition. Some observed teachers exhibited self awreness and self monitor during the delivery of the instructions. They were responding to their students needs and questions in classrooms and providing constructive feedback. Very few had the ability to change and consolidate their lesson plan as the teacher who had to re-adjust the lesson plan after identifying a gap in the students' knowledge in real-time. Other teachers had lower level of metacognition as they have mentioned that reflections happen mainly after lesson delivery and not during the delivery as shown in the interviews.

Table 61

Level of Metacognition

Table 1. The hierarchical AMERT framework for metacognition, showing five levels of metacognition, description and key verbs for each level.

	Levels of Metacognition	Description	Key verbs
Lower levels are pre-conditions and co-conditions for higher levels	*Self-Transfer cognition*	Intentionally uses and adapts cognitive processes to suit contexts new to one's self. A form of self-Regulation.	Adapt, apply
	Self-Regulate cognition	Intentionally changes or consolidates thinking processes, based on self-Evaluating	Plan, change, consolidate
	Self-Evaluate cognition	Compares and contrasts current thinking with desirable thinking, based on self-Monitoring.	Compare, contrast, judge
	Self-Monitor cognition	Actively gauges thinking processes, based on self-Awareness.	Detect, gauge, check.
	Self-Aware of cognition	Conscious of and understands own thinking processes, uses internalised cognitive labels.	Metacognitive Knowing & understanding

Teaching with metacognition seems to be still in the development phase. Teachers focus more on planning skills and at a lower extent on reflections This is shown in the higher perceptions of teachers to planning rather than to monitoring and reflecting in the quantitative dataVery few teachers monitor their instruction during the lesson and are able to regulate their

metacognition in the classroom to respond to unexpected changes as observed in lesson observations. In the survey, the minimum score was in the monitoring phase in metacognition skills “I ask myself periodically if I meet my teaching goals while I am teaching” (3.2). Both quantitative results as well as qualitative thematic analysis supported this conclusion. From observations and survey, it seems that most teachers are still at the level of self-evaluation cognition. This is an advanced level yet they still need to be able to regulate and transfer this cognition in response to situational contexts in real time practice. Therefore, there should be a focus on developing teachers’ applicability and adaptability of metacognition skills.

The findings from the survey confirm that science teachers demonstrate positive attitudes towards using metacognition skills in planning, monitoring and evaluating their teaching practices with a particularly strong emphasis on monitoring students' comprehension and questioning teaching materials before use. Moreover, quantitative data show that there is slight significance in teachers’ motivation and awareness of pedagogical strategies. So while teachers reflect moderately high self-awareness of their metacognition knowledge and use as well as reflection in PME skills, there are areas of improvement in understanding and utilizing metacognitive strategies in practice. This highlights the importance of continued professional development and support in how teachers perceive the effectiveness of the strategies they use while implementing their lesson plans. This is further confirmed in many studies such as the study by Saks, Ilves and Noppel (2021) who revealed that teachers require interventions that focus on developing teachers’ procedural knowledge in order to enable them to advance in their teaching practices through experience and reflections. These planned interventions would help teachers grow their motivation and sense of growing their own learning experience.

Results from such studies as well as from the data collected meet the expected outcomes of growing metacognition in reference to the conceptual and theoretical framework presented in Chapter 2 of this research. “Motivation and reflection” as well as “Professional Development” are other themes that were discussed while referring to the third research question.

5.2.2 Empowering Teachers with Adequate Instructional Strategies

According to literature and the conceptual framework encompassing this thesis, teachers’ awareness and proper use of instructional strategies increase their competence and ability to achieve successful learning experience with students within their classrooms (Amin & Mariani, 2017; Fathima & Vimala, 2020; Langdon et al., 2019; Lynch, 2021; Pudiquet et al., 2019). The findings in this research confirmed this concept since teachers who had post-graduate degrees in education had higher metacognition awareness and better ability to use metacognition skills according to results from the survey. While an instructional strategy can optimize the learning outcome in students and inform them of best educational practices, there are concerns related to sustainability of these strategies. Strategies need to consider duration and content of instruction as well as characteristics of learners (De Boer et al., 2018; Meher, Baral & Bhuyan, 2021b). Furthermore, it was confirmed that teaching practices are highly correlated to metacognition awareness and teaching “with” metacognition. Moreover, studies suggest that teachers need to study metacognition explicitly in order to improve their instructions (Ozturk, 2018). This is reflected in the survey within the Metacognition as experience variable where teachers agreed that group discussions help improve the learning experience (M=4.2; SD=0.7). However, many were usure how to respond to emerging

situations such as “I know that group discussion do not apply when time is short for teaching” (M= 3.5, SD=1). Therefore, teachers need to improve their adaptability and flexibility in their instructional strategy design in response to contextual settings in order to best promote learning in students. This is also reflected in data collected in qualitative study while answering research question 3.

One of the effective practices that involved extensive use of metacognition was the integration of Bloom’s taxonomy and Solo taxonomy. As discussed in the conceptual framework, Bloom’s taxonomy relies on the knowledge domain; however, the Solo taxonomy relies on the depth of understanding of the task and attainment in the subject (Ahmed, 2020; Irvin, 2017; 2021). While using the combination of these two instructional strategy teachers were able to assess both achievement level as well as metacognition level in students. If teachers are able to use these strategies in class and monitor students, this can reflect the strength of the teachers’ metacognition. Solo taxonomy was introduced by Biggs and Collins in 1982 which focuses more on the “teaching rather than the learning domain” (Biggs & Collins, 1982 as cited by Irvin 2021, p.15) since it measures the complexity level of students’ learning based on the teaching. Therefore, using Solo taxonomy requires metacognition. Teachers possessing metacognition skills are able to strategize, plan and navigate through the learning process (Loksi et al., 2022). Therefore, using the effective instructional strategy would help teachers motivate students and adapt new learning approaches whenever required to increase both their students’ performance and their own performance. It was even advised to use Solo taxonomy as a framework to restructure the teaching content in order to improve the learning experience (Yıldız & Atman, 2023). All of these studies, even though relate to

students, they reflect the importance of metacognition skills in teachers as they select and deliver their instructional strategies to increase their competence and efficiency in improving students' performance.

In observations and lesson plans, teachers who used Blooms and Solo taxonomy, E-cycle and inquiry based strategies exhibited higher metacognition skills than the teacher who used tasks based on achievement level alone i.e Bloom's taxonomy and who used solely modelling. The students were less engaged and the learning experience was very slow and not motivating.

In his book, David Perkins (1992) concludes his findings from over 20 years of research on metacognitions and offers advice to teachers on how to guide students to use metacognition through strategies that they can use. He then divides metacognitive learners into four levels. The first level is referred to those who lack metacognition knowledge of their own by which he called them "Tacit" learners. "Aware" learners are those who can generate ideas and find evidence without deliberate thinking or planning. Followed by "Strategic" learners who can find answers through problem solving, organizing their thoughts and making decisions. Finally, there are the "Reflective" learners who monitor the success of their strategies and respond to changing them when needed rather than only being strategic. In this study, it is evident that teachers vary from being strategic to reflective. Quantitative data as well as qualitative data reveal how all teachers use metacognitions skills and try to find proper strategies and make decisions as they plan and reflect on their lessons. However, it seems that monitoring their delivery of the strategies is the part that would require enhancement and

training to become fully “reflective” teachers and help build metacognition in students properly.

5.2.3 Metacognition as a Policy for Inclusive Education

In the conceptual framework, metacognition is a hidden part within the policy for national and international education systems. IB, Cambridge, Common Core are all education systems that discuss metacognition as an element to be incorporated into the teaching standards (Beach et al 2020; OECD 2019; Sawyer 2005). Therefore, metacognition has become a hidden theory required to equip the students with the 21st century skills (Krischner & Stoyanov, 2020; OECD Insights, 2014; Pena-Lopez, 2017).

It was clear from survey, interviews and class observations that metacognition is becoming a part within the inclusive teaching framework where metacognition skills and knowledge may develop among various groups of learners and teachers depending on demographic factors such as habits, ages, abilities and cultures. This is in accordance with studies by Alder, Zion and Rimerman-Shmueli (2019); Mitsea, Drigas and Mantas (2021) and Prediger and Buró (2021). For them metacognition helped teachers focus on planning their open-inquiry pedagogical instructions and reflect on their plans. These studies started a training paradigm by including metacognition in educational context as an element to access teacher’s abilities so that teachers can accelerate inclusion and success of students. Moreover, positioning “metacognition in an inclusive teaching framework” was one of the recommendations for the IB schools in a study set by the IB organization to investigate how schools following the IB programme address and support metacognition skills (Jessica et al.,

2023). In this study, the authors recommended including “explicit, comprehensive and clear” mentions of metacognition in school guidance trainings where IB educators can recognize gaps in descriptions and applications of metacognition knowledge and skills. This approach should be adopted by all schools as it promotes inclusivity and improves the teaching and learning experiences in classrooms.

5.2.3 Contextual Teaching and Learning (CTL) Model to Enhance Teacher’s Metacognition

Metacognition theory and Neo-Piagetian theory are two theories that guide this research. Moshman (2018) indicated a strong link between metacognition and constructivism; mainly Neo-Piagetian theory. Both theories include the social and contextual influence on the development of cognitive ability in adults (Case, 1986; Downing et al., 2009; Kallio, 2015; Pennequin et al., 2020). Results from both quantitative and qualitative data support this link. Moreover, it lead to linking to another model while analyzing data which is the “Contextual teaching and Leaning (CTL) model” . CTL was defined by Berns and Erikson (2001) as “Contextual teaching and learning is a conception of teaching and learning that helps teachers relate subject matter content to real world situations; and motivates students...” (p 3) (as cited by Clemente & Vesta 2008). CTL allows teachers to consider the cognitive ability of their students, allow collaborative learning and build self-regulation which embodies metacognition (Berns & Erickson, 2001; Jubhari, Sasabone & Nurliah, 2022).

Using CTL would require strong PME metacognition skills for teachers to learn new instructional skills as they plan their lessons and monitor the delivery of the lessons since CTL requires teachers to be facilitators and designers of the learning situations (Clemente & Vesta, 2008). Teachers need to model self-regulated learning and metacognition to nurture these traits in their students. Adaptive metacognition can lead to effective teaching as teachers are able to adjust their own selves and the learning environment in response to the dynamics of the classroom and social interactions. It enables them vary their instructions and become more flexible (Lin, Schwartz & Hatano, 2018).

The quantitative data identified a potential weakness in response to emerging situations in class as reflected in statements such as response to items related to time limitations or collaboration and grouping techniques during instructions; moreover, interviews and lesson observations again had evidence of teachers' weakness to respond and adapt their instruction within the context of the lesson environment. There is a call for flexibility and adopting contextual teaching and learning to allow students and teachers to respond to real life situations and adapt different approaches according to emerging needs. The use and awareness of metacognition skills can be enhanced through exploring innovative blends of various instructional strategies, classroom settings and students' attitudes same as discussed in a study

by Wall and Hall (2016) where they confirmed a correlation between pedagogies and teaching methods used by teachers to foster metacognition in their students and the teachers' own learning and metacognition expertise. These methods should be flexible and adaptable according to classroom situations.

In summary, metacognition is crucial across education to enhance learning and emotional regulation. It underpins both individual self-awareness and collective decision-making to enable more informed, fair, and reasonable judgment by teachers. According to the cultural origins, metacognition's personal and social functions are largely shaped and refined through cultural learning and adaptation due to social interaction as confirmed in a study by Heyes (2020) and reflected in the survey in this research.

5.2.4 Gains from Teaching with Metacognition

Many studies relate metacognition to improved students' performance as well as improved teaching efficacy (Babaie & Abdenia, 2016; Kusmaryani et al., 2016; Stanton Sebesta & Dunlosky, 2021). The findings of a study by Karlen and colleagues (2023) indicate a strong positive correlation between teachers' understanding, confidence in their abilities and motivation and in the use of metacognition skills. For teachers to foster metacognition skills, they need strong motivation and self-regulated learning abilities and beliefs (Karlen et al., 2023). These are the same factors that are discussed in the conceptual framework as expected

outcomes for raising metacognition in teachers. Self-regulated learning embraces metacognition and motivation (Ozimik &Forester, 2021).

In the lesson observations and document analysis of lesson plans, teachers with high metacognition skills mirrored an engaging classroom where students are motivated to work on their tasks and collaborate to enhance their learning experience. The teachers were more as facilitators and had control over their teaching practices using the proper instructional strategies and responding to students' needs. In the survey, teachers who responded high in experience variable that encompasses experience, motivation and strong pedagogical awareness had the highest metacognition skills scores as well.

As a result, teachers' competence is highly linked to high levels of awareness and use of metacognition while teaching. The students' academic performance and accuracy in self-monitoring are directly correlated to teachers' use of metacognition (van Loon et al 2021). Not only content of instruction but methods of instructions require metacognition in teachers and increases the ability for teachers to raise metacognition and self-regulated learning in their students.

5.3 Conclusion

The pragmatic lens was used in this convergent parallel mixed method research to investigate the awareness and use of metacognition in secondary science teachers in Dubai private schools and the response of teachers to PD sessions on developing their PME metacognition skills. The main purpose of this study was to investigate the perceptions of science teachers to awareness and use of metacognition considering as well their demographic variations and to explore how science teachers develop their metacognitive skills in planning, monitoring and evaluation (PME) through in-service professional development (PD) sessions in secondary school in Dubai. This research was able to answer the research questions related to its purpose as it evaluated teachers' awareness and use of metacognition, explored their use of metacognition skills through planning their instructions, monitoring their delivery within their classrooms and reflecting upon the effectiveness of their teaching practices. It also highlighted a few weaknesses and potential for future improvements. Therefore, it is important to share some commendations and recommendations obtained from this study.

Data from survey –quantitative part- and from triangulation of observations, semi-structured interviews and document analysis of lesson plans –qualitative part- revealed strong awareness of metacognition as knowledge and skills in teachers. While teachers teach "for" metacognition with their students; there is a lack of teaching "with" metacognition especially when it comes to monitoring and evaluating phase. Moreover, there is a need for empowering teachers with proper instructional strategies, flexible and adaptable curricula, and proper time management skills in order to be able to better use contextual teaching and learning

experiences in classrooms and manage to reflect on the success of the lessons each time they finish instruction. These can be re-enforced through ongoing research-based professional development sessions and curricula reforms that encourage flexibility and adaptability in response to teaching contexts, students' needs and their socio-cultural demands.

In conclusion, cultivating a culture of metacognitive awareness and continuous self-reflection among teachers can significantly contribute to the development of adaptive, responsive, and effective teaching practices, ultimately benefiting student engagement, learning, and success. Overall, the findings underscore the complex interplay between planning, monitoring, evaluation, and motivation in shaping teaching practices. While there is a shared commitment to student success and engagement, there is a need for more dynamic and adaptive teaching approaches that prioritize real-time responsiveness to student needs, foster regular reflection on teaching practices, and leverage professional development opportunities to enhance teaching efficacy and student learning outcomes. It requires open mind-set for teachers to seek for PD sessions and take the initiative to build on their metacognition skills. It all starts with the willingness of teachers and their motivation to further improve their teaching efficacy.

5.4 Implication of the Study

5.4.1 Metacognition as a Part of the Inclusive Policy

Metacognition is a hidden policy within national and international curricula adopted during the educational reforms. The key performance indicators in assessing the teaching and learning practices in schools require observation of metacognition within classrooms as seen

in the KHDA inspection framework and OECD publications “Future Education and Skills for 2030” (KHDA, 2023; OECD 2017). However, criteria to performance indicators for teachers “teaching with” metacognition are not clear or stated within the school policies. According to the findings of this study, this area is still neglected and vague for teachers. Clear indicator points should be communicated and listed in the KHDA framework for inspection as well as in the internal school policies.

UAE government is dedicated to the United Nations Convention on the Rights of Persons with Disability through setting up laws advocating for inclusion of every student, irrespective of their disability, into the education system. Teaching with metacognition is seen as one of the elements that empowers inclusiveness and provides equal chances for all learners to learn at their own pace facilitated by their teachers. Empowering Teachers with metacognition PME skills will help achieve this target and lead a self-regulated learning environment for all types of students. Therefore, metacognition should be the key element within the inclusive policies in schools. The Metacognition policy should (1) identify the three knowledge domains, the PME skills and the factor required for developing one’s own metacognition, (2) include prompts for teachers to ask themselves during the PME cycle and prompts for students to follow during their lessons (3) make available the Key performance indicators to rate the level of metacognition in reference to one of the metacognition tools available for teachers as well as for students such as AMERT framework or Perkin’s levels of metacognition discussed in the conclusion and (4) involve all stakeholders in building a culture of self-monitoring and reflective practices to improve the teaching and learning experiences within the school community.

5.4.2 Empowerment of Teachers Through Research-Based PD Sessions

Teaching requires pedagogical knowledge and skills beyond the subject knowledge itself. This is why in UAE all teachers are requested to sit for teacher licensing tests by the Ministry of Education. Teachers are also requested to hold any degree of education (PGCSE, Teaching Diploma, or post graduate degree in education) (MOE, 2017). The educational system is dynamic, and the needs of the students vary with time according to the socio-economic vision of the country. With the vision for 2030, continuous PD sessions should be tailored to upscale the skills required by teachers to prepare the citizens of the future (Berns & Erikson, 2001; UAE vision, 2021). These PD sessions should be designed as research-based long-term programmes that enable teachers to explore their skills, identify their weaknesses, and identify potential areas for improvement. Teachers collaborating with each other and exchanging ideas will help fill in the gaps in their skills and acquire the missing practices.

PD sessions tailored to improve planning, monitoring and evaluating skills are important to develop the metacognition skills in teachers. They need to know all elements required for planning their instruction, identifying methods for monitoring their lessons during real-time delivery of the instructions and finally finding the time and tools necessary to reflect on their own practices. This requires motivation, growth mindset and willingness to improve and only well-planned interactive PD sessions can offer this chance.

Empowering teachers with tools to teach “for” and “with” metacognition will help their students develop their own metacognition, improve their academic performance, drive their motivation, build their self-regulated learning skills and equip them with future skills

required to build successful efficient citizens. Studies shows direct correlation between teachers' metacognition, mindset, and motivation and their students. Building PME skills in teachers will prepare students who are resilient, reflective and empowered by the 21st century skills that help develop the economy of the countries.

5.4.3 The Use of AMERT

AMERT as defined by Willson and colleagues (2023) allows teachers to identify and monitor the development of their metacognition. Schools can design PD sessions to introduce this framework and train teachers to know how to monitor their progress in reference to key verbs that can describe each level of metacognition level. Circuating this framework helps build a culture of reflection and responsiveness to the continuous needs of teaching and learning practices.

Table 62

The Hierarchical AMERT Framework for the Five Levels of Metacognition

	Levels of Metacognition	Description	Key verbs
Lower levels are pre-conditions and co-conditions for higher levels	*Self-Transfer cognition*	Intentionally uses and adapts cognitive processes to suit contexts new to one's self. A form of self-Regulation.	Adapt, apply
	Self-Regulate cognition	Intentionally changes or consolidates thinking processes, based on self-Evaluating	Plan, change, consolidate
	Self-Evaluate cognition	Compares and contrasts current thinking with desirable thinking, based on self-Monitoring.	Compare, contrast, judge
	Self-Monitor cognition	Actively gauges thinking processes, based on self-Awareness.	Detect, gauge, check.
	Self-Aware of cognition	Conscious of and understands own thinking processes, uses internalised cognitive labels.	Metacognitive Knowing & understanding

Note. Taken from Willson et al.

5.4.3 Flexibility in Instructional Strategies

Teachers' responsiveness to emerging situations in classrooms and during lesson delivery requires flexibility in planning and implementing the instructional strategies in real-time application. Only metacognition helps teachers respond to contextual situations and adapt to the unexpected emerging events during the teaching experience.

5.5 Contribution

Answering the research questions in this investigation had contributed to the quality of teaching, the role of teachers in educational success and wyas that can contribute to building metacognition in teachers.

5.5.1 Contributions from Research Question 1

The importance of effectively managing pedagogical and instructional strategies cannot be overstated in enhancing the teaching and learning experience. In Dubai, science teachers demonstrate a strong awareness and application of metacognition, a critical factor that underpins the effectiveness of these strategies. By utilizing metacognitive approaches, teachers can better reflect on their instructional methods, making necessary adjustments to improve student learning outcomes.

5.5.2 Contributions from Research Question 2

The growth mindset in teachers plays a pivotal role in educational success, though it is often found that years of experience or age have little significance in its development. The

readiness of teachers to embrace growth is largely dependent on their awareness of pedagogical studies, which suggests that continued professional development and exposure to innovative teaching practices are vital in nurturing this mindset.

5.5.3 Contributions from Research Question 3

Contextual Teaching and Learning (CTL) models, such as those proposed by Bern and Erikson (2001), can be instrumental in enhancing teachers' metacognitive abilities. Through the use of these models, teachers can better engage in reflective practices that contribute to more effective teaching. Moreover, data-driven decision-making during the Plan-Manage-Evaluate (PME) cycle plays a crucial role in supporting this process, ensuring that instructional strategies are continuously informed by accurate, relevant data for optimal educational outcomes.

5.6 Recommendations for Future Studies

Metacognition is a developing area that requires many elements and is necessary in all subjects. Therefore, the findings in this research suggest the followings for future:

First, the PD sessions have to continue and cater to the needs of teachers. Teachers need to be grouped according to the identified areas of weaknesses. Personalization of targets in the PD sessions would yield a more effective outcome.

Second, schools need to place clear internal policies for teaching "with" and teaching "for" metacognition. It is important to share prompts and key indicators of the PME elements

to be used with teachers as well as with students. This will build awareness across the school community and would integrate all these recommendations into the school's curriculum and development plan for teachers.

Third, metacognition is not only required in science subject. PME skills are required in all STEAM and language subjects. Therefore, it would be beneficial to adopt the approach of this research and upscale it to meet the needs of all departments within the school.

The researcher in this study had gained more insights into the learning practices in schools and the teachers' involvement in improving science education across the Dubai secondary schools. The approach made the researcher identify "what works" in real life and how schools are responding to expectations of the UAE government and its vision for first class learning system. Studying, developing and rating metacognition in teachers is an identified gap in literature that allowed the researcher to delve into how teachers respond to the need of using metacognition skills and how they are using these skills in real life applications.

5.6 Limitations of the Study

The researcher used multiple resources and mixed method approach to collect data. Triangulation of data, statistical calculations as well as thematic analysis through transcribing data manually added reliability and validity to the analysis and findings. However, the study faced many challenges listed below.

The first challenge was the ability to reach all secondary science teachers in private schools in Dubai. E-mails were not enough to motivate teachers to answer the questionnaire. It was a struggle to reach out to school principals and have them encourage their science teachers to participate. This yielded 85 teachers answering the questionnaire. Since the study targets only science secondary teachers, this community was limited as some schools had only one or two science secondary teachers. Therefore, the sampling itself was a limiting factor targeting a narrow range of convenient participants.

The second challenge was time. PD sessions designed for teachers were time consuming and required dedication from teachers as well as the school to offer venue and time for teachers to participate. The first two sessions had a large number of turn over for participating science teachers; however, only five teachers were able to dedicate time for the lesson observations and interviews. For the other teachers it added stress and more load to be able to participate according to some feedback collected after each PD session.

The third challenge was finding the time to collect all the data for qualitative part. Some teachers prepared lesson plans but had to be observed for another lesson for time-constraints and according to readiness from their side and the school's running schedule.

The biggest challenge was the resources in the educational field. Almost most of the studies focused on students and if on teachers it would be tackling the use of metacognition prompts during instruction. Very few studies were dedicated to metacognition in teachers and to teaching "with" metacognition.

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Appendices

Appendix A

Educational Institute

School Branches	Curriculum	Number of science secondary teachers	Number of students
First Branch	International Baccalaureate and American Curriculum	6	1000
Second Branch	International Baccalaureate	12	1990
Third Brach	International Baccalaureate	16	2500
Fourth Branch	International Baccalaureate	12	1400
Fifth Branch	British Curriculum (IGCSE- A-levels)	12	1800

Note: Information Achieved from the schools' websites

Appendix B

B1 This letter will serve collect data through a survey from secondary science teachers in Dubai private school. It will address school principals to forward to their secondary science teachers.

Dear School Principal,

As a PhD student in Education in the British University in Dubai, I am researching the "Secondary Science Teachers Awareness and Use of Metacognition in private schools in Dubai".
I am addressing you because I am aiming at reaching as many as possible secondary science teachers in Dubai schools to fill in a completely anonymous survey on the topic mentioned above. If approved, kindly forward this email to the secondary science teachers in your school.
The purpose of this email is to allow me to send this survey to the secondary science teachers in your school. The study requires responses from teachers on metacognition. The survey is anonymous and all data collected will be confidential and will serve solely this research.
For any further queries, feel free to contact myself or my supervisor Professor Sufian Forawi.
Thank you for your time and looking forwards to your cooperation in this academic endeavor.

B2 This letter will serve collect data through a professional development training programme for 4 sessions to develop the PME skills in secondary science teachers in one of the branches of the 5 different schools that belong to the same institute and share the same CEO. This will be followed by class observations for teachers involved in the training and volunteering for this purpose.

Dear [redacted]

As a PhD student in Education in the British University in Dubai, I am investigating "The effect of developing Planning, Monitoring and Evaluating Metacognitive skills in Secondary Science Teachers in private schools in Dubai".
I am addressing you as the CEO of "Innoventures" and since I am a member of this academic institute, I wanted to take this opportunity to conduct my research in one of your schools.

The aim of this research is to conduct a four days in-service programme to engage as many as possible secondary science teachers in your schools in a training to develop their metacognitive planning, monitoring and evaluating skills.

Teachers who would like to volunteer in the programme will be guaranteed full confidentiality, anonymity, and no harm ethics during the whole research process. Data will be confidential and solely used to serve the purpose of this research.

Teachers who volunteer to take role in this programme may be asked to be observed in classroom settings without any interference from the researcher. Those teachers will only be observed if they are comfortable to take part in this process. Complete observer stance will be considered. No harm will affect teachers or students in classroom setting and no data will be shared with anyone but the teacher of concern and the researcher to ensure accuracy and transparency.

The programme would require 4 visits to the school for one hour each during the PD sessions, followed by visits to observe teachers in classrooms who volunteer in this stage. Withdrawal at any stage from this research is definitely secured and eligible at any stage for the schools and/or for any of the teachers.
For any further queries, feel free to contact myself or my supervisor Professor Sufian Forawi.

Thank you for your time and looking forwards to your cooperation in this academic endeavor.

Appendix C

Below are the survey questions

1=Strongly Agree, 2=Agree, 3=Undecided, 4=Disagree, to 5=Strongly Disagree

MAIT themes	
1- Declarative knowledge	(1) I am aware of the strengths and weaknesses in my teaching
	(7) I know what skills are most important in order to be a good teacher
	(13) I have control of how well I teach
	(19) I know what I am expected to teach
2-Procedural Knowledge	(2) I try to use teaching techniques that worked in the past
	(8) I have a specific reason for choosing each teaching technique I use in class
	(14) I am aware of what teaching techniques I use while I am teaching
	(20) I use helpful teaching techniques automatically
3- Conditional Knowledge	(3) I use my strength to compensate my weaknesses in my teaching
	(9) I can motivate myself to teach when I really need to teach
	(15) I use different teaching techniques depending on the situation
	(21) I know when each teaching techniques I use will be most effective
4-Planning	(4) I pace myself while I am teaching in order to have enough money
	(10) I set my specific teaching goals before I start teaching
	(16) I ask myself questions about teaching materials I am going to use
	(22) I organize my time to best accomplish my teaching goals
5- Monitoring	(5) I ask myself periodically if I meet my teaching goals while I am teaching
	(11) I find myself assessing how useful my teaching techniques are while I am teaching
	(17) I check regularly to what extent my student comprehend the topic while I am teaching
	(23) I ask myself questions about how well I am doing while I am teaching
6- Evaluating	(6) I ask myself how well I have accomplished my teaching goals once I am finished.
	(12) I ask myself if I could have used different techniques after each teaching experience

TMI Extracted themes	
1-Experience	I always worry about students feel tedious in my classroom
	I am worried that I can't control the pace of classroom teaching well.
	When my classroom teaching fails, I always feel anxious
	When I successfully complete the classroom teaching task, I feel very relaxing.
2-Knowledge about pedagogy	I clearly know demonstration can make the abstract knowledge concrete.
	I know exactly catechetic method can inspire students to think
	I know that group discussion do not apply to the case when time is short for teaching.
	I know very well that interact with students can make them concentrate.
3- Reflection	I re-evaluate the appropriateness of my teaching goals after each lesson.
	I reflect on whether my teaching design is appropriate after each lesson.
	I ask myself if I have considered other possible teaching methods after each lesson.
	I reflect on whether my teaching performance is proper after each lesson.

Demograohic Factors

Teacher age	20-30	30-40	40+
Years of Experience	1-2 years	3-5 years	6+
Gender	Female	Male	
Nationality			
Educational level	BSc	Teaching lisecence	Teaching Diploma
	Masters	PhD/Doctoral	

Appendix D

D1. The semi-structures interview questions will be based upon the themes of the questionnaire, the training sessions for the in-service science secondary teachers, and the conceptual framework of the study:

Interview draft questions

Planning	Do you set a specific teaching goal for each lesson?
	How do you choose your resources and class instructions
	Are you prepared for unexpected situations?
Monitoring	What is your feeling, when you successfully complete the classroom teaching task?
	What's your feeling, when your teaching fails?
	How and to what extent do you consider the students' feelings and the pace of classroom?
	Do you think using techniques like demonstration by pictures, flashcards and slides, group discussion and using catechetic method at the beginning of each session are useful for better understanding of the students?
	How do you evaluate your students' strengths and weaknesses during the lesson?
Evaluating	Did you reflect on accomplishing the teaching goals, possible methods of teaching, and the effects of your teaching on the learners after each lesson?
	Are you aware of your weaknesses and advantages of teaching the concepts and methods of the subject you teach?
	Do you check regularly teaching progress, the students' comprehension of the content, and applicability of your teaching method?
Motivation	What makes you determined to prepare the adequate resources for your students?
Instruction	Are you aware of different instructional strategies? How?
	From where do you get your resources
Reflection	What do you think of the training?
	What did you learn? Did it impact your teaching experience?

D2. The consent letter shared with participating teachers.

Dear Participant,

As a PhD student in education at British University in Dubai I am researching" Secondary Science Teachers' Awareness, Perceptions and Professional Development of Metacognition in Dubai Private Schools" .

I would like to thank you for agreeing to participate in this interview where you will be anonymous participant and none of the information shared here will be disclosed. Any data will be solely used for this research. Anonymity, confidentiality and transparency are ensured in this research. The transcribed data from the interview will be shared with you to ensure transparency and avoid any bias by the researcher.
You can decide to stop your interview at any time. Thank you for your time and for agreeing to run this interview.

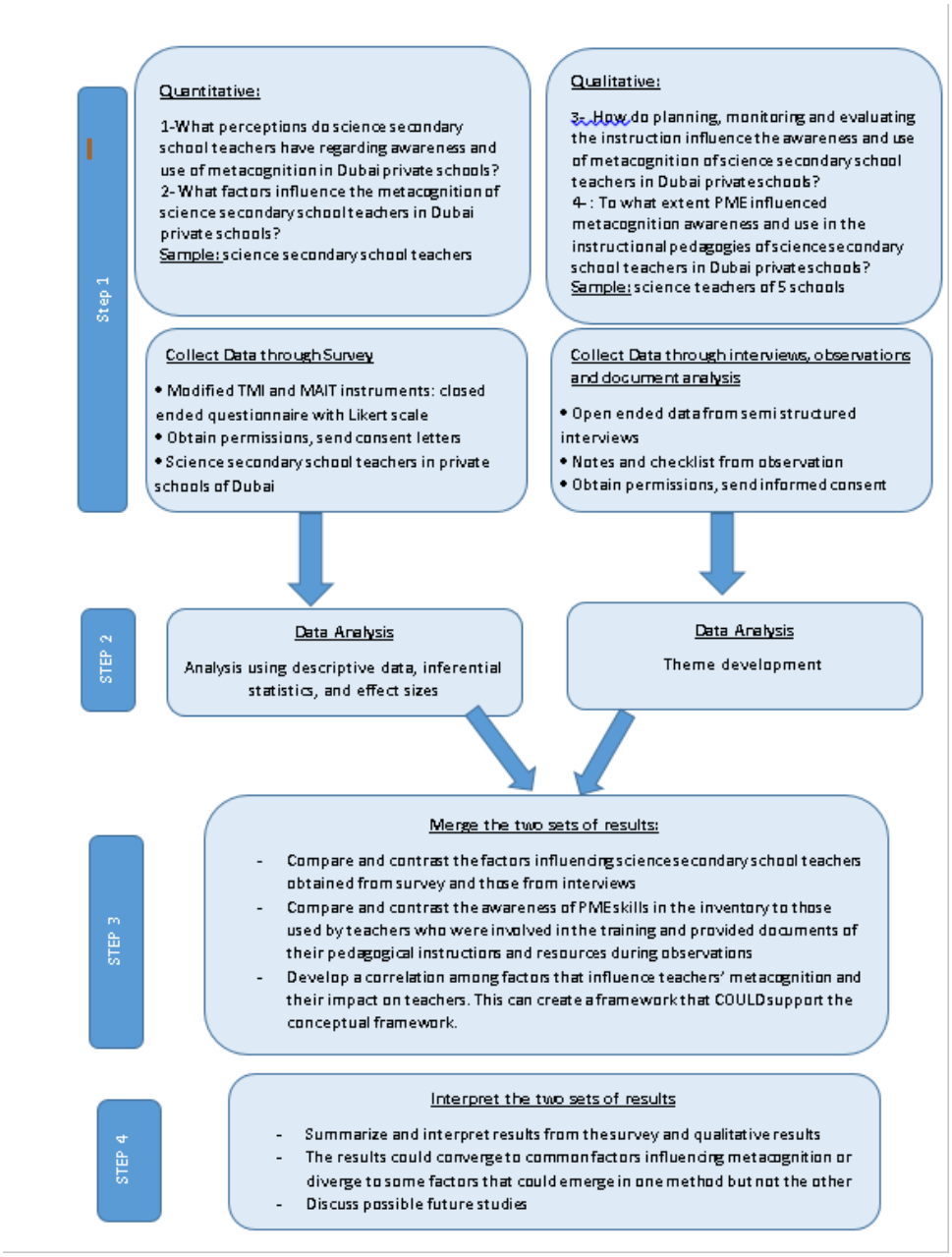
Appendix E

The Observation Inventory for the researcher as a complete observer stance:

- Choice of Instructional Strategies
  - Which instructional strategy/ies have been followed?
  - Did the teacher use one or more strategies?
  - Is the strategy suitable for these students? Why?
- Choice of pedagogical resources
  - What resources are used?
  - Are they adequate?
  - Is the choice justified by data?
  - Do they meert students' needs?
  - Are they differentiated? How?
- Use of metacognitive prompts
  - What prompts are used?
  - How often are they used
  - Do they indicate metacognitive strength in teacher? How?
- Response to emerging contextual effects
  - Did the teacher follow the lesson plan ?
  - Did she need to do adjustments?
- Response to different needs of students
  - Differentiation? Scaffold?
  - Any alterations to plan
- Evidence of metacognition knowledge in teacher
  - Choice of task
  - Choice of strategy
  - How information are passed to students?
- Evidence of metacognition awareness in teacher
- Evidence of Use of metacognition skill by teacher

Appendix F

A suggested flow chart of the convergent mixed method design in this research modified from Creswell (2015)

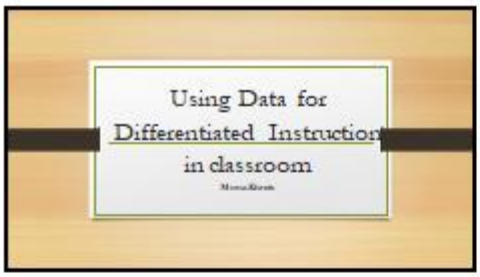


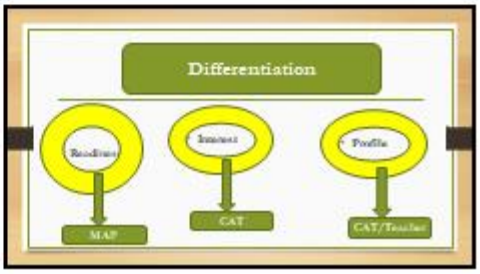
Appendix G

Note: credits to Michael Norton and Teachers.

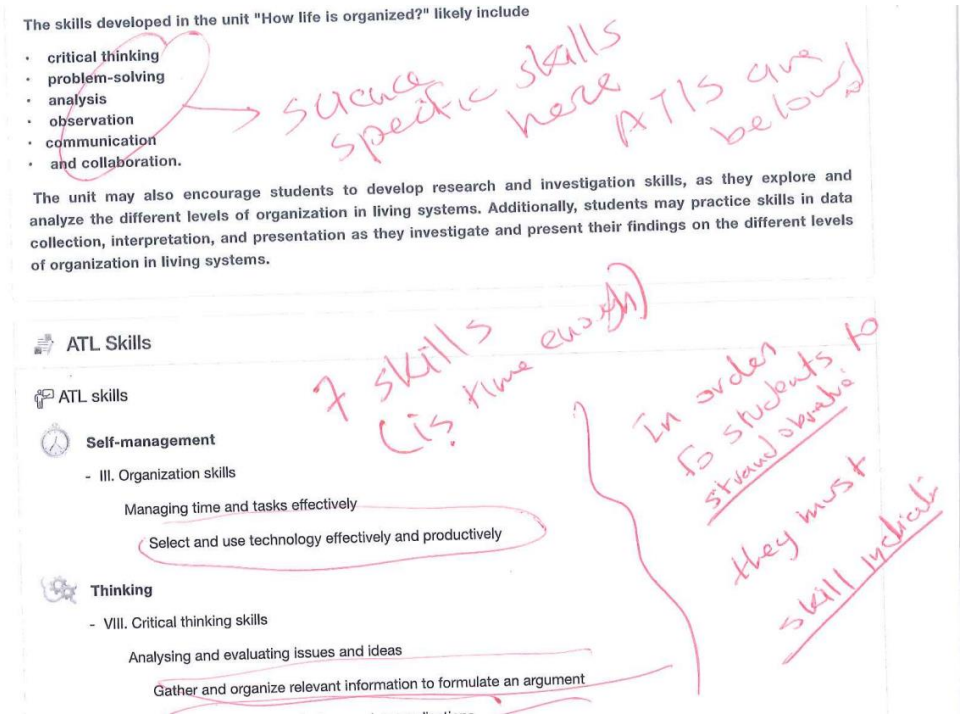
Appendix H

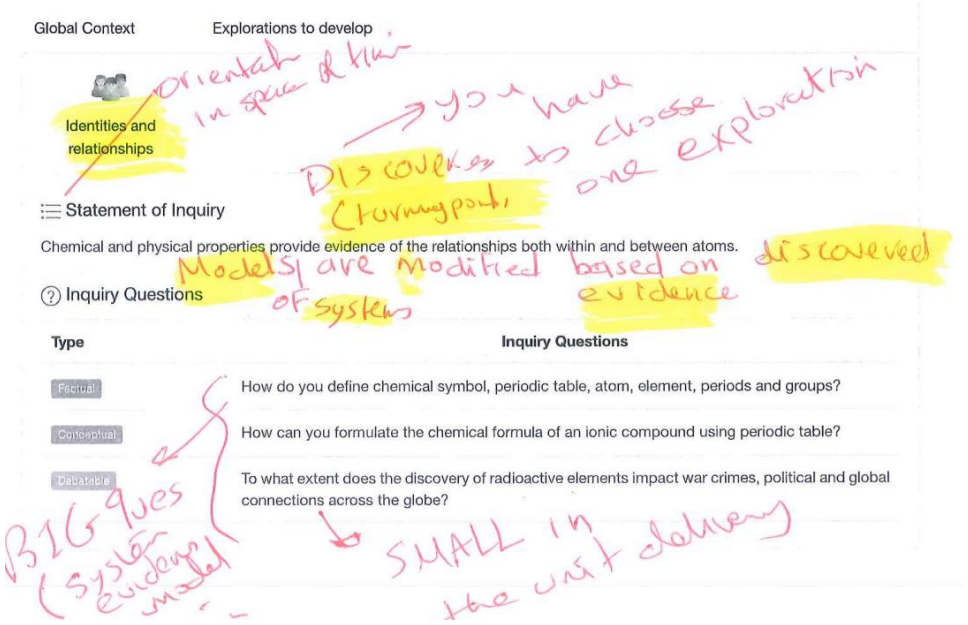
Power point slides





Appendix I





Note: Credits to Ruba Jeshi and teacher