Comparative Multiple Case Study into the Teaching of Problem-Solving Competence in Lebanese Middle Schools

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Abstract

This multiple case study investigates how problem-solving competence is integrated into teaching practices in private schools in Lebanon. Its purpose is to compare instructional approaches to problem-solving across three different programs: the American (Common Core State Standards and New Generation Science Standards), French (Socle Commun de Connaissances, de Compétences et de Culture), and Lebanese with a focus on middle school (grades 7, 8, and 9). The project was conducted in nine schools equally distributed among three categories based on the programs they offered: category 1 schools offered the Lebanese program, category 2 the French and Lebanese programs, and category 3 the American and Lebanese programs. Each school was treated as a separate case.

Structured observation data were collected using observation logs that focused on lesson objectives and specific cognitive problem-solving processes. The two logs were created based on a document review of the requirements for the three programs. Structured observations were followed by semi-structured interviews that were conducted to explore teachers' beliefs and understandings of problem-solving competence. The comparative analysis of within-category structured observations revealed an instruction ranging from teacher-led practices, particularly in category 1 schools, to more student-centered approaches in categories 2 and 3. The cross-category analysis showed a reliance on cognitive processes primarily promoting exploration, understanding, and demonstrating understanding, with less emphasis on planning and executing, monitoring and reflecting, thus uncovering a weakness in addressing these processes. The findings of the post-observation semi-structured interviews disclosed a range of definitions of problem-solving competence prevalent amongst teachers with clear divergences across the three school categories.

This research is unique in that it compares problem-solving teaching approaches across three different programs and explores underlying teachers' beliefs and understandings of problem-solving competence in the Lebanese context. It is hoped that this project will inform curriculum developers about future directions and much-anticipated reforms of the Lebanese program and practitioners about areas that need to be addressed to further improve the teaching of problem-solving competence.

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Abbreviations

English Language Arts	ELA
Center of Educational Research and Development	CERD
Cognitive Load Theory	CLT
Complex Problem Solving	CPS
Common Core State Standards	CCSS
Ministry of Education and Higher Education	MEHE
Next Generation Science Standards	NGSS
Organization for Economic Co-operation and Development	OECD
Program for International Student Assessment	PISA
Trends in International Mathematics and Science Study	TIMSS

Declaration Statement

No material contained in the thesis has previously been submitted for a degree in this or any other institution.

Statement of Copyright

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Chapter One

Introduction

1.1 Theoretical background

"Only with life do problems and values enter the world" (Popper, 1999, p.73). Popper considers problems as an inherent component of our lives and describes organisms as problem finders and problem solvers. Rapidly changing societies, globalization, technological advancements, global market demands, and competition are among the numerous factors compelling education stakeholders to emphasize the importance of developing in twenty-first century learners, the skills, abilities, attitudes, and values to adapt to the demands of contemporary societies. The ever-growing digitized world is significantly transforming the work environment. It is becoming technology-rich and team-based, often requiring multidisciplinary teams to deal with ill-defined situations, thus altering how information is used and with it the structure of the workforce. At the dawn of the twenty-first century, humanity is said to be confronted with four main imperatives: seeking an innovative and creative economy, reducing inequalities through social justice, maintaining sustainable living through reaching original and technological solutions, and finally, producing a new cohort of skilled and responsible leaders (Hargreaves, 2010). Advocates of twenty-first century skills preach about developing independent learners, critical thinkers, problem-solvers and decision-makers through education.

Education has always faced the challenge of improving students' minds to enable them to solve novel problems that confront them. Among the most significant challenges confronting educators is teaching in ways that allow students to apply what they have learned, use it in new situations, and enhance their problem-solving capacities (Mayer &Wittrock, 2006). Success is framed in terms of developing in twenty-first century learners the abilities to communicate, share and use information to problem solve and, even more importantly, adapt and innovate. Adaptability and unpredictability are defining characteristics of the twenty-first century to deal with uncertainty (Binkley et al., 2012). Integrating, synthesizing, and creatively applying content knowledge is essential when confronted with novel situations.

Cultivating students' minds, assisting them in developing their reasoning skills, and applying knowledge beyond the school context are as old goals as the goal of schooling itself (Dede, 2007). Collaboration, creativity, and problem-solving were targets in the 20th century; however, a small proportion of students were required to put into application these skills in everyday life outside the classroom. Dede notes that despite the strong emerging need to address the complexity of present times, the 20th century teaching legacy continues to impact current pedagogical thinking and practices with the pervasiveness of approaches favoring learning about rather than learning to do. Conceiving knowledge as revealed truth, an independent entity separated from skills, and isolating problem-solving skills from their application to knowledge are other examples of practices that contradict the concept of knowledge as a constructed understanding making the transfer to real life settings even more challenging.

While problem solving is regarded as a major educational goal, Van Merriënboer (2013) compares a scientific discussion on problem solving to the Tower of Babel due to the difficulties in reaching a consensus on how to teach it. Underpinning the challenge in teaching problem solving is the disagreement among educational researchers and practitioners on the definition of problem solving. Van Merriënboer identifies four of these definitions. The first definition describes problem solving as applying weak methods to solve unfamiliar problems in any domain. The second definition refers to strong methods, typically domain-specific methods used to deal with well-structured problems. The third definition includes knowledge-based methods which fall mid-way between weak and strong methods. Finally, the fourth definition combines well-structured and ill-structured problems and is relevant to real-life problem solving. Authentic learning tasks are related to the fourth definition. These real-life problem tasks are increasingly perceived as the driving force for teaching and learning. It is through engaging learners in solving real-life problems that learning is further enhanced. In this respect, Merrill (2002) considers that the most effective learning products or environments are problem-centered, built on five "prescriptive design principles for problem-centered instruction" (p. 45). In addition to considering problem-centered environments as the first principle of learning, the other four principles conceive learning as further enhanced when learners are given the opportunity to engage in real-world problems, when the activation of their prior knowledge leads to the acquisition of new knowledge, when this new knowledge is demonstrated, applied and integrated into the learner's world.

Developing the ability to solve real-life problems and transfer problem-solving skills to deal with problems in cross-curricular contexts were among the targeted learners' capacities for evaluation. The assessment of problem-solving skills in PISA 2003 came as a response to the rising need to find means to measure the impact of innovative methodological practices. Within the PISA 2003 assessment framework for assessing Mathematics, Reading, Science and Problem-solving knowledge and Skills, problem-solving competencies are defined as:

> "…an individual's capacity to use cognitive processes to confront and resolve real, cross-disciplinary situations where the solution path is not immediately obvious and where the content areas or curricular areas that might be applicable are not within a single subject area of mathematics, science or reading" (OECD, 2004, p. 26).

This definition brings to the fore an understanding of problem-solving processes that involve putting students in a problem situation where they demonstrate their abilities to understand and characterize the problem, represent the problem, take decisions, analyze and propose solutions to solve the problem, reflect on the solutions, and finally communicate the problem solution (OECD, 2004). Pellegrino and Hilton (2012) describe twenty-first century competencies as encompassing the acquisition of knowledge in a specific domain to include how, why, and when to use this knowledge to solve problems. The ultimate aim is to allow learners to adapt, generalize, and apply across different contexts. The development of transferable knowledge reflects the close relationship between twenty-first century competencies and deeper learning. Such a relationship is embedded in the concept of transfer. Pellegrino and Hilton describe deeper learning as a learning process with twenty-first century competencies as the learning outcomes of this process. Problem-solving competence needs not to be taught in separate courses; it can be acquired within subject-specific domains to ensure its development into transferable skills (Mayer & Wittrock, 2006). However, the transfer of knowledge and reasoning skills acquired in specific domains is not an automatic mechanism; for it to occur, it requires an "active facilitation" (Scherer & Beckmann, 2014, p. 19). Taking the concept of transfer beyond the domain-specific principle (Mayer & Wittrock, 2006), Scherer and Beckmann observe that efforts to improve students' problem-solving competence can be achieved through fostering problem-solving competence within certain subjects such as math and sciences.

The emphasis on complexity highlights the role of problem-solving competency across the various occupational fields. Fisher and Neubert (2015) note that important questions are directly linked to complex problem solving and the concept of complexity, such as understanding what complex problem situations entail, the connection of complex real-life problems to psychological constructs, and how these constructs facilitate solving authentic problems within and across disciplines. Dealing effectively with the complexity of non-routine situations in the different domains brings a shift from the well-defined analytical forms of problem-solving thinking into dynamic, interactive and collaborative elements. According to Funke, Fischer, and Holt (2018), it is an approach in which problem solving is conceived of building models of dynamic processes, making predictions, and implementing planned and practical actions to overcome obstacles. It is a process that requires cognitive and non-cognitive factors. This is where a fundamental shift occurs: s shift from viewing problem solving solely as a cognitive activity to a system thinking comprised of analytic, creative, and pragmatic thinking. Solving complex problems, as Fischer and Neubert (2015) contend, generally brings forth many interrelated elements. Typically, it requires dealing with a lot of information with more or less relevance to problem solving (complexity). Furthermore, it considers multiple effects of actions (interconnectedness) while expecting that the process is happening with incomplete knowledge of the effect of the various interventions ("intransparency"). Consequently, a dynamic adjustment of the course of action ("dynamic decision-making") is continuously required (p. 2).

In spite of the rich and fruitful research on complex problem solving (CPS), research in the field has been mostly based on empirical data at the expense of theoretical considerations (Fischer, Greiff, & Funke, 2012). Beckmann (2019) further highlights this point stressing the conceptual ambiguity and the challenge of defining complex problem solving. The concept of CPS is either taken from a narrow perspective reducing it to a skill, or from a wide perspective upgrading it to a competency. Beckmann points out that such a conceptual flexibility is in itself problematic, especially since ability, skill, and competency are treated as synonymous, causing vagueness instead of shedding clarity. The absence of a common framework in complex problem solving presents an important obstacle to properly and beneficially integrating the insights and findings from studies over more than four decades. Addressing questions about where and how to position

CPS at the conceptual, methodological, and psychometrical levels remains a pending matter (Beckmann & Goode, 2017).

Bringing the focus to teaching, the discrepancy between what learners need to know in dealing with complex, ill-structured problem-solving situations and what formal education is actually offering is a complex, ill-structured problem that instructional designers are expected to deal with and improve (Jonassen, 2000). The limited understanding of the breadth of problem-solving activities and the insufficient acknowledgment of problem solving in instructional design literature constitute important reasons for the inaptitude in engaging and supporting students in problem-solving situations. When problem solving is at the center of practice in contemporary learning theories such as student-centered learning environments, open-ended environments, and problem-based learning, Jonassen contends that this is one more reason for focusing on problem-solving. Kirschner (2009, p. 144) observes that a strong debate today is splitting practitioners and researchers into two ideological camps. On the one hand, there are old-school educators with their classical "sage-on-the-stage", didactic, and expository approaches to teaching and learning. On the other hand, there are the constructivists, described as the "fuzzy-brained" social constructivists, whose beliefs are rooted in a conception of learners who can only learn by constructing their own knowledge and action through undirect experiences. While this debate has widely disseminated into discussions on teaching and learning, neither camp, according to Kirschner, is correct, and the "truth" is somewhere in the middle.

Hence, two fundamental issues are at stake when considering complex problem solving. While there is a general agreement about the necessity to deal with the complexity that describes real-life problems, at the practical level, it is not as evident to frame complex problem solving and identify the best ways to translate it efficiently into instructional processes.

In summary, the panorama that has been presented aims to highlight the complexity of the issues surrounding the teaching of problem-solving competence. Underpinning the challenges educators and practitioners in the educational field are facing is a fundamental shift in emphasis from assessing whether students can apply what they have learned to whether they can "extrapolate" and apply in a new context (Schleicher, 2007). The PISA definition of problem-solving competence emphasizes the role of the learner's abilities to deal with complexity in varied contexts through activating various forms of resources including knowledge, skills, motivation, attitudes, and emotions, in addition to other social and behavioral components (Schleicher, 2007). The necessity for individuals to acquire transferable knowledge and skills is accompanied by the challenge of creating learning environments that enable twenty-first century learners to acquire and develop cognitive, interpersonal, and intrapersonal competences for transfer in new situations. Pellegrino and Hilton (2012) note that there are limitations to how far the knowledge and skills acquired can be transferable. They frame transfer in terms of the effectiveness of instructional methods, the development of knowledge that can be possibly retrieved and transferred to new situations, and extensive practice accompanied by continuous feedback.

Thus, ensuring the successful transfer of learning is the crux of the challenges underpinning problem-solving teaching and learning. This research project was motivated by a desire for a comprehensive understanding of the complex relationship between conceptual understanding of problem solving and its translation into teaching practices. The Lebanese context, where many foreign programs are offered in addition to the Lebanese program, presents a rich opportunity to inquire about instructional approaches and how they facilitate the integration of problem-solving competence into teaching. This study was motivated by the possibility of comparing various approaches to problem-solving teaching across different programs and within the same context. It was an instigator to conduct this study that was driven by the following overarching question:
How does the teaching of problem-solving competence -at the middle school level- in Lebanese private schools compare across different curricula?

1.2 Setting the context

My particular interest in twenty-first century competences and their integration into teaching practices stemmed from more than three decades of experience as a middle school teacher and then as a principal in one of the largest schools in Lebanon. The exposure to the different programs offered at school, the American program, the French Baccalaureate Program, the International Baccalaureate Diploma Program (IBDP), in addition to the Lebanese program was undoubtedly a unique opportunity to immerse into the various approaches and methodologies underlying each, and a driving force to compare between approaches to teaching and learning. The need to develop an in-depth understanding of the requirements of the four programs, their nuanced similarities, and differences and the way they are translated into teaching and learning was an extremely enriching experience. Discussions on practices, methodologies, approaches, and programs necessarily converge into professional exchanges on what education in the twenty-first century calls for, bringing in the multiple perspectives of the different programs.

Several reasons underpinned my decision to embark on a study focusing on problem-solving competence in middle school (grades 7, 8, and 9). First, my experience as a teacher and principal is rooted in this cycle providing a compelling personal reason to investigate problem-solving competence in middle school. Second, this cycle occupies a strategic position when considering two international assessment exams, TIMSS (Trends in International Math and Science Study) and PISA (Programme for International Student Assessment), with the former test administered in grade 8 and the latter in grade 10. The low national performance on these large-scale assessment tests constituted a strong reason to ponder on the teaching practices as well as the assessment means that yielded such a low performance. In a country where obtaining an outstanding national result on the French Baccalaureate exams and the International Baccalaureate Diploma is not unusual, it is somewhat paradoxical to have such contrasting results. The impetus for this exploratory study was the search for explanations to clarify the observed differences in student performance. The third and final reason behind choosing the middle school cycle as the focus of this study is related to the programs offered. An important number of private schools in Lebanon offer at least one foreign program in addition to the Lebanese program. If this offering is a source of richness, it is also a source of complexity, particularly at the middle school, where a clear separation between programs is not always possible. This makes this cycle an intriguing subject for a comparative investigation based on programs' requirements, how they are translated into instruction, and teachers' beliefs that shape teaching approaches. For all of the above reasons, the middle school provided the cycle of interest and focus for the study. A brief overview of the Lebanese educational system is presented in the next section to shed light on the structure of schools, vis-à-vis their program offerings.

1.3 Overview of the Lebanese educational system

The education system in Lebanon is a centralized system with the public and private sectors regulated by the Ministry of Education and Higher Education (MEHE). The public sector is well-established but suffered tremendously in the last three decades due to the civil war, followed by a long period of political and economic instability till the present. This sector is surpassed by a dynamic, diverse, and highly competitive private school sector, which has given the Lebanese educational system a distinguishing position with a respectable and reliable reputation in the Middle East. Its diversity stems from the privileged geographical position of Lebanon, which historically turned this country into a crossroad of civilizations. This is reflected in the teaching of languages, where in addition to Arabic, the mother tongue, French, and English are taught as second and third languages. Schooling in Lebanon is compulsory through grade 9 (age 15).

The Lebanese national curriculum is offered in all public and private schools. In addition to the national curriculum, the private sector has the option of providing a foreign curriculum, such as the French Baccalaureate Program, the International Baccalaureate Program, or the American one. Moreover, private schools have the freedom to implement the teaching and assessment methodologies of their choice. They are allowed to bring foreign hire teachers and staff provided they abide by the laws of the Ministry of Labor. All Lebanese students take two national high-stakes examinations. The Brevet examination is designed for ninth-grade students between the ages 14 and 15. Students are examined in nine different subjects, and these exams are aligned with national standards. The Brevet diploma is a pre-requisite for admission to upper secondary education. After the completion of the Brevet, a minimal number of students opt for vocational education. This path has not improved for at least three decades and was tremendously affected by the civil war. The other high-stake examination, the Lebanese Baccalaureate, is taken by students in grade 12. Similar to the Brevet, it is aligned with national standards. The satisfactory completion of this exam is a prerequisite to transitioning to higher education. The Ministry of Education and Higher Education directly controls the organization of these exams. This includes devising the tests, implementing them nationwide, and analyzing results.

1.3.1 Grade 9, a pivotal grade level

The Brevet examination possesses a strategic importance: it falls in year 9, a pivotal year in the life of students. After successfully passing the Brevet, students may opt to continue in one of the following paths: Lebanese Baccalaureate Program (Grades 10, 11, and 12) French Baccalaureate Program (Grades 10, 11, and 12), International Baccalaureate Diploma Program, IBDP (Grades 11 and 12), or American program.

The French Baccalaureate diploma is officially equivalent to the Lebanese Baccalaureate one. To understand the reasons behind this equivalency, it is necessary to shed light on the privileges the French educational system possesses in a large number of schools in Lebanon. Historically, Lebanon was a French mandate, and after its independence in 1945, Lebanon maintained a special relationship with France. French missionaries were among the first groups to intervene in the Lebanese educational system through the establishment of a network of schools. These schools cater to the French Baccalaureate Program. The equivalency of the French baccalaureate with the Lebanese one facilitates students' access to universities in Lebanon and abroad. Other foreign programs, such as the International Baccalaureate Diploma Program (IBDP) and the American program, gained in popularity among Lebanese looking for an English program. Recently (February, 2019), the Ministry of Education approved the equivalency of the IBDP diploma with the Lebanese Baccalaureate. Hence, Lebanese students have the possibility, after succeeding in the Brevet exams, to opt for one of these foreign programs (French Baccalaureate, IBDP, and American high school) or continue in the national program track. Students who fail may repeat the year, drop schooling, or shift to vocational and technical education.

1.3.2 The reality of the Lebanese educational program

It is regrettable that Lebanon's last major curricular reform occurred in 1994 when the foreign programs underwent several major reforms to adapt to the demands of the twenty-first century. In 2000, the Ministry of Education and Higher Education developed a comprehensive plan which identified strategic directions to improve the quality of teaching in Lebanon. It resulted in the publication in 2010 of a plan consisting of broad recommendations. To date, the 2010 reform plan is, alas, still frozen; its implementation faced all sorts of political and economic obstacles.

Pointing at some of the challenges that Lebanon and other Arab countries face, Bashshur (2005, p. 293) considers that what is needed is " a complete focus of attention from relying on big dreams, big goals and big words and stressing on what the actual educational act takes place: the classroom and the school, the learners and the teachers, and all what they need to succeed in their mission". Karami Akkary (2014) believes that the "top-down" political preponderance in advancing prefabricated reform ideas indicated the failure to consider the various factors that may hinder the implementation of any effective reform. School-based bottom-up initiatives are needed to drive the change and be supported and congruent with top-down policymaking. Although the Lebanese educational program has been renowned for its rigorous math and sciences curricula, the results of TIMSS for the last ten years reveal a gap between this perception and the actual meager results. Karami Akkary argues that the poor results on TIMSS are essentially due to the failure to bring change to improve the teaching practices, the school climate, and consequently, students' achievement. She considers that improvement in students' performance can be accomplished through a "culturally grounded understanding" (p.18) of internationally agreed upon effective practices for school improvement and implementation practices.

1.4 Aim, scope and research questions

1.4.1 Aim and scope of the study

This study is a systematic exploration of the approaches to teaching problem-solving competence, considering private schools in Beirut, Lebanon which cater to one or more programs in addition to the Lebanese program. It examines teachers' understandings and investigates how problem-solving competence is integrated into instruction at the middle school level, grades 7 to 9. Only private schools are considered in this project, as public schools only offer the national program. For the scope of the project, only schools in central Beirut are included in the sample.

1.4.2 Research questions

As presented before, the overarching question framing this study is the following:
How does the teaching of problem-solving competence -at the middle school level- in Lebanese private schools, compare across the different curricula?

To address it, the investigation poses three sub-questions:

a- What are the teaching practices that delineate the curricular requirements for the teaching of problem-solving competence in middle school?

b- How does the teaching of problem-solving competence reflect each of the curricular requirements in middle school?

c- How are the teaching practices of problem-solving competence influenced by teachers' understanding of the requirements of the different curricula in middle school?

1.5 Significance of the study

This comparative study aims to offer insights into the extent to which the programs prepare students for the demands of the new millennium, focusing on problem-solving competence. The urgent calls arising- in the Lebanese arena- for a radical and comprehensive reform of the national educational programs, accentuated by the low performance of Lebanese students on international assessment exams, such as TIMSS and PISA, prompted an interest to examine how schools are integrating problem-solving competence into instruction. The purposeful selection of three categories of schools allows comparisons and examination of contrasts in how problem-solving competence is fostered in the middle school cycle, taking into account the Lebanese, French, and American programs. Such a comparison of teaching approaches is expected to reveal the programs' strengths as well as weaknesses in facilitating the teaching of problem-solving competence within the Lebanese context, allowing to raise recommendations and propose directions for any future and much-anticipated reforms. Albeit the pedagogical concern has been concentrating on encouraging learning "beyond the box", this has not been accompanied by a deep interest to turn to "inside the box" priorities that need to be addressed as well (Broadfoot, 2000). It is the "inside of the box" that this project examines: looking into classrooms and exploring perceptions and understandings through a blend of methodologies. As Broadfoot puts it,

> "It is the unique privilege of the comparitivists to straddle cultures and countries, perspectives and topics, theories and disciplines. Thus, we have a particular responsibility to carry the debate beyond the discussion of means alone. And towards ends" (p. 370).

1.6 Structure of the thesis

Following this introductory chapter, which aimed to lay out the context for the research project's interest, the questions sought, and the significance of the study, chapter two, the literature review, addresses the concept of problem-solving competence by examining its multifaceted aspects. It depicts instructional approaches that facilitate integration, with a discussion framed by Sweller's Cognitive Load Theory (CLT). Chapter three, the methodology, provides a detailed description of the research design delving into the nature of the sample and sampling strategy, and the methods and procedures for data collection. Issues related to the validity of the findings are examined. In addition, findings of the pilot phase, the precursor of the main empirical phase are described. Chapter four presents the documentary analysis of the three concerned programs. The chapter outlines the learning outcomes in connection with problem-solving competence as prescribed by each of the three program's offerings. Chapter five is devoted to the analysis of structured observation data followed by chapter six which deals with the analysis of post-observation interview data. Chapter seven combines documentary data analysis with analysis of data derived from structured observations and interviews, putting together the results of the analytic processes in order to offer a holistic description and discussion of the phenomenon under study. Moreover, the key findings of the research project are summarized and conclusions are drawn. This includes outlining the main contributions, reflecting upon the study and its limitations, and the implications of the findings for practice and future research.

Chapter Two

Literature Review

2.1 Introduction

The literature review investigates the multi-faceted features of problem-solving competence that underpin its conceptual complexity. The first part of the chapter outlines and describes the different forms of problem-solving competence, taking into account specific, general, and collaborative problem solving. Then, using Sweller's Cognitive Load Theory (CLT), various issues in connection with approaches to teaching and learning are examined. Instructional practices that facilitate problem solving are addressed, and arguments supporting guided instruction in problem solving are presented. The implications of the learning environments that facilitate problem solving are discussed before concluding the chapter with some closing thoughts.

2.2 Perspectives on problem-solving competence

Research on twenty-first century competences and skills has flourished with the rapid advances in technology and the resulting changes in the nature of the workplace. Globalization and major technological advances impacted the world economies and societies, causing a fundamental shift in pedagogical understandings and approaches. The list of twenty-first century skills includes but is not limited to creativity, flexibility, self-efficacy, fluency in information and communication technology, the ability to solve complex problems, teamwork, decision-making, social skills, cross-cultural skills, and civic literacy. Dede (2007) describes twenty-first century skills as a conceptual construct that develops through future research and presents a thriving force for all stakeholders in education to build strategic plans to manage complexity and deal with uncertainty. While such a change does not eliminate the role of routine cognitive skills in instruction, it rather de-emphasizes fluency in routine processes as an end of itself to consider them as substrates for mastering complex cognitive capabilities that will be valued in future workplaces. As Dede contends, "problem finding, the front end of the inquiry process" encompasses making observations, drawing inferences, formulating hypotheses, and experimenting. These processes, among many others, are essential to provide opportunities for a "work team" to problem solve (p. 20). Both individual and team metacognitive procedures are vital to construct meaning out of complexity. A range of definitions is offered for twenty-first century skills and competences. The terms competences, competencies, and skills are sometimes used interchangeably in the literature or with some minor differences varying with countries and languages. Ananiadou and Claro (2009) suggest that the distinction provided by the OECD is a useful one, indicating that the concept of competence is not limited to knowledge or skills, but has a broader scope encompassing the ability to respond to complex demands, bringing in psychosocial resources, including skills and attitudes.

The different frameworks for twenty-first century skills or competences show a relative agreement as to the key competences needed for the preparedness of twenty-first century students. Voogt and Roblin's (2012) study synthesizes the different policy frameworks developed to integrate twenty-first century competences. Three of the different frameworks had been initiated by international organizations (EU, OECD, UNESCO); the remaining ones were supported by private organizations. This study shows that the different frameworks are, to a large extent, consistent in terms of identifying twenty-first century skills /competences. All of the frameworks include competences in communication, collaboration, information and communication technology (ICT) in addition, to social and /or cultural awareness. Creativity, critical thinking, problem solving, and the capacity to develop quality products and productivity related-matters have their predominant place. ICT occupies the core of each framework. The development of ICT entails a need for the identification and development of new competences by all frameworks. As for the differences between the different frameworks, they mainly reside in the overarching importance accorded to the various competencies and the way they are grouped and classified. For instance, Dede (2010) notes that OECD framework puts more emphasis on affective and psychological skills compared to frameworks developed by US organizations. For example, "students acting autonomously" constitutes an important category in the OECD framework, when it is not the case in the US frameworks.

Pellegrino and Hilton (2012) present three domains for grouping twenty-first century skills: cognitive, intrapersonal, and interpersonal domains. The cognitive domain includes thinking abilities such as reasoning, problem solving, and memory. The intrapersonal domain contains feelings, emotions and self-regulation, and the interpersonal domain consists of the competences used as forms of expressions, interpretations of both verbal and non-verbal messages, and ways of responding appropriately. The different twenty-first century skills are assigned to various "clusters" of competences within each of the three domains. These skills represent the knowledge that is applied and transferable to new situations. It is the "blend" of transferable knowledge and skills that, according to Pellegrino and Hilton, is referred to as twenty-first century competences. The implementation of twenty-first century competences is regarded by Voogt and Roblin (2012) as one of the most controversial issues: how to define their role and the place they occupy in the curriculum are complex questions that must be addressed when considering school curricula. Essentially, three general approaches have been proposed for implementation: twenty-first century competences can either be added as new subjects or as new content within traditional subjects, be integrated as cross-curricular competences or be part of a new curriculum. While they are different approaches adopted, most frameworks favor the integration of competences across the curriculum due to their complex and cross-disciplinary nature.

The European framework of key competences, adopted by the European Parliament and the Council in December 2006, identifies eight key competences for life-long learning. It considers them equally important and to a certain extent, they intertwine and overlap. The first three competences are directly connected to traditional subjects, whereas, the other five possess a cross-curricular nature and require transversal abilities and skills, such as critical thinking, creativity, sense of initiative, problem solving, risk assessment, and constructive management feelings. Successfully promoting these cross-curricular key competences, as Gordon et al. (2009) put it, necessitates a different approach to teaching, entailing a cultural and organizational change at the school level. These key competences will be the subject of overview and discussion in chapter four on document review of program requirements as they underpin the French Program, a subject of focus in this study. This framework puts emphasis on cross-curricular themes which are regarded as valuable means of promoting these competences.

While there is a strong call for the necessity of enabling twenty-first century learners to acquire these skills, the fact remains that clear definitions and methods to develop and measure them are yet to be established. Van Merriënboer (2013) highlights this issue and notes that since problem solving is anchored in complex cognitive processes about which there is still much to discover, a thorough understanding of the breadth and complexity of problem-solving processes is indispensable to succeed in effectively engaging learners in them.

2.3 Problem solving, a complex construct

> "*The central point of education is to teach people to think, to use their rational powers, to become better problem solvers*" *(Gagné, 1980).*

There is a general consensus in the literature that the meaning of problem-solving competence encompasses the knowledge, the skills, and the attitudes or the abilities. Fischer and Neubert (2015, p. 1) define this competence as "a bundle of skills, knowledge and abilities, which are required to deal effectively with complex non-routine situations in different domains". As a twenty-first century competence, problem-solving competence is presented as a construct necessary to deal effectively with the complexity of non-routine situations in the different domains. It brings to the fore a holistic thinking approach, one in which analytic, creative, and pragmatic thinking processes are intertwined. Funke, Fischer, and Holt (2018) consider that dealing with non-routine situations requires the creation of new paths of action to overcome barriers and seek goals. Flexibility in dealing with acquired knowledge, adjusting and adapting it to new and non-routine situations, as well as malleability of cognitive abilities, are required for effectively dealing with rapid societal changes. Albeit higher-order thinking systems are necessary to create these paths, heuristics and metacognitive strategies interplay in the problem-solving solution process. Thus, problem solving can be considered a regulation process that regulates both cognitive and non-cognitive factors (Funke, Fischer, & Holt, 2018).

Problem solving, in its broad meaning, is defined by Mayer and Wittrock (2006, p. 287) as "cognitive processing directed at transforming a given situation into a goal situation when no obvious method of solution is available". This definition consists of four main elements of problem solving: cognitive, process, goal-oriented, and personal, when a problem-solver's knowledge and skills determine the level of difficulty in overcoming obstacles to reach solutions. Several cognitive processes underpin problem solving. They include representation, planification and monitoring, execution, and self-regulation (Mayer & Wittrock, 2006). Within the PISA 2012 problem-solving framework, these cognitive processes were grouped into four dyads or strands. The groupings included exploring and understanding, representing and formulating, planning and executing, and monitoring and reflecting (OECD, 2014).

2.4 Two ends of the spectrum

Current educational systems face the challenge of fully exploiting students' cognitive abilities in the area of "domain-general problem solving" needed for the personal development and fulfillment in the twenty-first century. Greiff et al. (2014) present domain-general problem solving as one of the most important cross-curricular skills. It includes skills needed to deal with cross-curricular problems that characterize the technology-rich and fast-paced contemporary societies. Domain general problem-solving competence is described as,

> "It [domain general problem-solving competence] touches on several cognitive and non-cognitive skills such as information processing, representation and evaluation of knowledge, reasoning, self-regulation, meta-strategic thinking, proactive planning, and decision making" (p.75).

Examples of recurring efforts, such as testing this skill in large-scale international assessments such as PISA, demonstrate the growing attention given to this skill compared to domain-specific problem-solving skills. Domain general problem-solving strategies are sought to help students develop structured, semi-structured, and heuristic processes when approaching new problem situations. Facilitating domain-general problem-solving skills, as Greiff et al. contend, is a challenging endeavor due to the complexity of the processes inherent in these skills. Examples of such processes comprise focusing on relevant information and being able to discard irrelevant ones, constructing a mental representation of knowledge and drawing links with existing knowledge, selecting specific actions and relevant operations when seeking a goal, and verifying the validity of mental models. Emphasis should be placed on training students to apply the relevant problem procedures outside the particular context to identify similarities and draw comparisons between the different situations. The decontextualization of thinking processes from their content needs special attention.

Fischer and Neubert (2015) suggest that domain-general and domain-specific competences constitute two ends of a continuum. One end is formed of "content neutral cognitive structures" (p. 2), such as working memory, and the other end consists of the very specific knowledge located in long-term memory. The position they are proposing is regarded as a conciliatory position, a middle ground between two extremes. On one extreme, a strong position is based on the assumption that success in problem solving heavily depends on a limited set of domain-general skills that defines performance across various problems. On the other extreme, opponents to this position strongly advocate the perspective that emphasizes the importance of domain-specific knowledge and expertise. Mayer and Wittrock (2006), strong advocates of the latter position, consider that "teaching of domain-specific thinking skills represents one of the educational psychology's greatest successes" (p. 296). They argue that one of the principles of problem solving is to teach problem-solving skills in connection with specific domains, referred to as "domain specific principle" thus highlighting the high degree of knowledge specificity. The conciliatory position Fischer and Neubert (2015) propose, acknowledges the interplay of a multitude of influences and constructs when dealing with complex tasks, as well as the relevance of constructs across complex problem tasks. It considers problem-solving competence as,

> "… the product of the combination of domain-general facets that are relevant across complex problems (e.g., intelligence) and domain-specific facets (e.g., problem-specific knowledge) with the degree of importance of these elements varying in accordance with the problem situation at hand" (p. 6).

Kalyuga, Renkl, and Paas (2010) propose the concept of flexible problem-solving skills within the same perspective on the continuum of domain-general and domain-specific problem-solving competence. This category of skills is not considered a separate entity of skills but a feature of domain-specific structures. The argument rests on the distinction between different levels of knowledge, and presents a category of knowledge structures possessing higher levels of generality than the ones needed to deal with routine situations in a specific domain. Function-Process-Structure schema adopted from technical domains is suggested as an example of generalized schematic knowledge. This triad generates an interwoven mix of elements resulting in a hierarchy of knowledge structure. This schema is neither specific nor absolutely general; it is at a medium level of generality. Making such a schema explicit in instruction could possibly help learners develop flexible problem solving in a domain. While they belong to domain-specific structures, the flexibility they possess gives them possibility to go beyond their particular domain of application.

Scherer and Beckmann (2014) introduce the concept of math-science coherence. It is defined as the set of cognitive processes, such as reasoning and information processing, that are included in both disciplines and hence, independent of domain-specific knowledge. As such, a low math-science coherence means that students succeed in acquiring knowledge and skills in math, yet it does not necessarily imply that they are successful in acquiring knowledge and skills in science, and vice versa. Based on such formulation, the assertion is that math-science coherence improves problem-solving performance by facilitating the transfer of knowledge, skills, and insights across subjects. The study's findings suggest that the higher the levels of coordination between math and science education, the more positive the effect on the acquisition of cross-curricular problem-solving competence. Even more importantly, findings show that in order to improve problem-solving competence, it is necessary to ensure a coordinated improvement of both math and science literacy while stressing the acquisition of problem-solving competence within the two subjects. Reaching a higher level of curricular coherence is expected to "create effective transitions of subject-specific knowledge and skills into subject-unspecific competences to solve real-life problems" (p.19).

Despite the fact that domain-general problem-solving approaches may help solve problems in an unfamiliar situation, Van Merriënboer (2013) questions the role of domain-general problem solving or weak methods in dealing with unfamiliar and new situations across the different domains, providing three main reasons to justify his claim. First, the effectiveness of these weak methods depends on the correctness of the information upon which they operate. They fail to generate acceptable behavior when the information derived from the outside world or the learner's memory is incorrect. Second, using of weak methods is highly costly; the process is slow, most often leading to unsuccessful ends. More importantly, it puts an extremely heavy load on the working memory. The interpretation of declarative information (facts and concepts) requires an ongoing retrieval of this information, whether from memory or the outside world, thus remaining active in the working memory. Third, it is generally assumed that weak methods are innate, and it is not possible to teach them because they are 'wired' into the human cognitive architecture.

Bringing the scope of the discussion to the classroom level, Greiff et al. (2014) identify three main challenges for promoting domain-general problem-solving skills in educational contexts. The first challenge requires raising awareness that these skills exist and are relevant. Teachers of all subjects must promote these skills to enable their students to use them beyond a specific context. They must encourage students to look for similarities and recurrences across problem tasks. This cannot be achieved without an explicit integration into the extant domain-specific school curricula. Such an integration entails teachers, irrespective of the discipline they teach, create situations to help their students acquire the flexibility to apply relevant problem-solving processes beyond the specific context. More importantly, students must be trained to identify similarities and recurrences across problem situations. The second challenge is to make these skills visible to teachers as they often go unnoticed when students apply them because of the diverse cognitive processes involved. The third challenge is integrating problem-solving within professional development and training, which still needs to be well-established. The three challenges are closely intertwined and presuppose a clear description of the strategies involved in domain-general problem-solving. While domain-general problem solving was sought as a response to the need to work in novel environments, face problems that were never previously encountered, and apply skills that are not linked to a specific domain, some positions remain skeptical about general-problem solving domain abilities. These positions emanate from the belief that possessing domain knowledge relevant to the problem-solving task is a condition to solve problems successfully (Mayer, 2013) and that domain-general problem solving is not strongly supported as an educational goal (Van Merriënboer, 2013).

Dealing with the issue of transfer, which constitutes the underlying drive for domain-general problem-solving thinking shifts the focus to complex problem solving (CPS). These considerations are based on designing problem tasks in such a way as to be similar to real-life situations. The definition of CPS proposed by Fischer, Greiff, and Funke (2012) is underpinned by three concepts: complexity, problem, and problem solving. It is defined as "a) knowledge acquisition and b) knowledge application concerning the goal-oriented control systems that contain many highly interrelated elements (i.e., the complex systems)" (p. 19), thus, portraying CPS as a kind of problem solving with many highly interrelated elements, giving it its complexity. Dealing with complex problems requires the problem solver to move between phases in a complex way. The knowledge acquisition assumption is that the problem solver explores the system in the best suitable way resulting in some knowledge that must be applied to achieve the goals. This assumes making assumptions about the strategies for identifying interventions that have acceptable consequences. Furthermore, in the monitoring process, the problem solver is supposed to detect progress in light of the feedback provided and make decisions about future steps.

It is worth noting that CPS remains an abstract concept in need of further research to identify its concrete operations. The lack of agreement over a unified meaning of CPS is one of the reasons for the lack of coherence in CPS studies. Beckmann and Goode (2017) identify four different meanings. The first is used to represent a paradigm where research focuses on information processing, decision-making, and causal reasoning. The second meaning is associated with ability constructs, such as the ability to manage uncertainty, whether it is connected or not with intelligence. The third is used in large scale assessment, and the fourth is a label for a certain type of behavior exhibited when confronted with a specific challenge. The disagreement over the term complexity presents "a major roadblock" (p. 3) for progress in CPS research. Depicting the various facets of problem-solving construct carries to collaborative problem solving, which is gaining increasing attention, and identified by OECD as a key skill for the twenty-first century.

2.5 Collaborative problem solving

Collaborative problem solving came to the fore as a promising twenty-first century skill as it draws upon different social and cognitive skills that are teachable and measurable within classroom settings. Incorporated into testing in PISA 2015 and the ATC21S (Assessment and Teaching of Twenty-First Century Skills), it constitutes a shift in focus from individual skills. Collaborative problem solving, as described by Hesse et al. (2015), is a complex process whereby problem solvers externalize their individual problem-solving processes and orchestrate their activities and contributions into a coherent sequence of events. As an underpinning requirement for communication, and interaction, this gives collaborative problem-solving the rationale to be considered as a skill in its own right. Collaboration possesses three constituting features, communication, cooperation, and responsiveness. The three combined together add observable characteristics to the description of problem solving. The processes involved in individual problem solving apply to collaborative problem solving yet, in different and more complex ways. The complexity resides in the process that is not uniform but requires distinguishable subskills needed for specific problem-solving situations.

Learning skills are inherent in all of the stages of collaborative problem solving. These skills are conducive to knowledge building and are intimately linked to the capacity of the problem solver to learn during group interaction. Problem solvers can learn about the content domain, the strategies and the skills. Furthermore, they learn how to manage obstacles by collaborating and orchestrating their activities through coordination and negotiation. Working in dyads, according to Beckmann et al. (2015), helps learners improve their performance during the exploration phase in a simulation-based environment. This is demonstrated in the increased time spent on reflection, which progressively turns into increased efficiency reflected in the shorter time spent on decision making. Working in pairs or in groups, especially in a computer-mediated context, presents an enriching experience for the development of problem solving. Such activities serve as a bridge toward collaborative problem solving incorporated into the PISA 2015 assessment (Csapó & Funke, 2017). Chi (2009) highlights the importance that interaction plays in learning. In a detailed analysis generating a taxonomy of three types of overt activities, active, constructive and interactive, Chi presents interaction as resulting in three types of activities for the learner: self-construction based on a partner's contribution, guided construction, the result of interaction with an expert, sequential and/or simultaneous co-construction with a partner. In all of the different cases, the interactive journey undertaken is of a constructive nature. The interesting result of this taxonomy is the derived hypothesis that interactive activities might be better than constructive activities; constructive activities are better than active ones, which might be better than passive ones. Whilst this framework is proposed to enhance practitioners' understanding of how the various activities foster learning, many caveats and challenges, as Chi notes, remain to be acknowledged in identifying the ways for designing specific instructional activities. Highlighting the challenge of assessing collaborative problem-solving tasks, Funke et al. (2018) point out that devising problem-solving situations with appropriate communication requirements and identifying appropriate measuring criteria for analyzing communication behavior remain important challenges.

This brings to closure the discussion on the multi-faceted aspects of problem-solving construct. This discussion aimed to highlight the complexity of the issues underpinning problem-solving competence and shed light on a similar complexity inside the classrooms. The four facets reflect the challenges of teaching problem-solving competence related to transfer within domains (domain-specific problem solving), interdisciplinarity (domain-general problem solving), open-ended, real-life tasks (complex tasks), and collaboration scoring-related criteria.

2.6 Problem solving and the nature of problems

Engaging learners in problem solving requires an appropriate and relevant selection of instructional activities. Jonassen (2000) considers that problem solving varies with the nature of the problem, its mental representation as well as an array of individual differences, all of which mediate the process. Based on the assumption that different learning outcomes for problem solving necessitate different forms of instruction, this entails that specific models of problem-solving instruction need to be designed to support the learning of problem solving. Problem solving is considered to possess two essential attributes. First, it involves a mental representation of the problem task. This mental construction, known as problem space, is a crucial step in problem solving. Second, it requires manipulation of this problem space. Jonassen describes problem solving as an activity that is not uniform: cognitive schema development for problem solving varies with the type of problem. Schema development will be further explored when looking into Cognitive Load Theory (CLT) (section 2.7). Jonassen categorizes problems based on their "structuredness", their complexity, and their abstractness or domain specificity and classifies problems into two general categories: well-structured and ill-structured. The second attribute that characterizes problems is their complexity; such complexity is based on issues, functions and variables that define a problem and the interrelationships among them. Finally, the third attribute, domain specificity, rests on the assumption that problem-solving activities are specific to a domain; they are embedded and dependent on the nature of the domain.

Drawing parallelism between Jonassen and Mayer and Wittrock's (2006) distinctions of routine and non-routine problems, routine problems appear to be more well-structured to an experienced learner, whereas transfer in non-routine problems entails what Jonassen refers to as "high road transfer", a process that is more cognitively demanding compared to the "low road transfer", which requires less conscious attention. Added to the learner's familiarity with problems, another powerful predictor of problem-solving skills, according to Jonassen (2000), is the degree of integration of domain knowledge, referred to as structural knowledge and described as the degree of interrelatedness and organization of concepts within a certain domain. This factor is an even stronger predictor of success in problem solving than familiarity. Van Merriënboer (2013) defines well-structured problems as problems that possess all known components for the learner. Solving them requires a limited set of rules or procedures. Typical school tasks fall into this category. The learner can readily use the specific information she or he possesses when the problem is categorized and has the applicable rules and procedures. Being inflexible, the correct application of these highly domain-specific methods under suitable conditions is a guarantee of successfully solving the problem. With practice, strong methods become automated allowing rapid and low pressure on working memory. Taking the same position as Mayer and Wittrock (2006), Van Merriënboer (2013) contends that even if, for some educators, the domain-specific strong methods are perceived as routine practices, they are nevertheless, "the most extreme, efficient type of problem solving one can think of" (p.154).

Dealing with real-life problem solving, as described Van Merriënboer (2013), is a combination of perspectives on ill-structured and well-structured problem solving. Real-life problems require, in most, if not all cases, a combination of well-structured and ill-structured problem-solving. This necessitates the coordination of cognitive base processes of ill-structured problem solving, typically knowledge-based methods, and the strong methods of well-structured problem solving. Knowledge-based methods can be considered as possessing a mix of weak and strong methods features. When a problem solver has a solid grasp of general knowledge such as conceptual, causal, and structural models, he or she can eventually apply this knowledge to restructure a problem situation and infer possible solutions for the problem at hand. Authentic learning tasks, such as case studies, projects, and simulations are gaining increasing interest in educational contexts because they play a crucial role in enabling learners to integrate the knowledge, the skills and the attitudes. Hence, in this context, "problem-solving always refers to the simultaneous use of strong methods for routine aspects of performance and knowledge-based methods for non-routine aspects of performance" (2013, p. 155).

With this aperçu on the nature of problems of well-structured and ill-structured problems or routine and non-routine problems, the next section turns to the cognitive loads that are inherently linked to problem solving. A concise overview of the Cognitive Load Theory is proposed so as to frame the subsequent discussion in this chapter on approaches to teaching, specifically instructional designs and learning environments.

2.7 Cognitive Load Theory

Over four decades, cognitive load theory (Sweller, 1988), primarily proposed as an instructional design theory, has been used to investigate instructional techniques considering human cognitive architecture. Knowledge of the characteristics of working memory, long-term memory, and the intertwining relationships that connect them constitute the basis for this theory. It is built on the fundamental premise that the limitations of the working memory heavily hamper human cognitive processing. When confronted with a novel situation, learners can only process a limited number of information elements at a given point in time. When the cognitive load is too high, learning and transfer are hindered.

Instructional techniques require students to engage in activities that often assume a processing capacity that does not consider the limitations of human processing capacities. Intellectual mastery in any subject domain is rooted in two essential mechanisms underpinning the learning process: schema acquisition and transfer of learned procedures from controlled processing to automation (Sweller, 1994). Schema is defined as "a structure which allows problem solvers to recognize a problem state as belonging to a particular category of problem states that normally require particular moves" (Sweller, 1988, p. 259). When instructional techniques do not target schemas acquisition and automation, they are likely to end up being defective. The organization of knowledge into schemas is a determining factor when dealing with new information and their operation clarifies much information about learning-mediated cognitive performance (Sweller, 1994). Automatic processing happens without conscious effort, with well-acquired knowledge being automatically processed. More importantly, this automatic processing allows attention effort to be directed elsewhere.

Both schema acquisition and automation, as learning mechanisms, substantially reduce the cognitive load placed on the working memory, which possesses limited capacities to process a few discrete items at any given time. Schema acquisition permits the development of an intellectual skill gradually and incrementally and not in an all-or-none way. The possibility of chunking different elements into one element, which schemas can allow, effectively increases the amount of information held in the working memory (Sweller, 1994). Hence, schemas not only allow storing an important amount of information in long-term memory but also improve working memory limitations. As for automation, it allows bypassing of the working memory: with automatic processing taking place, less working memory space is required, and hence, working memory capacity is free to deal with other functions. The workload must be as small as possible to alleviate the pressure exerted on short-term memory and spare its capacity for processes relevant to learning.

When a learner is dealing with a new situation, working memory limitation plays a critical role. As familiarity with the material gradually increases, the working memory limitation becomes less critical as more and more information from long term-memory is used. When investing knowledge that is anchored in long-term memory, the limitations of short-term memory become irrelevant. Consequently, problem solving is closely dependent on the information stored in the long-term memory to determine the problem state and the strategies to adopt to move from one stage to another (Paas & Sweller, 2014). As described above, developing an intellectual skill is not an all-or-none way: "alterations must be small, and a small working memory when one is dealing with new information is a consequence" (p. 48). Understanding and long-term memory alterations are tightly linked. This means that nothing can be understood in the absence of a change in long-term memory. This brings to the importance of instruction in facilitating this fluency. Paas and Sweller consider that the fundamental role of instructional design is to provide the needed assistance for the learner to acquire this fluency. Such fluency indicates that the necessary information to manipulate procedures in a skilled performance has been acquired.

In CLT, there are three kinds of workloads, intrinsic, extraneous, and germane cognitive load. The three play a role in the acquisition, storage, and usage of knowledge. The discussion of these loads is done in connection with the element interactivity, the subject of the next section.

2.7.1 Element interactivity

"Our limited processing capacity is one of the most important and well-known of our cognitive characteristics" (Sweller, 1994, p. 310). With this characteristic of human cognitive architecture as a premise, CLT has been used to develop instructional designs taking into consideration the cognitive load that arises because of the material itself, and the way the material is presented to students. The former represents the complexity of the information, whereas the latter is a function of instructional techniques used to present this information.

Intrinsic cognitive load is connected to the complexity of information that learners must grasp and learn, "unencumbered by instructional issues" (Sweller, 2010, p. 124), which are related to the way the information is presented to the learner or the choice of the instructional activities. The level of the intrinsic cognitive load varies with the level of interactivity of the elements in need of processing. An element can be a concept, a procedure, or any information that needs to be learned. The intrinsic complexity of the task depends on the way the elements of the task are interrelated. When elements can be learned independently of one another, they are said to have low element interactivity. In contrast, high element interactivity occurs when learning is concurrent with the learning of the various connections between the various task elements. This high interactivity element results in a high intrinsic cognitive load, and dealing with high interactivity tasks is in effect, dealing with schemas acquisition (Sweller, 1994).

What the discussion on interactivity suggests is basically that low level interactivity material does not require understanding but just learning, whereas, high level interactivity material necessitates both understanding and learning. Understanding, in this perspective, is defined as "the learning of high element interactivity material" (1994, p. 311), and it happens when schemas linked to high element interactivity material are acquired. When schemas are automated, a level of deep understanding is achieved. Even when a task is considered difficult, if the various elements are learned independently of each other (low element interactivity), it does not exert a heavy load on the working memory. Processing each element's information is learned independently and in isolation from the others. Whereas in the case of learning that involves high interaction of elements (high element interactivity), a heavy cognitive load is exerted on the working memory. As an illustration of the low interactivity of elements when new information is presented, is learning the French word "mouse". This can be accomplished independently of learning the French word for "elephant". In this example, learning element interactivity is low, and consequently, the working memory load is also low. On the other hand, learning the word order in a sentence such as "what is your favorite food" cannot be done by learning each element alone. It is necessary to consider the words and the relationship between them. The interaction between words involves high element interactivity resulting in a high intrinsic load.

This element interactivity is not limited to intrinsic cognitive load. It is an important source of working memory load underpinning both intrinsic cognitive load and extraneous cognitive load. Instructional procedures which do not optimize learning are referred to as extraneous cognitive load (Sweller, 2010). Inappropriate instructional procedures can provoke an unnecessary and avoidable increase of interactivity elements requiring the learner to use working memory resources for processing information. However, this processing is not conducive to knowledge acquisition (Paas & Sweller, 2014). Hence, the same information may put both intrinsic and extraneous cognitive load, depending on what needs to be learned. Intrinsic and extraneous cognitive load heavily depends on the characteristics of the material, especially since working memory load, in its entirety, is determined by the levels of element interactivity (Sweller, 2010).

Last, a germane cognitive load may also be defined in terms of the interactivity element, though its status is not the same as intrinsic and extraneous cognitive loads. Its dependency solely relies on the learner's characteristics. It is a function of the working memory resources available to deal with the interacting elements underpinning intrinsic cognitive load (Sweller, 2010). The more memory resources are invested dealing with extraneous cognitive load, the less will be devoted to manage intrinsic cognitive load, which is conducive to lesser learning. This occurs even if the learner's motivation is high and memory resources are invested to deal with both intrinsic and extraneous cognitive load. Paas and Sweller (2014) assert that germane cognitive load put simply, is effective cognitive load.

In summary, instructional designs cannot bypass the human cognitive architecture. The acquisition of knowledge, limitations of the working memory when a learner is dealing with a novel situation, and the elimination of those limitations have fundamental implications on instructional designs and their effectiveness in ensuring learning. The next section explores the consequences of cognitive loads on novice-expert learning differences.

2.7.2 Implications on instructional activities

The important role of schemas is evident when considering the novice-expert learning difference, primarily in the capacity to access large storage of schemas. This ability constitutes a critical characteristic of skilled performance. At an early stage in acquiring a cognitive skill, it is possible to use this capacity, but not without exerting a heavy cognitive load. As previously described, with time and practice, a cognitive skill becomes automatic and requires minimal thinking effort, thus bypassing the working memory (Sweller, 1994). This means if learners, through previous exposure, developed a complete schema for a certain problem type, then the mapping of a specific schema type with the problem allows them to solve it (Jonassen, 2000). For instance, novices who do not possess the range of schemas fail to identify the problem types and are forced to use general problem-solving strategies, which are weak strategies for reaching problem solutions. Sweller (1994) contends that in the absence of automation, performance is "slow, clumsy and prone to error" (p. 298). Novice students tend to use, in most cases, heuristics strategies, such as means-ends analysis. This involves creating a goal and developing steps to reach it. If the goal is not accomplished, a subgoal is created to eliminate encountered obstacles (Mayer, 2013). While this technique is highly effective in reaching a solution, it is designed solely to attain the goal problem (Sweller, 1994). It is not a learning technique and has little to do with schema acquisition; the important step is for problem solvers to learn to identify the problem state. Sweller contends that while the various steps do lead to the goal state, they fail in allowing to reach schemas acquisition and automation. Expert learners, on the other hand, are capable of filtering information and ignoring irrelevant information to construct a problem space (Jonassen, 2000). They essentially rely on domain-specific knowledge rather than solely on heuristics or general approaches, such as means-ends analysis, to solve problems (Mayer, 2013). The role instructional designers play in helping novice learners construct a problem space is essential in the learning process (Jonassen, 2000). The provision of cues, prompts, and clues are critical in facilitating the process, as will be discussed further in the following sections of this chapter. The clarity with which these indices are provided determines the problem's difficulty and complexity.

The differences in the way novice-expert learners deal with novel situations bring the line of argument to the question of whether it is more beneficial for learners to increase or decrease the intrinsic cognitive load. The answer to the question, according to Sweller (2010), is not as straightforward. When the subject area is to be learned, and the intrinsic load is inevitably high, if the working memory falls short in handling this load, then element interactivity must be reduced even if grasping and understanding essential concepts did not occur yet. However, when an instructional practice possesses a low intrinsic load and learners fail to process essential interacting elements, then the intrinsic load must be increased without overloading the working memory.

Undoubtedly, seeking the right level of intrinsic cognitive load, as Sweller (2010) notes, is more complicated and difficult than identifying the appropriate techniques to reduce extraneous cognitive load. While extraneous load should always be reduced, increasing or decreasing intrinsic cognitive load has to reach an optimal level. In practical terms, instructors in their classes are routinely confronted with the concern of how much information should be provided to students (i.e., determining the appropriate level of intrinsic cognitive load). Regarding extraneous cognitive load, Sweller (2010) considers that reducing it can be accomplished by modifying instructional activities that disengage learners from activities that are extraneous to learning; or by directly instructing learners to exploit cognitive processes that push them, rather than the instructor, to engage in activities conducive to learning, which can be achieved by eliminating activities extraneous to learning.

In summary, this outline of the basic concepts underpinning CLT and the issues in connection with it, such as task complexity and learner's expertise is needed to frame subsequent discussions, especially when presenting arguments in favor of guided instruction in teaching (section 2.8). Before getting to the critical discussion on discovery learning, problem-based learning, and guided instruction, the next section brings together the relationship between the learner, task, and instructional environment (situation) that underpin problem solving.

2.7.3 The P, T, S triad: person, task and situation

The study of problem solving, as Beckmann (2010) proposes, involves three variables. The first variable, the person, includes psychological aspects, such as motivation and ability levels, among others. The second variable, the task, is conceived as a specified requirement for cognitive behavior: this involves the processing of various stimuli from either the information provided in the task, or from within the frames of the task domain. The third variable, the situation, includes the context or the environment within which the task is performed. While there is a conceptual difference between the situation and task characteristics, both determine the complexity of the task. Beckmann defines the complexity of the task as resulting from the combination of "the physical properties of the stimuli represented by the task *per se* and the requirements for a particular cognitive behavior" (p. 253). Situational characteristics bring their own situation-specific elements of the stimuli along with non-task related acts. These non-task cognitive acts are necessary to manage specific conditions under which the task is proposed. Hence, complexity is defined in terms of both task and situation. With this perspective on complexity, Beckmann's argument enlarges the frame of the sources of cognitive load by going beyond the CLT's focus on the concept of interactivity as the only source of cognitive load. It explicitly brings the inclusion of the "set of required cognitive behaviors" (p. 253) in the definition of complexity. Moreover, while interactivity has been specified as the mechanism underlying intrinsic cognitive load, the framework Beckmann is proposing considers interactivity as underpinning both extraneous and germane loads.

Drawing a connection between the argument and instructional design, Beckmann classifies extraneous cognitive load in the category of "avoidable" elements of interactivity. With this new perspective of interactivity element as underlying intrinsic and extraneous cognitive loads, instructional design needs to identify, in advance, the features of the task as well as the cognitive behaviors that are necessary to perform the task. This should help in limiting the sources of cognitive load to the "unavoidable" (p. 253) interactivity, an inescapable source of intrinsic cognitive load. Beckmann's argument leads to the important proposition that "a priori estimations of mental load need to consider not only the number of information carrying elements the stimulus material comprises but also specify the set of mental acts needed to process this information" (p. 262). This means, that "our" prior knowledge about the task, the situation, and the learner is inherently linked to the concept of cognitive load. This is the core of the argument as it brings crucial and direct implications on the teachers' planning. Teachers should not, as is often the case, concentrate primarily on designing the task per se. The nature of the group class which should be an inherent component of planning and instructional design, ought to be considered. This means that when designing the task, teachers must be conscious of the mental load that learners are expected to exert when completing the task. Following an examination of cognitive loads in connection to task complexity, learner expertise, and the nature of instructional designs, the subsequent discussion focuses on the role of instructional support in learning.

2.8 Perspectives on problem solving and instruction

As previously mentioned, Instructional design is driven by the understanding of human cognition and the way its cognitive structures process information, specifically working and long-term memories. The knowledge of the intricate relationship between the two memories is crucial in determining the effectiveness of instructional designs. Cognitive Load Theory ensured the integration of our knowledge of cognitive human architecture structures with instructional design principles. This section deals with a specific implication of this theory on approaches to teaching by tackling the role of instructional support (i.e., types of guidance).

2.8.1 A case for unguided instruction: Inquiry-based learning

Inquiry-based learning is a family of approaches which include under its umbrella, project-based learning, problem-based learning, and learning through design (Barron and Darling-Hammond, 2010). The first category, project-based learning, encompasses the acquisition of factual knowledge and the development of abilities to transfer through applying this knowledge in new problems as well as in performance tasks. While projects highly promote student-centered instructional approaches, prior setting of goals and outcomes for the problem tend to decrease the learner's role (Savery, 2006).

The second category, problem-based learning, involves small groups of students investigating a meaningful, ill-structured problem. Being exposed to the problem prior to learning the required content knowledge, students collaborate together in order to identify what they need to learn to deal with the problem, locate relevant information, and set the strategies to reach the solution (Ertmer & Simons, 2006). These open-ended, complex problems are constructed in such a way as to resonate with students' experiences, hence enabling them to raise arguments and receive convenient feedback. Of critical importance to problem-based learning approaches is the selection of ill-structured problems, often interdisciplinary in nature, with teacher's responsibility being to guide the process and ensure a detailed debriefing at the end of the learning experience (Savery, 2006). Problem-based learning's primary goal is to improve students' application of knowledge, problem solving, and self-directed learning (Jonassen & Hung, 2008). As self-directed problem solvers, students put into application new knowledge, reflect on their learning, and evaluate the effectiveness of the strategies applied. Hmelo-Silver (2004) contends that self-directed learning is a key feature of problem-based learning methodology. With such an approach to learning, students are actively involved in constructing their own knowledge, while teachers are actively leading them through guiding the process, making their thinking visible, channeling participation, and nurturing reflection.

Problem-based learning approaches require a reconsideration of the curriculum in its entirety and beyond the short-term instructional outcomes (Barell, 2010). Units of instruction must be designed to provide students with opportunities for inquiry, critical thinking, purposeful investigations, reflection, and the development of meaningful solutions. Jonassen and Hung (2008) propose general principles for designing problem-based learning problems. These authentic, open-ended, and ill-structured problems should possess a moderate degree of structuredness. Their complexity should stimulate enough motivation and challenge to engage students and provide them with opportunities to deal with a problem from multiple perspectives. Problems should be adapted to students' prior knowledge and appropriate to their cognitive development and readiness. This approach to teaching and learning, according to Hmelo-Silver (2004), carries two essential aspects. First, it allows the learner to be an active participant in constructing knowledge in collaborative groups and second, the teacher is no more the sole bearer of knowledge but the guide in the process of scaffolding through modeling and coaching. More importantly, such an approach is not expected to come at the expense of lecturing and explanation which should "be crafted and timed to support inquiry" (Barron & Darling-Hammond, 2010, p. 205). While shifting learning responsibilities from the teacher to students is sought in order to promote critical thinking and problem solving, this shift should not create situations where, in the absence of proper support and guidance, students may feel disoriented or frustrated. Even more importantly, it should not push teachers to react to students' frustration by reverting to directed approaches. Consequently, supporting or scaffolding is fundamental to ensure a safe transfer of learning responsibilities (Ertmer & Simons, 2006). Hmelo-Silver, Duncan, and Chinn (2007) stress the role that scaffolding plays in problem-based learning to argue against Kirschner, Sweller and Clark's (2006) categorization of problem-based learning under unguided discovery learning or minimally guided learning. Scaffolding allows students to deal with complex tasks while acquiring the means to work independently (Ertmer & Simons, 2006). However, Glazewski and Hmelo-Silver (2019) note that an adaptive scaffolding is needed since it is not possible to anticipate every difficulty, and not all forms of support can be pre-planned. In this respect, as the authors contend, more research is needed to know more how comparatively, it is possible to support learners.

The last category of inquiry-based learning, learning through design, is built on the principle that students deeply grasp concepts when they are put in situations to design and create artefacts (Barron & Darling-Hammond, 2010). Designing and creating bring together both understanding and applying knowledge. Moreover, it requires students to collaborate and share expertise in order to deal with the complexity of the design task.

To summarize, inquiry and design-based approaches as well as collaborative work are presented as essential for promoting communication, collaboration, creativity, and deep thinking. Leat et al. (2012) note that inquiry-based approaches constitute the natural format for the development of competences. They facilitate experiential learning through which students pursue questions, deal with problems, and apply knowledge through their personal engagement. They seek "doing and becoming" (p. 405). While there are challenges to the proper integration of these approaches into teaching, specifically the ones related to design and implementation, Barron and Darling-Hammond (2010) note that further research may be channeled towards strengthening the possibilities to enact pedagogies that promote deep learning for both students and teachers; while opportunities for students are provided to promote their collaborative and academic skills, openings for teachers are offered to enrich their repertoire for nurturing 21st century learning.

2.8.2 A strong case for guided instruction

Based on the premise that human cognitive processing is seriously hampered by the limitations of human working memory, ignoring human working memory limitations has strong implications for the teaching of problem-solving, particularly for novices (Van Merriënboer, 2013; Sweller, Van Merriënboer & Paas, 2019). A novice problem solver who has not yet developed cognitive schemas can only use weak methods to solve a new problem. As previously mentioned, the cost of this process is very high for the problem solver as the result of the strong pressure on the working memory, thus preventing learning and transfer. Expertise in any domain is based on building and storing a vast number of schemas that makes it possible to deal with a problem situation in that domain (Sweller, Clark, & Kirschner, 2010). The only way to reach a level of expertise is through the provision of a large amount of specific problem-solving strategies related to specific problems. Sweller, Clark, and Kirschner contend that separate, learnable general-problem solving strategies are inexistent. For instance, learning through worked examples for novices surpasses in its efficiency and effectiveness learning by simply practicing in the absence of any reference to worked examples. These examples provide a full problem solution for the learner to study, facilitating knowledge construction and transfer (Sweller, Van Merriënboer, & Paas, 2019). The worked-example effect, according to the authors, alleviates the pressure put on the working memory, a pressure that constitutes an unnecessary load that prevents transfer to the long-term memory. This worked-example effect is essential in all subjects and, in particular, in areas that are difficult for learners, such as mathematics.

Kirschner, Sweller, and Clark (2006) observe that minimal support and guidance in subjects such as mathematics is conducive to minimal learning. They claim that in the absence of robust evidence to support advocates of minimal guidance during instruction, any instructional recommendations or theories that do not take into consideration the alterations that take place in long-term memory or do not raise recommendations on how to increase its efficiency are likely to be ineffective.

> "The onus falls should surely be on those who support inquiry-based instruction to explain how such procedure circumvents the well-known limits of working memory when dealing with novel information" (p. 77).

In this respect, Beckmann and Goode (2014) observe that discovery learning is challenged by one of its essential features, mainly its reliance on context. High contextualization causes knowledge and understanding to be tightly connected to specific learning environments, which can be detrimental to the transfer process, especially in novel yet homomorphous situations. Mayer (2004) draws the attention to the distinction between constructivist teaching and constructivist learning. The argument rests on the hypothesis that various instructional methods can be conducive to constructivist learning. The challenge is to find those instructional methods that lead to relevant cognitive activities in learners instead of methods that promote hands-on activities or group discussions as ends in themselves. Mayer points out that every decade has seen a new pattern for unguided instruction, from discovery learning to experiential learning which gave way to inquiry-based learning and then constructivists' approaches to teaching. However, all of these approaches lacked the solid empirical evidence to favor them over guided approaches to teaching. In contrast, guided instruction is supported by stronger evidence based on controlled experimental studies, especially in the case of novice and intermediate learners.

2.8.3 Debate on the effectiveness of problem-based learning and inquiry learning

In a strong response to Kirschner, Sweller, and Clark's (2006) criticism of problem-based and inquiry-based learning, Hmelo-Silver, Duncan, and Chinn (2007) identify two major flaws in the argument raised against the approaches described as minimally guided instruction. The first flaw is pedagogical in nature, stemming from the classification of numerous distinct pedagogical approaches to teaching under minimally guided instruction. The argument is raised against such a classification, particularly for problem-based learning (PBL) and inquiry learning (IL), which do not correspond to the description of minimally guided instruction. Instead, Hmelo-Silver et al. contend that these methods are intimately linked to different forms of scaffolding that are very similar to and indistinguishable from some forms of guidance promoted by cognitive load theorists. The second flaw is evidence-based. It is built on the argument that empirical evidence supports the claim that problem-based learning and inquiry learning are powerful approaches to foster deep and meaningful learning as well as improve students' results.

Taking a similar stance against Kirschner' et al. (2006) classification of PBL as minimally guided instruction, Schmidt et al. (2007) built their counterargument on the premise that cognitive load theory and PBL are closely compatible. In PBL, problems come first; this means that students are initially engaged in within-group problem discussion and analysis, activating their prior knowledge and sharing expertise, two processes which help alleviate the task's intrinsic cognitive load and enable students to deal with complex tasks. Moreover, groups of students are expected to receive training on collaborative skills prior to instruction in order to reduce any extraneous load that may arise. In the design of the task itself, students are exposed to simple-to-complex sequence of learning tasks. Such exposure seeks to lighten the intrinsic load as students' expertise gradually increases. These various elements (i.e., learning task, small groups, discussion, and training) inherent in PBL curricula allow for adaptive and flexible guidance. In addition, they provide the means to manage appropriately the various cognitive loads.

Pertinent to the debate on the effectiveness of PBL, Strobel and Van Barneveld's (2009) meta-synthesis of meta-analyses aimed to identify common and generalizable findings to address the claim that PBL is inefficient for learning. The meta-synthesis attempted to account for the areas of divergence in the conceptualization and measurement of PBL effectiveness in both quantitative and qualitative studies. It sought to demonstrate how the differences in the conceptual definition of learning and measurement of learning account for the failure to reach conclusive claims among the different meta-analyses on the effectiveness of PBL. Eight meta-analyses and systematic reviews constituted this study. Almost all of them drew on primary studies in the medical field. The analysis demonstrated diverging findings on the effectiveness of PBL for knowledge retention. While measures of short-term knowledge acquisition and retention tended to be in favor of traditional instruction, the assessment of knowledge which is based on long-term knowledge retention gave an advantage to PBL. The results showed that PBL meaningfully enhances long-term retention. Further solid research bases in other fields, such as K-12 education, are needed to delimit the boundaries of this approach clearly.

Walker and Leary (2009) contributed to the debate on the effectiveness of PBL by conducting a meta-analysis involving studies extending outside the field of medicine and related health fields. Across 82 studies and derived 201 outcomes, the findings tended to favor PBL, yet not without a certain lack of homogeneity warranting more evidence-led studies. Underpinning this meta-analysis were two objectives. The first was to explore the differences in PBL learning outcomes across different disciplines and assessment levels. The second was to look into the characteristics of PBL implementation.

In terms of the disciplines, the results of the different analyses showed that PBL students did as well or even better than lecture-based students. In addition, PBL students tended to outperform in disciplines outside the medical field, an encouraging result for researchers performing PBL in other disciplines such as teacher education, social studies, and the catch-all other categories. Moreover, the analysis showed that PBL students engaged in backward-driven reasoning in a far better way than their counterparts, lecture-based students. This process type of thinking involves hypothesis-driven reasoning and reasoning backward along probabilistic principles. Although backward-driven reasoning has been criticized as a method conducive to more errors in problem-solving (Kirschner et al., 2006), the analysis interestingly showed that PBL students managed to perform well. Thus, the results of this meta-analysis highlighted the conditions under which PBL gave similar or even better results than lecture-based approaches.

It is worthy of considering at this stage the quality of this meta-analysis, following Torgerson, Hall and Light's (2012) recommendation to subject a meta-analysis study to PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) checklist for quality appraisal. The introduction of this meta-analysis frames the conceptual issues through a structured presentation of the literature, setting a clear context for the research questions. The various sources of information for methods searching are cited. A coding scheme is independently undertaken by two researchers, a favorable condition for screening, data extraction and quality appraisal (Torgerson, 2003). Nevertheless, the inclusion criteria should have been more explicitly and transparently reported. Moreover, there is no information about the exclusion criteria, and no detail is provided about the disregarded research papers. This lack of transparency and the absence of justifications for inclusion and exclusion inevitably affect the quality of this systematic review (Torgerson, 2003). A further drawback to be noted is the absence of any indication regarding the assessment of publication bias. The protocol lacks a clear description of the assessment of the risk of bias for quality appraisal of included studies, when a transparent assessment of bias potentials is expected to be pre-stated. One last observation concerns the derived conclusions. In the concluding statement, limitations and sources of bias are accounted for yet in a very succinct manner and sometimes with vague justifications specifically when mentioning the high level of missing data and the possibility of under reporting negative PBL findings. Hence, it is necessary to acknowledge that the lack of rigor associated with issues of clarity and transparency raises some concerns regarding the quality of this meta-analysis. Nevertheless, the derived results are still useful for supporting the claim that direct and guided approaches to instruction are preferred, a claim that is consistent with Kirschner et al.'s. (2006) argument against minimally guided instruction.

Continuing with the same discourse on the role of guidance in instruction and the effectiveness of methods considered minimally guided, Lazonder and Harmsen's (2016) meta-analysis of inquiry-based learning compares the efficacy of different types of guidance in inquiry learning. The driving purpose is to demonstrate, as Hmelo-Silver et al. (2007) argue, that the debate should shift in focus from inquiry-based learning as such, to the conditions which best promote this learning. The quantitative synthesis of 72 studies' findings confirmed that guidance has a positive and substantial impact on inquiry activities, performance success, and learning outcomes, confirming the findings of recent comparative studies on guided and unguided inquiry learning. It also corroborated with conclusions derived from other meta-analyses on guidance, yet performed from a relatively different perspective. The contribution that this meta-analysis brought is the confirmation that the benefits of guidance to inquiry learning can be generalized, that guidance has a positive effect on different age groups, and encompass learning activities, performance success in addition to learning outcomes. The implications of this meta-analysis call for the need to reconsider the assumptions that are built on the typology of the types of guidance. This framework used for the first time in this meta-analysis helps classify the types of guidance, but does not support the assumption that prior knowledge and skills can be matched with the types of guidance. Both learning activities and learning outcomes are equally promoted by the different types of guidance, suggesting that younger learners with low inquiry skills may benefit from less specific types of guidance. In contrast, older learners with more sophisticated inquiry skills may take advantage of more specific guidance, such as scaffolding and explanations. Further contributions of this meta-analysis emphasize the necessity of considering dimensions such as frequency and duration of guidance as affecting inquiry learning, particularly working memory. Furthermore, this meta-analysis draws the strong conclusion that inquiry-based teaching requires the intervention of support to assist learners in completing the task and learning from the activity. Guidance is not solely limited to short-term inquiries but should include large inquiry tasks and projects spreading over many sessions. The implications of the findings lead to the differentiation between "adequate" and "highly specific guidance". Such a nuanced difference is essential so as not to challenge the nature of the inquiry process when using highly specific guidance, in light of the findings which point to the comparable effect of less specific guidance on learning activities and outcomes with more specific guidance.

Similar to the process of meta-analyses quality appraisal (PRISMA checklist) displayed above, it is noted that for this mate-analysis the protocol includes a detailed review of the main issues that underlie the research questions and hypotheses. It offers a structured overview of the various systematic reviews and meta-analyses in the field of interest with a clear and coherent presentation of their outcomes. It ends with conclusions offering a framework that shapes this meta-analysis. In addition, the protocol specifies the study characteristics (PICOS), mainly the participants (children, teenagers or adolescents with their respective age category), intervention (types of support), outcomes (learning activities, performance success, and learning outcomes) and study designs (randomized trials and quasi-experiments). Further components of the protocol are all clearly described (research questions, inclusion and exclusion criteria, strategy for information retrieval, methods for searching and coding). A table is included with a comprehensive summary consisting of the list of included studies, publication type, study design and the different moderators (seven in number). The step-by-step search strategies are provided. Data related to the inclusion and exclusion criteria are well described. Screening is done by two reviewers. Moreover, the internal consistency of the outcome measures extraction and coding is scored independently, and inter-rater reliability is checked. Indications of the publication bias are described, along with other biases that constitute some of the limitations of this study. Hence, it should be recognized that the features mentioned above make this meta-analysis an appropriate one (Torgerson et al., 2012), with all quality appraisal criteria well-respected.

The combined contributions of Strobel and Van Barneveld's (2009) meta-synthesis, Walker and Leary's (2009), and Lazonder and Harmsen's (2016) meta-analyses yielded the following conclusion about PBL and IL. First, the PBL approach is more effective than traditional, lectured-based instruction when the focus is on instructional practices which target the learner's performance in authentic situations and the learner's long-term knowledge retention, instead of performance on tests that emphasize short-term knowledge retention. Second, PBL students can do as well or even better than lecture-based students in fields outside of medical education and health-related areas. Third, 'adequate' guidance plays a significant role in inquiry-based activities, performance success, and learning outcomes. This last finding sheds light on Kirschner et al. (2006) position vis-à-vis the high specificity of guidance as a condition for better learning by including other dimensions, such as the frequency and duration of guidance. These dimensions might be necessary to reduce the cognitive load on working memory during inquiry-based activities. Hence, findings point to the necessity to distinguish between highly specific and adequate guidance, where the former may threaten the nature of inquiry-based learning. In addition, emphasis is placed on the need to use guidance in various forms of inquiry, ranging from short-term inquiries to long, comprehensive ones.

Closing the discussion on problem-based learning, it appears, as Savery (2006, p. 17) observes, that problem-based learning is not just "a fad in education". The heated debate among opponents (Kirschner et al., 2006) and proponents of problem-based learning and inquiry learning (Hmelo-Silver et al., 2007; Schmidt et al., 2007) constituted a turning point in the discussion of problem-based learning approaches by accepting its limitations, highlighting its strengths in promoting higher order thinking while drawing on the advantages of traditional instruction for constructing students' basic knowledge (Hung et al., 2019).

Research in the field of problem-based learning, as Barron and Darling-Hammond (2010) note, have reached two key conclusions. The first highlights the efficiency of conducting small group inquiries which are driven by clear objectives, well-defined learning goals, appropriate scaffolds, regular assessment, and rich resources. The second conclusion points to the importance of assessment design in showing the benefits of inquiry-based approaches through promoting both group and individual efforts, in addition to success of learning. Nevertheless, implementation issues related to the selection of material and classroom practices remain sources of concern to practitioners. In this respect, Hung, Jonassen, and Liu (2008) point to the nature of the problem as a challenge in connection with performance tasks design. The range of complexity and structuredness, along the continuum from well-structured to ill-structured problems, needs to be addressed in order to identify the problems that can be efficiently solved using problem-based learning approaches. In direct connection with this point, it is still unclear, as Hung et al. (2008) note, whether the same problem-based learning implementation methodologies apply in the same way to the different types of problems, or the method used needs to be adapted to deal with the different types of problems. Hence, directions for future research should seek to address challenges related to the design of the tasks and implementation approaches. Furthermore, as increasing efforts are geared to embed problem-based learning into K-12 schools where research is relatively scarce, issues related to the learners' characteristics need to be addressed as well. Answering questions generated even more questions about the pedagogical system of problem-based learning. The experimental journey with its successes, failures, and lessons learnt shifted research on problem-based learning, as Hung et al. (2019) observe, from investigating whether problem-based learning works, to how it works, and then how it works in different specific contexts.

This takes the discussion to its final stage by looking into the learning environment that promotes the teaching and learning of problem-solving competence. It combines various issues already tackled in this chapter concerning cognitive loads, transfer, and support systems.

2.8.4 Learning environment

Transfer of learning is, without any doubt, the most difficult challenge that instructional designers face, which Kirschner and Van Merriënboer (2008) refer to as the transfer paradox. When specific methods work best to reach targeted objectives, these same methods may not be the best to attain integrated objectives and, consequently, transfer of learning. The learning environment, according to Kirschner and Van Merriënboer, should provide means for students to acquire the knowledge, skills, and attitudes as an integral set. It is the integration of knowledge, skills, and attitudes that constitutes complex learning. Focusing on authentic tasks is primordial and should form the driving force for teaching and learning as they provide learners with opportunities for integration. Such integration is necessary to enable students to manipulate new combinations that can be applied in novel situations, thus facilitating the transfer of acquired knowledge to these new situations. By striving for efficiency, instructional designers may select methods that aim to minimize the frequency of practices, time spent on tasks, and learner workload. While choosing a certain sequencing in practice can be efficient in helping students construct very specific knowledge and perform in accordance with specified objectives, this process results in a low transfer of learning. If the goal is to transfer knowledge, the chances are high that the task may take more time or require more effort and investment from the learner and may be less effective in reaching isolated objectives. However, with time, the process becomes more conducive to higher transfer of learning, as the learner develops the ability to construct abstract and general knowledge instead of knowledge targeting isolated objectives, and hence, acquire the ability to make better diagnoses of new encounters.

An essential factor in instruction is linked to the level of learner's control (Kalyuga et al., 2010). For instance, learners with some expertise may greatly benefit from an environment that provides them with relative freedom to undergo processes, such as selecting and structuring complex tasks. Whereas in the early stages of developing complex skills, a learner-controlled environment may turn out to be harmful to learning as the learner may fail to exercise full control under the pressure of cognitive overload. Kalyuga et al. contend that adaptive guidance positively affects the acquisition of strategic knowledge and skills and improves the complex skills inherent in the transfer process for advanced learners. This point matches with Lazonder and Harmsen's (2016) adequate guidance, as described in the previous section. Such adaptive guidance reflects the relationship between instructional support and the learner's knowledge and skills, implying that support must be differentiated to best fit the learner's (Jong & Lazonder, 2014). Well-guided instructional setting can help deal with the limitations of working memory while promoting the acquisition of new knowledge in long-term memory (Hmelo-Silver et al., 2007). Hence, the level of guidance should be well-balanced so as not to fall short in providing support leading to failure or falling into excessive guidance, jeopardizing the self-directed nature of discovery learning (Jong & Lazonder, 2014). Maintaining balance has implications in the classrooms, where continuous monitoring of students' performance is required to tailor the level of support to the learners' needs and the pace of fading (i.e., gradually reducing the amount of guidance).

2.9 Final thoughts

In this chapter, the concept of problem solving is treated by primarily focusing on its complexity with a discussion framed by Cognitive Load Theory. Problem-solving construct is explored from its various facets, starting with an understanding of what problem-solving competence is, then delving into examining the factors that interplay in the teaching of problem solving. I have presented how this construct's complexity is reflected in teaching and instruction by examining the intertwining relationship between instructional strategies and human cognitive architecture. The discussion centered on raising arguments around the debatable spectrum of instructional strategies ranging from discovery learning, problem-based learning, and inquiry learning to guided instruction in facilitating problem solving.

This literature review demonstrates that implementing the problem-solving construct in the classroom is as complex as the problem-solving construct itself. Even though cognitive science may have significantly impacted learning, there is still a pervasive gap between what this science offers and practice. The heated debate among practitioners on the advantages and disadvantages of guided and minimally guided instruction is one facet of a myriad of issues connected to students' preparedness to develop into twenty-first century problem-solvers. With the concept of transfer that is more than ever ubiquitous, domain general problem-solving competence with its underpinning cross-curricular nature still needs to mature to translate into well-articulated approaches to teaching, especially since cross-curricular competences occupy a preponderant position in both the European framework for key competences as well as in the OECD. Integrating cross-curricular competences in the curriculum, as Nieveen and Plomb (2018), describe it, is "not a trivial enterprise nor a one-off event at the school and the classroom level" (p. 261). It entails fundamental changes at all levels, classroom, school, and system. Albeit the notion of cross-curricular competences and themes and a road that ensures the transfer of knowledge may appear attractive, a clear and common definition of these constructs across the various existing frameworks is still missing.

This study focuses on the classroom environment and the teaching practices that craft the learning by turning to the grassroots, to the teachers. In light of this literature review, it is as much intriguing to look into how the US Common Core State Standards and New Generation Science Standards, the European framework through the French socle commun de connaissances, de compétences et de culture, and the Lebanese program, may reflect the complexity of problem-solving construct. Even though teaching practices are expected to mirror program requirements, teachers' understanding of these requirements is an essential factor to be explored. After theoretically examining the myriad of issues that frame problem solving as a construct, descriptive and exploratory research was conducted to investigate the relationship between programs' requirements, teaching practices, and teachers' beliefs and understanding of problem-solving competence teaching and learning.

Chapter three

Methodology

3.1 Introduction

This chapter presents the rationale underpinning the research project design. It explores teachers' perceptions and understandings of problem-solving competence and how it is translated into teaching practices in the classroom. The investigation aimed to draw similarities and contrasts in the instructional strategies that are implemented in the middle school, in the Lebanese program, the French program, and the American program. To answer the overarching question of how the teaching of problem-solving competence-at the middle school level-in Lebanese private schools, compares across the different curricula required a comparative, multiple case study design. Three objectives guided the investigation: examining programs' requirements for the teaching of problem-solving, exploring participants' understandings of the concept of problem-solving competence, their views and opinions regarding the efficiency of the programs in facilitating the teaching of this specific competence and, how instruction in the classroom reflected understandings, views, and applicability of this competence into teaching practices. In order to respond to these objectives, data was collected through classroom observations, interviews and document analysis. The first part of the chapter describes the research design, with a discussion centering on comparative strategies. The next section of the chapter addresses the sample and the sampling strategy, followed by a detailed description of the data collection instruments and procedures. In the last section of the chapter, considerations related to the validity and trustworthiness of the findings are considered before closing with research ethics.

3.2 Comparative, multiple case study design

3.2.1 Perspectives on comparative studies

Pedagogy reflects the culture as an expression of the national life and character using Sadler's maxim. As described by Alexander (1999), pedagogy presents a window into the culture to which it belongs. It mirrors the tensions and contradictions that underlie this culture as well as the public educational policies. Any quest to improve teaching and learning, as Alexander contends, necessarily involves a comparative perspective that allows differentiation between aspects of teaching that go beyond international boundaries from the ones that are specific and culture-bound. Alexander notes that in classroom research in particular, considering the parts and the whole is problematic. There is a tendency in research to subject teaching to the processes of an adroit dissection. This, however, comes at the expense of struggling with the processes of reconstruction. Inquiring into the realm of effective classroom practices has been successful when approached through an investigation of isolated factors. Yet it is less able to demonstrate how both teachers and students reconstruct these factors into coherent and successful learning opportunities.

The complexity and the multi-faceted aspects of the curriculum put limitations on the scope of curricular comparisons and analysis as well as on the possibility of capturing the whole picture (Adamson & Morris, 2014). The explicit comparison makes the differences more visible and is revelatory of the similarities. Comparison of curricula encompasses the analysis of "what is planned, what is learned that is planned, and what is learned that is not planned" (p. 315). Data consist of curriculum manifestations ranging from documents to behaviors. For comparative curricular studies, it is important, as Adamson & Morris consider, to identify the distinct components or the elements for comparison to constitute the research focus. These may include:

- the ideologies and societal cultures that shape the curriculum;
- the systems that underlie curriculum development and planning as well as the processes and products of curriculum development;
- the curriculum implementation that involves the various modes of teaching and learning experiences; and
- the experiences, that comprise all the planned and unplanned learning events, values, and messages that learners go through.

It is the curriculum implementation component upon which this particular study focuses. Referring to Adamson and Morris's distinction between "tangible" and "intangible manifestations" (p. 322), accessing curriculum documents as one of the research methods is obviously a tangible manifestation as these resources can be easily obtained from various sources. In contrast, teaching and learning experiences are more challenging to obtain, not only logistically vis-à-vis accessing schools and classrooms, but also analytically. These experiences are intangible manifestations, far more difficult to access than documents, and take the form of subjective and indirect manifestations of human behavior during lessons and post-lesson thoughts and reflections on the lived experiences. In this respect, Alexander (1999) notes that even if it is possible to reach general conclusions about the direction, characteristics, and impact of an observed lesson, it remains difficult to elucidate the underneath and deeper layers of this lesson within the time constraints. The strong challenge is to succeed in conserving in the analysis phase and reporting, the essence of the lesson so that it remains familiar and recognizable to the architects of this lesson, teachers and students. One should be aware that what goes in the classrooms, the observed manifestations and the hidden in the actors' minds, is anchored into the culture. Schools and classrooms can provide ample information about a country and the national education system on condition that the research tools are sufficient to allow an examination beyond the "observable moves and counter-moves of pedagogy to the values these embody" (p. 158).

> "If we wish to unearth what in teaching really drives pupil learning we should concentrate less on those generalized organizational strategies that happen to catch the untutored eye and more on the generic features such as teacher-pupil discourse whose impact on cognition is clearly supported by psychological evidence" (p. 170).

Ragin (2014) describes qualitatively oriented comparative studies as being based on identifying the various conditions or causes that fit together in one context to contrast with the way they fit together in another context. This means analysis is performed considering each observational entity as a whole, consisting of "an interpretable combination of parts" (p. 13). One should be aware that such a holistic approach as well as explanatory combinations pose a threat to the rigor of the argument. Interestingly, it is not the number of cases that militate against the rigor but the limited variety of combinations since their analysis is constrained by the boundaries of the cases represented as "configurations of characteristics" (p. 51). Ragin points out that the comparative method is a case-oriented strategy, focusing on drawing comparisons between cases, and examining the similarities and differences among them, with cases examined as a whole, in other words, as combinations of characteristics. More importantly, case-oriented strategies are often used to identify patterns with constant association; they are not used to explain variation. With the contextual background on comparative studies, this comparative, case-oriented study is about how classrooms are perceived in the context of each program and the relationships between perceptions, theories of pedagogy, and actual implementation in the classroom.

3.2.2 Multiple case study design

Delving into a comparative research design does not require a specific research method or theory; instead, it depends on a plurality of approaches driven by the research question and based on its conceptual and theoretical formulation (Palmberger & Gingrich, 2014). As an explicit research tool, the comparative approach is an inquiry into the variation of the manifestations of phenomena among different groups. In this particular study, it is sought to identify the differences and similarities among the three categories of schools in their approaches to teaching problem-solving competence, hence carving out diversity as well as similarity.

The nature of the study entailed an inquiry oriented toward exploration, discovery, and inductive logic to generate general trends and recurring patterns. Such an inductive perspective is aimed at developing an understanding of the interrelationships among dimensions derived from the data. The nature of the research question required direct field experience, with my role as a researcher seeking, as Miles, Huberman, and Saldana (2014) describe it, a holistic understanding of the context studied. Holistic, in this case, refers to the systematic, encompassing and integrated overview, studying the social arrangement, how it functions, and paying attention to both the explicit and implicit rules (p. 9). It is looking at the phenomenon to study in its complexity with an understanding embedded in its context, trying to convey a comprehensive picture (Punch, 2005). Seeking an in-depth understanding requires a case study design. Such a design, according to Merriam (1998), plays an appealing role in education, that of allowing the examination of educational processes, problems, and programs for a better understanding "that in turn can affect and perhaps even improve practice" (p. 41).

The proposed multiple-case design seeks to collect and analyze data from more than one case, within each category of schools, based on a "replication design" (Yin, 2009). Such a collective instrumental case study investigated in order to gain insight is, according to Punch (2005), extended to include many other cases to know more about the researched phenomenon, the population or a general condition. The focus is both within and across cases, making it a multiple-case or comparative case study. At the levels of conceptualization and development of propositions, findings can be proposed as "being potentially applicable to other cases" (p. 146).

Hence, replication aims at duplicating as much as possible the same conditions within each category, a kind of "literal replication" so as to predict similar results. If a pattern is established, this provides as Yin (2009) states "substantial support for the initial proposition" (p. 88) and is conducive to findings that could be considered robust. In addition to seeking "literal replication" within each category of schools, this investigation further aims to a "theoretical replication", across the three groupings of schools so as "to predict contrasting results for anticipatable reasons" (p. 87).

3.2.3 Strengths and limitations of case study design

The multiple-case approach offers an opportunity to look at a range of similar and contrasting cases. Following Yin's replication strategy, it helps in strengthening the precision, validity, stability, and worthiness of the findings (Miles, Huberman, & Saldana, 2014). More importantly, if the finding in one setting is comparable in another setting but is not comparable in a contrasting setting, then the finding is even more robust. Merriam (1998) highlight the advantage of adopting a multiple case study design. The more cases the sample includes, the greater the variation across the cases, the more interesting the interpretation is. Notwithstanding the fact that the strength of a design is intimately linked to the rationale for constructing a plan that best addresses the research question, nevertheless, adopting a case study design presents its own limitations. As a researcher, being the primary instrument of data collection and analysis, a case study design is limited by the sensitivity and integrity of the researcher, the degree of bias awareness, as well as the researcher's experience, training, and abilities (Merriam, 1998). Moreover, relying on the replication logic presents its own limitations when it comes to assessing the prevalence of the phenomenon under study. As Yin (2014) notes, the potential generation of a large number of variables linked to the study entails a large number of cases as well, which cannot possibly be deeply examined.

3.3 Sample and sampling strategy

While it is more attractive to compare large samples to include more variables for comparison, this does not necessarily lead to finer comparison (Palmberger & Gingrich, 2014). For this study, the aim of the comparative approach is understanding rather than measuring the differences across the cases. Patton (2002) considers that judgment and negotiation constitute a practical solution to determine the sample size, with an understanding that research design is "flexible and emergent" (p. 246).

3.3.1 Convenience sample of schools' categories

The study considered three categories of private schools grouped according to their program offerings. The public sector was not included in this study, primarily because it solely provides the official Lebanese program. Category 1 consisted of private schools which exclusively cater to the Lebanese Baccalaureate program; category 2 included private schools that offer, in addition to the compulsory Lebanese Baccalaureate program, the French Baccalaureate program, and finally, category 3, which is comprised of private schools that offer the American program, in addition to the Lebanese one. This purposeful grouping of schools permitted an examination of contrasts to draw comparisons as to how problem-solving competence is integrated into teaching in the middle school cycle, hence addressing the comparative nature of the research question underpinning this project. The schools in each of the categories presented above were defined as the cases. Due to time and resource constraints, the sample was limited to schools in Beirut (in areas referred to as Beirut one, two and three). The empirical work was severely delayed because of the instability in the country, with an uprising in October 2019, added to it the COVID 19 pandemic. Both unfortunate events forced schools to close their doors for around a year and a half. The uncertainty about setting a date to launch the empirical phase was a primary reason for choosing a convenience sample, thus limiting the selection of schools to the area of Beirut. In addition to the location criterion, schools included in the list were all K to 12 mixed schools (boys and girls), with a total number of students exceeding 500. Based on these criteria, 33 schools were identified.

3.3.2 Within-category random selection

The selection of the cases/schools in each of the three categories was randomly performed. Opting for a random selection over a purposeful selection which typically characterizes the case study design, was linked to the exploratory nature of this investigation. The random sampling has the strength of allowing equal chances in the selection process for the schools in each category. This purposeful random sampling is possible even for small samples and its randomness increases "substantially" the credibility of the findings by minimizing suspicion that may arise when specific schools are selected for the study (Patton, 2002, p. 241). With such a purposeful random sample, the aim is to pursue credibility and not representativeness through statistical generalizations. Determining the number of schools/cases deemed necessary for this comparative study is necessarily based on discretionary judgment instead of a formulaic one (Yin, 2014). Miles, Huberman, and Saldana (2014) suggest that a minimum of five richly researched cases for multiple-case sampling is adequate, warning that with high complexity, a study that includes more than 10 cases may end up being unwieldy.

Since this is a comparative study to generate patterns within and across the three categories, this particular rationale necessitates at least two individual cases within each category in order to allow for a theoretical replication across categories, complemented by literal replications within each of the three categories (Yin, 2014). The thought-provoking advice from Lincoln and Guba (1985) "Redundancy is typically eschewed in life, but in this instance, it is a most useful criterion: Repeat until redundancy-and then just one more time for safety" (p. 219), guided the choice of the number of schools included in the sample. While considering a sample of six schools (two per category) may present the risk of not yielding sufficient data to develop patterns in line with Yin's theoretical replication, a sample of 12 schools (four per category) would not be possible for one researcher to cover, and hence deemed very difficult to achieve. Consequently, after thoughtful consideration, the decision fell on a total of nine schools to constitute the sample (three per category). Using the Excel program, the nine schools were randomly identified from the pool of 33 schools: 3 out of 16 from category 1, 3 out of 9 from category 2, and 3 out of 8 from category 3. The random sampling was performed by a colleague who received three lists of schools, where each school was represented by an alphabetical letter. The anonymity of the lists was considered essential to avoid any bias and ensure a randomized selection.

3.3.3 Participants

Participants constituting the sample in each school were middle school teachers (Grades 7 to 9) teaching one of the following subjects: languages, mathematics, sciences, and social studies. The languages consisted of Arabic and a second foreign language, either English or French, depending on the school language of instruction. In Lebanon, the language of instruction is either English or French. School administrators were in charge of identifying the participants who were asked to give their prior consent and voluntarily participate in the study. This entails that such a sampling cannot be considered random as it requires the prior consent of teachers to conduct a class observation followed by an interview. Proceeding through a random sampling approach is not possible when interviewing is conditional on the interview participant's consent (Seidman, 2006). Hence, there is always the element of self-selection tightly connected with interviewing, an element inherently incompatible with randomness. Further careful considerations related to the number of participants in terms of feasibility as well as a balanced representation were required. The decision fell on conducting nine class observations per school, equally distributed among the three grade levels of the middle school, and with a fair representation of the various subjects.

In summary, constituting the sample for this study was conducted through three phases. The first phase included the purposeful selection of three categories of schools- depending on their program offerings- to answer the comparative nature of the study. The sample of schools was limited to three areas within Beirut, referred to as areas one, two, and three. This convenience choice was necessary in light of time and resource constraints. Thirty-three schools were identified based on specific criteria, and classified according to their program offerings. The second phase consisted of a random sampling within each category to identify three schools for data collection. The third and last phase involved the sample of participants formed of teachers who gave their prior consent to participate in the project. Nine middle school teachers per school was set as a target.

3.4 Data collection tools

Addressing the three sub-questions of this study required various instruments, each targeting one facet of the investigation (Table 3.1). Data collection was based on (a) the examination of the curricular document of the three programs under study, (b) structured classroom observations, complemented by (c) semi-structured interviews. No single instrument had advantages over the other. The three were chosen to complement each other and provide multiple sources of data, thus helping in addressing the issue of internal validity (Yin, 2009). The documentary analysis of the curriculum requirements for the integration of problem-solving competence into teaching addressed the first research sub-question of this inquiry. Structured classroom observations addressed the second research sub-question, with emphasis put on teaching strategies. The unit of analysis, was neither the teacher nor a particular student or a small group of students, but rather the group class with a focus on classroom instructional learning processes. Observations were followed by semi-structured interviews. They constituted the third stage of this investigation and aimed at answering the third research sub-question. They sought to refine the analysis of the observation- driven data through an exploration of teachers' views, attitudes, and opinions.

Table 3.1 The three research questions and their corresponding data instruments.

	Documentation	Observation logs	Semi-structured interviews
Sub-question 1: What are the teaching practices that delineate the curricular requirements for the teaching of problem solving-competence in middle school?	Retrieval of information from publicly shared official documents relevant to program requirements		
Sub-question 2: How does the teaching of problem-solving competence reflect each of the curricular requirements in middle school?		Observation of middle school classes: languages, mathematics, sciences, and social studies	Post-observation interviews with teachers whose classes were observed
Sub-question 3: How are the teaching practices of problem-solving competence influenced by teachers' understanding of the requirements of the different curricula in middle school?			Post observation interviews

As a multiple-case study aiming to draw a cross-case comparison, a relatively standardized instrumentation is required in order to lay side by side the findings during the course of analysis. Need for common instrumentation is necessary to build theory, improve explanations or predictions, and raise practice-related recommendations. When interview schedules and observation schedules lack a certain focus, the risk is to end up with a large set of superfluous information, which challenges the efficiency and power of the analytical work. Opting for structured observations followed by semi-structured interviews aimed at bearing both exploratory and confirmatory aspects (Miles, Huberman & Saldana 2014). The subsequent three sections present the three instruments used for data collection.

3.4.1 Documents

Mining the data from documents involved a review of the Lebanese, French and American programs pertaining to the integration of problem-solving competence into teaching. This documentary analysis formed the basis for constructing and developing the observation protocol utilized for direct observations in the classroom. Document as means of data collection is used for the identification of data in the form of either words and /or images, recorded with no interference from the researcher, as is the case with interview and focus group methods (Silverman, 2014). The documents used in this inquiry are the official curricular documentation produced by educational organizations in each of the three countries, Lebanon, France and the United States. They are regarded in this inquiry as a resource, or put in other words, as sources of evidence. These electronic documents are readily and quickly accessible, without any ethical constraints. They are not to be criticized or assessed in terms of their apparent objectivity (Silverman, 2014). Instead, their analysis consists of identifying the various elements used and demonstrating how they function to reach certain effects. One of the greatest advantages of using documents, as observed by Merriam and Tisdell (2016), is their stability. More importantly, they are not subject to alteration by the researcher as is the case with observation and interviewing. Data derived from documentation are "objective" when compared to data derived from other sources (p. 182). Prior (2008) proposes a typology for the various approaches to the study of documents. Four of these are to be considered in social research, based on the distinction between topic and resource, content and usage, and function. The first solely focuses on what is "in" the document. The second considers how content comes into being, with attention concentrating on conceptual architecture. The third targets how documents are used as a resource for specific ends by different kinds of readers, and finally the fourth considers the impact of document's function on social organizations. Considering the four approaches, it is the first one, i.e., focusing exclusively on what is stated in the document that was needed for this investigation, with documents primarily "scoured" for evidence (p. 825). The documents studied were retrieved from the official websites of the Lebanese

Center of Educational Research and Development, French Eduscol, and US Common Core Standards and the Next Generation Science Standards.

3.4.2 Structured observations

Observation becomes a research tool, and not mere looking, when it is used to address a research question, is planned for and recorded in a systematic way, and is subjected to rigorous methods to check its validity and reliability (Merriam, 1998). The attractive and distinctive feature of observation is that it provides "live data in situ" of events as occurring naturally, first-hand information rather than second-hand data, driven by mediated or inferential methods (Cohen, Manion, & Morrison, 2017, p. 542). Anderson and Burns (1989) describe classrooms as settings where interaction is mostly based on verbal exchange and academic work. Students' learning, the intended outcome, is not directly observed. Rather, it takes time and is, to a large extent unobservable. Also unobservable are decisions related to instruction. These factors constitute a part of an interrelated chain of events, the sequence of which is not a matter to be ignored. The interrelatedness of the various sources of classroom complexities makes classrooms' environments not easy to be captured and studied. While the planning and the activities are relatively predictable, the "undercurrent of unpredictability" (p. 41) operating in classrooms often puts teachers under the obligation to make all sorts of adjustments. It is this entanglement of physical, social, and instructional elements that makes classroom observations a complex endeavor.

The strategy adopted for this investigation was of conducting structured observations. With such an approach to classroom observation, the merits of "taking an outsider looking in" position allow a focus on the emerging data related to the specific research question as well as on the aspects arising from the framework of ideas generated through the process of investigation (Gomm, 2004, p. 230). These observations, as described by Angrosino (2012, p. 166), are "reactive observations", meaning that they were conducted in the classroom with the consent of the teachers, and with the provision of the needed information about the intent of the study. Looking closely into the observation study, decisions concerning the selection of observable data were essential for this inquiry. It is as much about what to exclude from the data set as what to collect. The issue at stake is the window of observation where selected events and not others are observed. It is the size of the window of observation that constitutes the basis for deriving conclusions. Making inferences about the unobservable from the observable, in other terms, making generalizations has serious implications on the validity of the findings (Gomm, 2004). Nevertheless, one should be conscious that with the usage of pre-conceived parts of structured observations, the researcher runs the risk of breaking behavior into smaller parts, thus losing the big picture at the expense of noting and analyzing an easier and more standardized one (Punch, 2005). An important advantage of structuring observation is to control the effects of the observer's observation behavior. According to Gomm (2004), the observer's behavior may relatively influence what is observed considering the selective nature of attention, the constructive nature of perception (people tend to see what they expect to see), and the reconstructive nature of memory (people reorganize their memories in light of subsequent events). The pre-set categories forming the observation protocol allowed a focus on the relevant events at the exclusion of others, knowing in advance what it is that we are looking for, with these categories used to gather the evidence. Anderson and Burns (1989) highlight the essential and intimate link between conceptual frameworks and classroom research, considering them as the source which gives meaning to the collected evidence. Evidence by itself has no meaning; it is when it is classified within categories that, in turn, are linked to other categories that it is possible for evidence to acquire some meaning. When meaning is relational, a conceptual framework offers a language system to interpret and understand the concepts (e.g., categories) that are either imposed on the evidence or derived from it. They provide the meaning for the gathered evidence.

3.4.3 Link with post observations phase: interviewing

When the needed evidence is available, asking questions aim at corroborating the evidence or providing a better understanding of it. When the evidence looked for cannot be observable, when beliefs and understandings about the issue under study are sought, asking questions becomes the sole source of evidence (Anderson & Burns, 1989) and an essential path to the multiple views and multiple realities (Stake, 1995). Observation as a technique for data collection is rarely a stand-alone technique (Angrosino, 2012). It is used along with interviews and document analysis "to substantiate the findings" (Merriam, 1998, p. 96). The combination of the three permits to build a holistic interpretation of the phenomenon under study.

In this study, the post-observation interviews were built around the information arising from the observation phase. Resorting to semi-standardized interviews was not driven by the need to ask the right questions as much as about getting the right answers. In this case, right means the most informative and the most accurate answers. Hence, with such interviews, accuracy, information, and comparability are sought. They present the major strengths of these types of interviews (Anderson & Burns, 1989). Opting to conduct semi-structured interviews for this investigation was needed to delve into an exploration of genuine and authentic perceptions, thoughts and feelings. The one-to-one interviews were conducted with the aim of producing a picture based on the interviewee as a person, with her/his own understanding. The purpose of interviewing, notes Patton (2002), "is to find out what is in and on someone's mind" (p. 278). Understanding the interviewed teachers' experiences, opinions and ideas, gives access to authentic accounts and permits reaching of a certain level of depth and complexity that cannot be discerned through either observations or survey-based approaches (Gomm, 2004). Silverman (2014) points out that tapping directly into individual perceptions is desired, a desire that can be described as romantic. The interviewer neither monopolizes the interview nor fades away into the background. Since these interviews were planned to follow the observation session, they acquired a certain mundane aspect, with both parties collaborating in the interview. Kvale (1996) highlights this aspect, noting that when the objective is to explore implicit meanings and tacit understandings, then field studies followed by relatively informal interviews may give more valid information. The attempt is to collect descriptions of the relevant themes from the interviewee's world, descriptions characterized by their richness and "presuppositionless" (p. 196).

Incorporating interviews along with observational studies had two main targets: first, to relate what is observed in the classroom with participants' accounts, basing some of the interview questions on prior observations. Second, using observations as an opening door to explore teachers" understanding of problem-solving and the role of the programs in facilitating its integration into practices. The reason behind the decision to conduct post-observation interviews was to identify discrepancy if any, between what was said during the interview and what was observed during the prior observation session. These post-observation interviews provided the flexibility to tailor, adapt and even modify probing questions in light of what was observed. More importantly, the decision, as Kvale (1996) puts it, is not whether to lead or not to lead. It is primarily a decision on where the interview questions should lead. Each interview question can be evaluated with respect to both a thematic and dynamic dimension: thematically with respect to its relevance to the research theme, and dynamically with regard to the interpersonal relationship in the interview. An interview question should contribute thematically to knowledge production and dynamically to promoting a good interview interaction. Consequently, the semi-structured interviews allow for getting the desired information from the interviewees while keeping enough flexibility to conduct a more or less conversational type interview allowing "to respond to the situation at hand, to the emerging worldview of the respondent, and to the new ideas on the topic" (Merriam, 1998, p. 76).

A further element determining the nature of the interview questions is connected to decisions about how to analyze the data. The method of analysis planned for this inquiry involved the categorization of the answers. Hence, continuous clarification during the interview for the meanings of the answers with respect to the categories to be used later was necessary. A detailed description of how analyses of interviews as well as observations, are elaborated in section 3.7 of this chapter. The interviews with teachers about their curriculum and pedagogical practices were sought to provide means to draw comparisons with the documentary analysis as well as to shed clarification on the observation sessions that preceded the interviews.

The pilot testing phase with real time in the classroom preceded the actual data collection phase of the project. The intent of the pilot was to test the measurement methods of the developed observation schedule. Furthermore, pilot interviews were conducted with the same testing aim, putting into trial the processes of the interview format. The interview guide underwent several trials of "ruthless review" as Merriam (1998, p. 79) puts it. Questions were revised with colleagues on several occasions, before and after the pilot phase. A detailed description of the pilot phase along with the changes that were introduced to both the observation schedule and the interview one, is laid out in the next section.

3.5 Pilot phase

3.5.1 Description

The pilot phase trialed the research instruments and approaches. It was primarily aimed at anticipating and simulating the data collection procedures, testing the instruments and the procedures of using them (Punch, 2005). The pilot case is primarily informative, helping refine both the content data and the procedures (Yin, 2014). Putting into practice the observation protocol as well as the interview guide was sought. This consisted of experimenting with two types of categories, data collection categories and data analytic categories (Anderson & Burns, 1989). The former, upon which the structured observation protocol is built, directs the data collection and subsequently guides the analysis; the latter is inductively and comparatively developed during analysis, as the evidence is gathered during interviewing without limitations imposed by the categories. A convenience sample was chosen to conduct the pilot. It was performed in a K to 12 private school which caters to the three programs, American, French, and Lebanese. The possibility of observing classes from the various programs in one setting was a great advantage in terms of accessibility and time management. More importantly, having served in this institution for three decades, relying on the support of colleagues in facilitating access to classes and providing sufficient time for feedback was crucial. Such a less structured, less formal, and more prolonged relationship between myself and the participants/colleagues generated extensive and enriching input that helped bring in major modifications to approaches, as will be discussed in the next section. Yin (2014) compares this pilot case to a laboratory, a space to experiment with the protocol, make observations on the various phenomena, and perform various trials.

Whilst the aforementioned reasons were essential for selecting this particular pilot case, an even more important reason was behind choosing this convenience sample. The pilot was conducted under exceptional circumstances. During the fall of the academic year 2020-2021, schools in Lebanon remained closed due to the COVID pandemic from mid-October 2020 to open for a very brief two- week period in December, then shifting to online teaching for the rest of the academic year 2020-2021. Hence the pilot phase was squeezed within ten days, requiring an intensive schedule of class observations and interviews as shown in the table below. Two observations were conducted without follow-up post interviews due to a schedule conflict.

Table 3.2 Dates of class observations and interviews, classes observed per subject, program and grade level.

Teacher	Date of observations & post interviews	Duration of observation session	Duration of interview	Subject	Program	Grade level
T1	December 3, 2020	40 minutes	20 minutes	French language	French	9
T2	December 3, 2020	40 minutes	20 minutes	Physics	American	9
T3	December 4, 2020	40 minutes	15 minutes	Social studies	French	7
T4	December 4, 2020	40 minutes	No interview	Mathematics	Lebanese	9
T5	December 7, 2020	40 minutes	18 minutes	Social studies	Lebanese	8
T6	December 8, 2020	40 minutes	22 minutes	Chemistry	Lebanese	9
T7	December 10, 2020	40 minutes	20 minutes	Arabic language	Lebanese	7
T8	December 10, 2020	40 minutes	No interview	Biology	American	9
T9	December 10,2020	40 minutes	17 minutes	Arabic language	Lebanese	9
T10	December 11, 2020	40 minutes	16 minutes	English language	Lebanese	9
T11	December 11, 2020	40 minutes	15 minutes	French language	French	7
T12	December 11, 2020	40 minutes	15 minutes	Mathematics	American	8

3.5.2 Reflection and modifications

3.5.2.1 Reflection on observation log

Two areas were addressed and subjected to modifications: first, the frequency count of observable behaviors of the observation log template and second, the anecdotal record which consists of the notes taken during the observation session. The frequency measurement of the data collection categories required more thinking than the categories themselves. The observation sessions showed that noting the frequency of occurrence from 1 to 6 was not practical. Opting for a scale from 1 to 3 was more meaningful and would facilitate analysis. The scale introduced to the revised protocol was divided as follows:

1- Low (observed once or twice)
2- Moderate (observed three to four times)
3- High (observed more than five times)

The other area that required attention was the anecdotal record. Taking notes turned out to be essential in terms of providing support to the frequency rating of the categories by noting the specific type of classroom processes, which subsequently provided the substrate for sharing relevant information during the post-lesson interviews. Reflecting on ways to facilitate the analysis of these observations and make them more efficient was a reason to introduce into the anecdotal observation log focus points. These foci would bring structure into note-taking and, consequently, facilitate analysis. These points were selected based on the anecdotal records taken during observations. They included the topic of discussion, specific activities and tasks, and evidence of a connection to other content areas or content that comes before or after. Anecdotal records would center around these points, yet without being limited to them.

3.5.2.2 Reflection on interviewing

Venturing to try out the interviewing design was essential in terms of trying the interview guide and more importantly, practicing the interviewing approaches through the simulation of interactions. Such a field test was necessary to alert to the interview techniques used which may either guide or detract from the objective of the interviews. Hence, it was used as a means to assess the appropriateness of the content of the questions as well as the format, especially the delicate probing in order to conserve the open-endedness of the interview. As Seidman (2006) puts it, "the unanticipated twists and turns of the interviewing relationship deserve exploration before the researchers plunge headlong into the thick of their projects" (p. 39). Analytic decisions were taken simultaneously with data collection, and after data was collected, in a kind of "intuitive" data processing. Maintaining a balance between the usage of leading questions for clarification and conserving the spirit of more or less flexible interviews was a primordial objective during this testing phase. Initially, questions were phrased in such a way as to maintain generality and give space and freedom for the interviewees to express their thoughts and insights. Nevertheless, the first two interviews deviated from the main objectives. This was reflected in the digression that was observed, with the interview slowly drifting to issues related to generalities about program implementation or specific concerns in connection with the subject itself. Such a drift made it relatively hard to continuously strive to bring back the conversational interview into its focus, with frequent interruptions to keep the conversation concentrating on the interview question. Added to the difficulties encountered with interviewing, the direct transcribing of interviews showed that the conversations generated a load of irrelevant information. Thus, the difficulties encountered constituted the main drive to manipulate and rephrase questions in such a way as to make them relatively more structured and specific, taking the form of semi-structured interview questions rather than naturalistic, more open interviews. Nevertheless, it was important to maintain the congenial way of asking, sequencing the questions and segmenting them depending on the respondents (Miles, Huberman, & Saldana, 2014), especially since the interviews were driven by prior classroom session observations. Such a mix of more or less structured questions gives the flexibility to respond to the situation at hand, to the points of view of the respondent, and to new ideas on the subject of discussion (Merriam & Tisdell, 2016). Another aspect of interviewing with focus on techniques was also reflected upon. Listening to audiotapes and focusing on the conversation required careful attention be given to moments of unneeded interruptions and interventions indicative of leading questions. Scrutinizing verbatim transcripts turned out to be such an important self-criticism exercise, revelatory of the areas in the interviewing skills that required modification and improvement.

Taking into consideration that interviews were conducted in the three languages, an important issue in connection with translation had to be dealt with. Interview questions for the French and Arabic versions of the interview guide were discussed with colleagues, and modifications were introduced to the wording of the questions. Moreover, while practicing the transcribing process, the translation of the interviews conducted in Arabic into English turned out to be an exercise that was not time consuming as expected. As a consequence, for the main data collection phase, Arabic interviews would be translated and transcribed, avoiding the usage of a specific platform to accommodate the Arabic language. As for the interviews conducted in French, they would be transcribed without translation into English especially that NVivo- the software of choice for interview data analysis- can accommodate for the French language. Finally, the decision to opt for a verbatim transcription in order to maintain the integrity of the interviews entailed the need for a transcriber's help. A trade-off between doing my own transcription for all interviews and sparing more time for analysis led to such a decision, especially when considering the estimated number of interviews to be conducted, which could exceed 70 short interviews, in three different languages. Splitting the task between the two would certainly ease the tedious process of transcription without being completely detached from the process.

In summary, the pilot phase turned out to be essential in serving two main purposes. The first was explorative, putting into practice both the observation log and the interview protocol. The second was reflective of the interview techniques, transcription, and coding processes. These two exercises were significantly beneficial as a preparation for the main data collection phase.

3.6 Data collection procedures

3.6.1 Contact with schools

The main phase of the data collection was launched in November, 2021, a year after the pilot phase. The delay, as previously mentioned, was due to the COVID pandemic causing schools to shift totally to online teaching. Heads of schools were contacted during October, avoiding any earlier contacts so as to minimize the risk of rejection, especially after the prolonged schools' closure. Admittingly, the network developed throughout the long years as a school principal greatly facilitated contacts with gatekeepers, mainly the heads of schools, and gave access to the nine schools forming the sample without serious difficulties to be mentioned. Every school visit started with a meeting with the head of school to present the project and share relevant documentation in preparation for class observations and interviews. Samples of the project description letter (Appendix A) and participant's consent form (Appendix B) were provided as hard and electronic copies. Furthermore, the dates and plan of the visit were agreed upon during the meeting. One important consideration requested for the preparation of the visit was to ensure a balanced schedule of class observations. This balance entailed distributing the nine class observations per school over the three levels of the Middle School (grades 7, 8, and 9) and among teachers of the five disciplines (languages, either French/Arabic or English/Arabic, mathematics, sciences and social studies). Three to four class visits were planned per day, with subsequent interviews scheduled either on the same day or directly on the day after, depending on teachers' availability. In general, class observations and interviews were conducted within a three-day period with dates chosen at teachers' convenience (avoiding exam week, or class meeting periods). Teachers' participation was on a purely voluntary basis. The letters that were presented to heads of schools were electronically forwarded to all staff members. Based on teachers' acceptance to participate in the study, an administration staff member prepared the program visits that were subsequently sent to me for any suggested modifications or additions.

3.6.2 Observation procedures

Conducting observations was about making decisions about my role as an observer, what to observe, and how to record observations. Learning to be a careful and systematic observer came with years of experience as a principal. Being closely involved in teachers' appraisals implied not only observing classes but following-up and discussing with teachers on the teaching methodologies and practices. Such an exchange constituted an opportunity to reflect on observation notes and evaluate their objectivity and rigor. What Patton (1990, p. 201) highlights "as learning how to write descriptively; practicing the disciplined recording of field notes; knowing how to separate detail from trivia…" were gradually acquired through years of practice and training. Assuming the stance of complete and overt observer best fitted the needs of this study. However, taking the role of a 'spectator' raised concerns about the extent to which the presence of an observer affects what is being observed. In an effort to minimize any sentiment of intrusion or invasion of the class privacy that may arise in students and teachers alike, three cautionary measures were taken. First, it was necessary to clarify to students the reason for attending their class and second, to choose a suitable seat. Avoiding front and back seats was a class observation insight learnt through experience. Sitting in the middle has the great advantage of discretely fading away in the crowd of students during the lesson. Third, body language, specifically body posture and facial expressions, should reflect openness and keen interest in what is happening in the classroom. Consequently, assuming the role of the 'spectator'/observer demanded an increased alertness to maintain a balance between a deliberate display of interest in class activities and continuous focus on data notetaking.

The systematic recording of data carried by itself two challenges that had to be continuously dealt with: first, matching the exhibited behavior with the most convenient item of the observation schedule, and second, being consistent from one observation session to the other. Even if the years of practicing observations facilitated the task, it was primarily about the integrity of the process, striving to be as faithful as possible when recording the exhibited behavior while being as consistent as possible across the different observation sessions.

3.6.3 Interview procedures

Post-observation interviews were conducted either on the same day of the class observation or the following day. It was necessary to avoid any delay that may create a situation requiring remembering details about the observation session. These semi-structured interviews were relatively short, ranging between 15 to 20 minutes each. Starting the interview with a succinct description of the project, getting interviewees' consent to audiotape and clarifying the procedures related to confidentiality as well as the protection of the data, were crucial in gaining the trust of the interviewees. More importantly, launching the interview by conversing about the teaching practices and activities utilized during the observed session created a collegial and mundane atmosphere. Such a descriptive question based on a concrete situation helped lay the foundation to give way to interviewee's understandings and opinions (Kvale, 2007). With an interview protocol consisting of five relatively open-ended questions, it was possible to exhibit openness to what participants had to share and follow through with probes on new avenues. Moreover, employing leading questions primarily helped in checking on one's interpretations. Kvale considers that this allows to verify the reliability of those interpretations.

The constant awareness of the agreed upon time frame (around 20 minutes) was fundamental to the interviewing process. Based on personal experience, observations followed by interviews may present a serious risk of creating an overwhelming feeling of unease in teachers. Hence, putting a keen and conscious effort into respecting teachers' time helped in disseminating a comforting and reassuring message among teachers participating in the project. This, in turn, made the data collection a smooth process, with no serious obstacles to be mentioned.

3.7 Approaches to data analysis

The multiple case study design was looking into a cross-case comparison within and across the three categories of schools forming the sample. In order to achieve this comparative work, common and standardized instruments were required. It entailed, at the first stage, the analysis of documents relevant to program requirements, with a focus on problem-solving programs' objectives. Drawing a comparison across the three programs' objectives, American, French, and Lebanese, was conducive to the development of common observational templates, allowing comparison of the findings in the course of the analysis. The analyses of observations and interviews were primarily about mining the data for general concepts or patterns. Careful attention was given when looking for patterns to differentiate between the real behavior, what teachers are observed to do, what they consider as an "ideal" behavior, and what they share in the interviews that follow the observation session (Angrosino, 2012). Analytic processes were iterative as processes oscillated between discussion of design (Barbour, 2014), generation and analyses of data, with anticipation and retrospection inherently connected to them.

3.7.1 Analysis of observation-driven data

Typically, the evidence from structured observation systems is either in the form of the frequency with which a particular event occurred or the total length of time it occurred (Anderson and Burns, 1989). For this study, structuring observations permitted the development of frequencies of the targeted observable occurrences, and numerically quantifying them in such a way as to facilitate the analytic process of drawing similarities and differences in practices among the three categories of schools, the ultimate aim of this inquiry. The possibility of transforming the general observations into specific measurements was an a priori target. Counting the observations required specific questions that generated exact and easily quantifiable response categories (Marvasti, 2014). In addition to quantifying the specific behavioral occurrences, structuring the anecdotal notes around focus points as previously described (section 3.5.2.1) permitted to tabulate and organize the data in such a way as to facilitate the comparative, analytical work.

3.7.2 Analysis of semi-structured interviews

From the onset of the interviewing processes, the method of analysis directed not only the preparation of the interview guide and the interview process itself, but also the transcription of the interviews. Kvale (1996) considers that the mode of analysis heavily relies on "what" is analyzed, and on the "why", the purpose of the interview. Transcribing interviews was done at an early stage of data collection. Transcribing the first lot of interviews conducted in category 1 schools helped to immerse in the data on the one hand and reflect on the questions and answers to direct further interviews on the other hand. Moreover, this exercise, as Kvale (1996) puts it, sensitizes the interviewer to the various issues related to the acoustic quality of the recording, to the clarity of the interviewer's questions and the interviewee's answers. This early stage of coding was done on a word document, with codes and (memos) taken in the margin. It was basically an exercise for getting familiarized with the coding identification process.

The analytical approach was primarily based on the generation of themes via coding and categorization through a reorganization of the data, codes, and categories, mainly sorting out and comparing data, codes, and categories. Transcribing the data on NVivo helped in the organization, manipulation, comparison, and display of information as shown below:

- organizing the various files (one file per teacher) by grouping them per category of school,
- accommodating the French language making the coding of the interviews conducted in the French language feasible,
- manipulating the numerous codes identified for each category of schools, organizing them into branches and sub-branches in code hierarchy (Gibbs, 2007),
- displaying all developed codes for three categories of schools on one sheet, significantly facilitating the comparison of codes (per category and across categories) and accessing their references (quotes) across transcribed interviews.

This last step is crucial in the coding process allowing to look for patterns, make comparisons, produce explanations, and ultimately build models (Gibbs, 2007). Data analytic categories were developed, whereby the evidence was gathered without imposed limitations by the categories.

The analysis was built on Braun and Clarke's (2006; 2012) six-phase guidelines of thematic analysis. As defined by Braun and Clarke, this method of data analysis consists of the systematic identification, organization, and interpretation of patterns of meaning across the whole data set. These patterns of meaning represent the themes which are developed by focusing on meaning across the entire data set.

Familiarizing with the data, the first phase of the analytic process, consisted of getting immersed in the data set content. This was done through repetitive reading of interview transcripts per category of schools and identifying points of relevance to the research question through taking observational and casual notes. These notes helped in proceeding to the second phase built on generating initial codes which aimed to capture patterns as well as diversity within the data. The list of codes generated from this phase two was relatively long as it was primarily a bottom-up, inductive process, seeking to link a code to every chunk in the data of relevance to the research question. The list was revised several times in order to cluster codes, a process eventually leading to the search for themes, the third phase of the thematic analysis. The process was iterative in the sense that the construction of themes involved several trials of collapsing and clustering of codes, in the search for coherent and meaningful patterns in the data and areas of prevalence across the entire data set. The development of themes was semantic, meaning that the themes were identified within an explicit or surface meaning approach, without digging for any hidden or nuanced information beyond what was said during the interviews. As clearly put by Braun and Clarke (2006, p. 82), the 'keyness' of a theme depends on the extent to which it can capture essential elements in relation to the research question. Consequently, it was crucial at this stage in the analysis to make sure that the developed themes meaningfully captured the entire set of data in order to bring insightful information to respond to the research question. Drawing and redrawing many visual thematic maps helped in identifying themes and sub-themes and the connection between them, as well as in visualizing the multiple combination of codes to generate the themes. More importantly, it allowed to engage in an extensive review process when going through the whole data set.

Samples of these thematic maps, displayed in chapter six, sought to illustrate the phases in the development of the emerging themes through codes collapsing and clustering. From this stage, it was necessary to undergo revision of the emerging themes in relation to the coded data. This quality checking, the fourth phase in the analytical process, was necessary to make sure that the generated themes matched with the codes and even more importantly, it helped set clear boundaries for the derived themes in order to avoid redundancy and overlap. The fifth phase was built on the selection of compelling and interesting extracts to describe and analyze each theme, drawing on examples that sought to cover the entire data set. This phase opened the way to the development of the interview analysis report (chapter six) built on an analytic narrative that sought to display the interconnection and coherence among the themes.

Assessing the quality of a thematic analysis involves questioning the degree to which "in vivo codes" were put under interrogation by the researcher. Barbour (2014, p. 501) observes that the effectiveness of the analysis is measured by the degree to which "in vivo codes" reflect the understandings and thoughts of interviewees. Furthermore, the clarity of the explanation is an indispensable element of the process with precision and scrutiny accompanying the presentation of the various stages in the refinement of the coding categories and the generation of interpretations. Hence, the challenge is not in the identification of patterns, but in the attempt to explain these patterns. Seeking another form of concordance, one between the emerging conceptual scheme and the literature, was targeted. This kind of theoretical comparison (Barbour, 2014) helps in refining the theoretical constructs and carries the interpretation beyond the confinement of one's own data to aspire for some kind of theoretical rather than statistical generalizability.

With this descriptive overview of the analytical processes of observational and interview data, it is noteworthy to take the discussion to the main drive of the study, through a further examination of the comparative procedures underpinning the research design.

3.7.3 Comparative strategies

Various forms of comparisons were planned, which aimed for an in-depth exploration of the phenomenon, at different levels. The first form of comparison was at the level of the application of each method across the cases (schools) within the same category. In particular, the different observations in the different schools within the same category were compared as well as the post-observation interviews were subjected to comparative means to develop the themes. This resulted in the identification of commonalities and differences in the understanding of the interviewees and their practices. Taking a further step in the comparative study within the same category of schools, the results of comparisons across the cases when considering the two methods were examined: this was conducive to the derivation of similarities and differences of teachers' understandings in relation to the teaching practices and ultimately, elaborating a typology of relations between the teachers' understanding and their practices. This process of conducting a two-level comparison to reach a certain typology for a single category was replicated in the other two categories of schools. The complexity of the comparative levels resided not only in developing a typology but taking the comparison even to a higher level and comparing the typologies across the three categories. It is through continuous comparison that identification of abstract concepts and coding is possible, a process described by Punch (2005, p. 204) as essential in order to raise the levels of abstraction, to the "one upping" for conceptual development. The systematicity but also the constancy of comparative strategies is essential to conceptual development across the different levels in the analytical phase. Ragin (2014, p. 26) emphasizes the strong sense of "order-in-complexity" in comparative studies. It is about building an order into the different combinations, a patterning that is identifiable, understandable, and, if possible, predictive. This provides meaning to the diversity across the cases within the constrictions of a single, coherent framework.

3.8 Considerations of trustworthiness

3.8.1 Binding chain: rigor of the methodology, warranting the claims

We make sense of reality through concepts which can capture, with relative adequacy some aspects of this reality. Reality is "not something that exists as a self-displaying manifold which is open to view, if only we can get into the right position, or acquire the right spectacles, to see it" (Hammersley, 2008, p. 96). Methodological caution, as Hammersley observes, is a matter of degree. Adopting a skeptical position is about being continuously conscious of the necessity of high methodological caution and thoughtfulness. This should be translated into a step-by-step chain of reasoning inherent in the research design and anchored in the logical argumentation leading to the conclusions. The focus is on the trustworthiness of the inferences drawn from the data, the value of the methods used, and the adequacy of the way the research findings are presented. Each constitutes a premise for conducting a systematic and sustainable account. It should be acknowledged, as Freeman et al. (2007) note, that data arising from social interactions are constructions or interpretations. Data derived from interviews made by interviewees, and observations performed by the researcher are interpretations yielded by the different research methods. Data are constructions derived from interpretations, with these constructions subjected to further construction in analytic processes. There is no raw data as such, as it is necessarily contaminated by human thought and human action. The ultimate aim of the research process is to construct claims which through description, interpretation, deconstruction, critiquing, predicting, and explanation, represent as closely as possible the lived experience. The challenge that the researcher has to confront "is to elicit excellent raw material and then attend to the use of methods that mold the final product or closely as possible to the representation of the phenomenon" (Morse, 2018, p. 807). Focusing on methodological rigor is about striving to ensure the trustworthiness of the study with respect to internal and external validity and reliability or what Lincoln and Guba (1985) refer to as credibility, transferability, and consistency. Several strategies were used in this study to deal with these issues. Principally, the rationale behind the multiple-case study is to follow the replication design, which would allow the original evidence to be considered robust (Yin, 2014, p. 57).

Opting to use multiple methods of data collection (analysis of documents, classroom observations, and interviewing) and imposing on the interpretation process multiple theoretical analyses, both aimed at delving into the complexity of data interpretations to provide the needed warrants for the claims. Validity is not defined a priori by identifying a specific procedure to follow. Instead, careful attention to it at all times is required as the "study shifts and turns" (Freeman et al., 2007, p. 29). Data derived from document elicitations, observations, and interviews were considered complementary, with each allowing the examination of the overarching research question from different angles. They formed parallel data sets, each providing a partial view of the whole picture. The ultimate aim of using multiple data collection methods is to test for consistency which can significantly contribute to the credibility of the findings. This can be achieved through either examining consistency in the overall emerging patterns from the various sources, or through offering logical explanations of inconsistencies in the findings across the different kinds of data (Patton, 2002). Two types of sampling procedures were performed. The first is the purposeful selection of categories of schools according to their program offerings in order to address the comparative nature of the study, and the second one is the random sampling within each category. Such random sampling was sought as one of the strategies to address validity (Merriam, 1998). Striving to increase the "hardness of the data" as Morse (2018) puts it, increases its rigor. One way to move data toward "hardness" is through data saturation. Conducting as many observations and interviews was set as a target to explore patterns that are manifested by a larger number of participants experiencing the same phenomena and, more importantly, to connect similar concepts and processes in different circumstances, experiences, contexts and events. Hence, saturation was put as a goal to develop a certain concordance within a data set.

3.8.2 Dealing with validity and reliability of observational findings

Several issues in relation to methodological validity in observational strategies needed to be addressed. One of the major concerns is the obtrusiveness of the technique. It is natural that the presence of an observer relatively alters teacher or student behaviors in various ways. It may cause on the one hand, reactive effects increasing teacher's anxiety leading to a performance of a lesser quality than usual, or on the other hand, teachers' instruction may be slightly better than usual when teachers are aware they are being observed. In both cases, the validity of the inferences about what normally occurs in the classroom can be affected (Waxman et al., 2004). One way of addressing this issue is building trust with gatekeepers and certainly with teachers' participants. By building trust, it is possible to decrease any stress that the observation situation may cause. Lincoln and Guba (1985) perceive the credibility of the outcomes as dependent upon the extent to which trust has been established.

While the obtrusiveness of the technique is an important methodological issue to deal with, the consistency across the multiple observations (across classrooms, teachers, and schools) is a matter that requires as much thoughtfulness and care. Anderson and Burns (1989) note that the greater the consistency, the greater the credence of the claims, advising to seek out the factors that are linked to any inconsistencies observed. Opting to conduct between eight to nine observations in each school and in various disciplines aimed at verifying a first layer of consistency across class observations and semi-structured interviews within the same school. The second layer of consistency sought was conducting the study in three schools in every category (Lebanese, French, and High school programs), trying to optimize the number of class visits and interviews. Cohen, Manion, and Morrison (2017) caution that the reliability of results is dependent on the degree of applying the indicators "fully, consistently and securely, with no variation in interpretation" (p. 561). As a trained observer, it was possible to ensure to a certain extent the consistent usage of the observation log indicators across classes. Insisting on school staff to prepare a schedule of only three observation sessions per day addressed issues of fatigue that may arise from prolonged observations, thus allowing to maintain focus on detail with minimal attention drifts (Cohen, Manion, & Morrison, 2017). More importantly, it provided a break time between observations needed for reflection.

Determining the appropriate time of the observation session and the number of observations required to obtain a valid and reliable measure of instruction needed to be addressed. Attending the full period (45 to 50 minutes) was essential in order to make sure to get the whole range of teaching practices and activities from the onset of the session till its end. Furthermore, conducting up to nine observations per school, hence a total of 81 observations across the three categories of schools, aimed at reaching the intended replication, be it literal or theoretical. Yin (2014) makes the relevant point that "only with such replications would the original finding be considered robust" (p. 57). Through structuring observations including anecdotal notes, it was possible to address two causes of observation-related biases, "selective data entry" and "selective memory" (Cohen, Manion, & Morrison, 2017, p. 560). The observation log, with its specific behavioral occurrences, and the anecdotal records with their focus points, both sought to reduce the effect of personal judgment and concentrate on the specific behavior of interest and the teaching activity in connection with it. With observations recorded during the session and not after, the risk of either neglecting, overlooking, or selecting data was minimized.

Although not performed systematically, member check was possible when time permitted. Such an informal checking presented a meaningful opportunity to share the frequency ratings pertaining to the observation log and the anecdotal notes. This "respondent validation" as referred to by Merriam and Tisdell (2016), formed an important means to identify one's own biases and misunderstandings.

3.8.3 Dealing with validity and reliability of interview findings

The validity of the interviews is measured by the degree of accuracy between the responses and the reality of the responses intended to capture. The challenge, as Merriam (1998, p. 180) notes, is to succeed in constructing categories and themes that "capture some recurring pattern" to cutting across the "preponderance" of the data ending in the emergence of commonalities and tendencies in the various interviews. Validity is dependent on the underlying assumptions and intentions of the researcher. The extent to which researcher's neutrality is maintained has both methodological as well as ethical implications. Admittingly, opting for interviewees' validation was not possible in light of the large number of teacher participants in interviews (71 interviewees in total) spread over nine different schools. With such a one-off data collection procedure, respondent validation may be more causing distress than worth (Barbour, 2001). It should be observed at this point that the interviews contributed to a certain extent in member checking, with conversation naturally lending itself to the observation session that preceded the interview.

Peer review, specifically when starting the process of coding (refer to Appendix C for a sample of peer coding) and developing categories, was a useful means to examine the adequacy of the generated categories and codes. It allowed to compare, discuss and shed a critical look at the developed codes. Such an "intersubjectivity agreement" would ultimately help increase the reliability of the interview findings (Brinkmann & Kvale, 2015, p. 282). This peer debriefing, described by Lincoln and Guba (1985) as "exposing oneself to a disinterested peer" (p. 308), was not limited to issues related to transcribing and analyzing. It was helpful in questioning and discussing, at the various stages of the investigation, decisions pertaining to sampling, construction of the observation log, and the interview guide questions, all through to the analysis phase. Playing the devil's advocate by a peer helped probe, explore, and clarify. More importantly, this inner mind exposure made one's own biases and perspectives surface and presented a fertile soil for substantial questioning and reconsideration while presenting as well "an opportunity for catharsis" (p. 308) to cope with the strenuous pressure of the investigation journey.

Ultimately, increasing the thoroughness of the analysis and the rigor of the evidence aim at warranting the claims and demonstrating the relevance of the evidence to the inferences and conclusions. Acknowledging what Gorard (2002, p.147) advocates, mainly that "a piece of evidence cannot be either good or bad as long as it is presented with its appropriate caveats", it is essential to present a clear and transparent step-by-step chain of reasoning that links the evidence to the conclusion, making the warrant as explicit as possible. By explicit, as Gorard emphasizes, it is meant that it is open to argumentation and inspection, with simplicity and transparency being key characteristics in this chain of reasoning. The difficulty in making the warrant explicit is through the avoidance of conclusions that do not follow logically. This can take several forms such as falling into mere tautology, failing to take account of unobserved factors, tumbling into the trap of misleading arguments, and most importantly failing to take account of rival explanations. Finally, as Merriam and Tisdell (2016) observe, the validity and reliability of a study cannot be separated from the ethics of the researcher. The trustworthiness of the data is tightly linked to the trustworthiness of the researcher who collects and analyzes the findings.

3.9 Ethical considerations

As with any form of a research study involving human beings, respecting ethical principles is primordial. Working in real-world sites and dealing with interview transcripts cannot but be confronted with continuous ethical considerations and moral obligations. Ethical standards impose obligations on the researcher toward all those who are involved, whether directly or indirectly, in the study. In reference to the British Educational Research Association (BERA, 2018), ethical guidelines for educational research, adhering to an ethic of respect when conducting this research project entailed responsibility toward the participants on issues related to consent, right to withdraw, privacy and data storage. As clearly stated in the introduction, making decisions within this ethical framework becomes "an actively deliberative, ongoing, and iterative process" (p. 2) of continuously assessing and reassessing issues that arise throughout the study, from its planning to reporting. Working on the basis of informed consent was central. Voluntary participation is a fundamental right of any potential participant to choose to participate or not, with participants possessing the right to withdraw their consent at any time and for any reason in the research process. Gatekeepers including heads of schools and heads of departments were given enough clarification about the research. Participants in observation and interviews were supplied with a detailed, yet non-technical account of the project, to be able to decide whether they agreed to proceed or not, with the aims and expectations of the research project clearly stated in the participant information sheet. The declaration of informed consent sheet was signed by all participants and constituted the formal contract to participate in the study. Participants were advised that the interviews would be audio-recorded, which I have stated in the informed consent form and explained to them verbally prior to the interview. Confidentiality, privacy, and protection of anonymity were essential standards. Schools forming the sample were given fictitious names. The identities of participants in observations and interviews were not revealed at any stage in the study. Albeit observations and interviews did not involve any sort of harm or particularly delicate or intimate issues, nevertheless, such protection was considered a pre-requisite for the research work. In addition to maintaining a high degree of anonymity, taking necessary measures to securely store the collected data was done by using password protection and ensuring data is stored on secure premises. Notwithstanding the importance of the aforementioned ethical standards vis-à-vis the participants, one more important ethical principle that merited attention was the relationship between ethics and quality in research. In my capacity as a researcher conducting this project, seeking methodological rigor at all times in the process was placed as an utmost ethical commitment toward the readers, the community, and myself. The proposal for this project was granted approval by the Durham University School of Education Ethical Committee in February, 2019.

3.10 Summary and concluding thoughts

This chapter delineated the nature of the research design, the sampling strategies, and the methods for data collection. It described the analytical processes and addressed as transparently as possible issues related to the trustworthiness of the findings and the rigor of the design. Closing the chapter on this final note from Patton (2015) stated below, is to emphasize the intertwined relationship between the trustworthiness of the evidence and the ethical considerations that pervade the research and reflect the orientations and the ethical stance of the researcher.

> "Methods do not ensure rigor. A research design does not ensure rigor. Analytical techniques and procedures do not ensure rigor. Rigor resides in, depends on, and is manifest in rigorous thinking about everything, including methods and analysis" (p. 703).

Chapter Four

Document Review

4.1 Introduction

This chapter analyzes the curricular documents relevant to the three programs under study, the Lebanese Program, the French program, and the American program. The documents' elicitation addresses the first sub-question of this study, namely:

What are the teaching practices that delineate the curricular requirements for the teaching of problem-solving competence in middle school?

Emphasis is put on depicting from each program the key elements in terms of objectives, practices, or standards relevant to problem solving. The structure of the chapter consists of four main sections. The first three are dedicated to presenting the programs' requirements with a focus on problem solving, starting with the Lebanese program, then the French, and ending with the American program. The fourth and last section describes how the observation log templates were built. This comparative work constituted the key stage in constructing two templates used during the observation sessions: first, the lesson's objectives template, used to identify the general focus of the lesson, and second, the observation log, which served as the basic means for conducting the observations.

4.2 Problem solving in the 1995 Lebanese Program

As the title of this section shows, the Lebanese program did not undergo any sort of reform during the last three decades. Unfortunately, the political instability accentuated by the economic crisis hampered several initiatives to put in place a comprehensive reform of programs to respond to the needs of the twenty-first century. Only recently, a ray of hope started looming, with serious steps taken in early 2020 to devise a plan for a comprehensive reform of all programs, and all cycles (K-12). The documents that were explored and subsequently served to build the observation schedule templates were principally retrieved from the official and public site of CERD (Center of Educational Research and Development). Document review was restricted to the middle school cycle, grades 7, 8, and 9 (students aged 12-15). The curriculum objectives of the three languages

(Arabic, French and English), mathematics, sciences, and social studies were examined with a focus on objectives that explicitly targeted problem solving, or as I interpreted them as objectives linked to problem solving. Not all texts were written in English; therefore, Arabic and French texts were translated.

4.2.1 Languages, Arabic, English and French

Before examining each language objectives for Arabic, French, and English, it is worth mentioning that the Lebanese system requires teaching another main language in addition to Arabic as the mother tongue. This could be either French (in schools where French is the vehicle language) or English (in schools where English is the vehicle language), in addition to a third foreign language. Thus, in schools where French is the second main language, subjects such as mathematics, sciences and social studies are taught using the French language. In these schools, English is taught as a third language. As for schools where mathematics, sciences, and social studies are taught in English, then English is the second main language, and French is the third language. As alluded to in the methodology chapter when considering the Lebanese program category, two types of schools fall under this category: schools using English and Arabic as the main languages, and schools using French and Arabic as the main languages.

Regarding the Arabic language, one of the general objectives which can be associated with problem solving can be stated as follows:

- Acquisition of scientific reasoning, critical thinking, and the capacity to move from general to specific topics and ideas

Problem solving can be interpreted as targeted, assuming it can be classified under reasoning skills.

As for the English language curricular objectives, problem solving is clearly stated. One of the general objectives describes the developing of student's critical thinking skills as consisting of analytical, synthetic, and critical components. Branching from this general objective are the following specific targets:

- Development of strategies for *problem solving*, decision-making and conceptualizing.
- Development of critical thinking skills.
- Transfer of information from one context to another.

The objectives of the French language and literature curriculum emphasize the role of thinking skills. They target the development of the capacity for expression and analysis, which contribute to the intellectual maturity of the Lebanese learner. This is achievable through the development of critical thinking, aptitude for autonomous thinking, capacity to continuously renew methods of working and thinking and development of appropriate methods of thinking and reflection. It is worth noting that the development of transversal competences is mentioned under the French language and literature section. They are described as competences allowing the learner to establish links with competences acquired from other disciplines. It is the only subject alluding to transversal or cross-curricular competences.

To sum up, it is exclusively the English language curriculum that specifically targets problem solving and puts the development of problem-solving strategies as a well-articulate objective. The remaining two languages, Arabic and French, emphasize general reasoning and critical thinking skills.

4.2.2 Mathematics

In mathematics, it is natural to emphasize problem solving alongside mathematical reasoning and other general objectives. Several specific objectives emanate from problem solving, including those listed below:

- Analysis of situations to deduce the pertinent elements.
- Look for the necessary information to elucidate an incomplete given.
- Construct a mathematical model.
- Choose a strategy to deal with a certain situation.
- Deconstruct a difficult task into simpler tasks and reciprocally, construct and combine to derive conclusions.

4.2.3 Sciences

Several objectives can be connected to developing problem-solving competence in the sciences. Nevertheless, none of the listed general objectives particularly highlighted the role of sciences in promoting problem solving. The ones identified as contributing to the development of problem-solving competence were the following:

- To develop intellectual and practical scientific competences of learners.
- To prompt learners to invest acquired knowledge and scientific competences in new situations, particularly daily situations.
- To induce learners to respect values and adopt objective scientific methodologies.

Both autonomy and group work are emphasized and considered general objectives of the science curriculum.

4.2.4 Social Studies

In social studies, specifically geography, two objectives were identified in connection with problem solving, namely:

- Development of a sense of observation and description.
- Development of analytical skills to interpret phenomena and understand their evolution.
- Development of critical thinking to understand the various issues and acquire knowledge through research.

To conclude this section on the Lebanese program requirements with a focus on problem solving, only two subjects, English and Mathematics, have specific objectives that explicitly target problem solving. For the remaining subjects, the previously mentioned objectives were chosen based on a personal judgment of the potential to promote problem-solving competence. The next section turns to the analysis of the French program requirements pertaining for middle school, referred to as "Cycle 4".

4.3 The French Program

Before delving into an in-depth exploration of the French program with a focus on problem solving, it is necessary to define the term competence, especially as the French program is built on a competence-based framework.

In a comprehensive report comparing policies and practices adopted by 27 members of the European Union concerning the development and implementation of key competences for the twenty-first century (Gordon et al., 2009), the term competence (plural competences) is described as the capacity to apply the knowledge and the skills, as well as the attitudes and aptitude. Competences are described as essential for personal growth and fulfillment, active citizenship, inclusion and employability.

The term 'competency' (plural competencies), interchangeably used with "twenty-first century skill", is used in the American context. Anderson-Levitt (2020) points out that in the US, competencies as a term is used rather than competences and twenty-first century skills as a term is interchanged with competencies. By competencies, it is meant knowing *how to* or the skills and being *ready to* as the dispositions, as opposed to knowing *that*, or content knowledge. Competencies, as advocated for, bear a transdisciplinary or transversal dimension, as opposed to specific disciplinary skills. Within this formulation, twenty-first century skills are associated with higher order thinking, such as applying, analyzing, and evaluating knowledge. The nuanced difference between "competence" and "competency" is also clarified by Gordon et al. (2009). The EU usage of competence tends to be holistic, referring to the learner's attributes, capacities and qualities. Whereas the OECD competency is closer to the meaning of skills, the ability that can be learned, leading to the performance of an action, and achieving aspired outcomes.

the European Framework of Key Competences for lifelong learning and active societal role underpins the French program. This framework is constituted of eight key competences, four of which can be acquired within the classical subjects: communication in the mother tongue, literacy, mathematical competence, basic competence in science and technology, and communication in foreign languages. These competences are measurable. Another group of key competences, cross-curricular in nature, include digital competence, learning to learn, social and civic competences, a sense of initiative and entrepreneurship, and cultural awareness and expression. They are conceived as anchored in transversal competences such as critical thinking, creativity, initiative, problem solving, risk assessment, decision-making, and constructive management of feelings. The competence-based approach to teaching and assessment, as described by Gordon et al. requires a radical change in teaching and instruction, shifting from a teacher-centered approach to a student-centered learning approach. As facilitators of learning, teachers tailor their practices towards maximizing individual support rather than whole-class teaching. Instruction promotes key competences such as decision-making, in-depth thinking, and problem solving. Projects are encouraged to turn learning into more meaningful experiences conducive to reflective learning. The French program framework is built on the knowledge (savoir), skills (savoir-faire), and social competences (savoir-être). These competences form the basis for curriculum development as well as assessment.

The 'Program of cycle 4'-academic year 2018-2019- constituted the main reference to identify the objectives of problem-solving competence. The three-year cycle program designated as "Programme du cycle 4" (grades 7, 8, and 9) is embedded in the five domains of the "Socle Commun de Connaissances, de Compétences et de Culture". The 'socle' defined for compulsory education is constituted of both subject-based and cross-curricular components. It is presented as a framework with explicit competences emphasizing, in line with EU policy, life-long learning and effective contribution to society.

Underpinning the 'socle' are five main competences that correspond to the key competences of the European Reference Framework and are referred to as domains. Below is a succinct presentation of these general domains of the 'socle':

- Domain one, languages to think and to communicate, emphasizes the role of reflection. The rigor of expression and the capacity to translate this rigor into practice through conducting a dialogue, and the adaptation to diverse situations to act or problem solve, are at the heart of this domain. Languages are not only limited to the acquisition of the French language as the mother tongue, but encompass the learning (understanding and expressing oneself) of foreign languages, mathematical and scientific languages as well as performing arts (plastic arts and music), and physical education.
- Domain two, methods and tools to learn, includes the practices which teach students how to learn at school.
- Domain three, education for citizenship, is reflected in the development of critical thinking, openness to others, individual and collective responsibility.

- Domain four, natural and technical systems, allows the learner to grasp the concepts of proportional quantities in space and time. Sciences, including mathematics, play a fundamental role in allowing the learner to reach validation through deduction and induction, problem solving, and trial and error processes.
- Finally, domain five, world representations and human activity, aims at helping the learner construct her/his culture. This can be achieved through interdisciplinary projects.

To summarize, the five domains provide the conceptual framework for the different objectives underpinning the different disciplines. These domains highlight the integrated nature of disciplines. Promoting a domain is not restricted to one discipline but rather the interplay of many disciplines. This integration is reflected in the objectives pursued within the disciplines, as shown in the next section, which presents selected objectives per discipline in connection with problem-solving competence.

4.3.1 French language

The teaching of the French language, as described in the Cycle 4 Program, constitutes an important arena for building autonomous thinking based on the usage of correct and precise language and the development of a critical mind and judgment qualities. It contributes to developing argumentation competences and critical approaches to general humanistic issues addressed in literature. Amongst the listed general competences, the selected ones promoting problem solving emphasize understanding, interpretation, argumentation and debate, analysis and elaboration.

4.3.2 Mathematics

A review of mathematics curricular objectives reveals that problem solving occupies an essential place. In the introductory paragraph of the mathematics program objectives, problem solving is defined as the capacity to take initiative, conceive steps or strategies to reach a solution. This can be achieved by using analogy to link a specific situation to a more general category of problems. Such a process requires automatization, defined as the body of acquired knowledge and automatic processes immediately available in the memory. Acquiring these automatic processes is enhanced through daily activities. Such an automatization possesses a double objective: first, stability and perennity of the information, and second, persistence in the applying procedures and strategies. The teaching of mathematics is anchored in six specific competences constituting the pillars underlying all mathematical activities. They include searching, modeling, representing, reasoning, calculating, and communicating. It is worth mentioning that demonstration, a mathematical key competence, is considered a form of argumentation. This emphasizes the integrated nature of the program, given that through mathematical demonstrations, learners develop a form of argumentation, allowing the teaching of mathematics to concur with other disciplines in the development of argumentation competence.

4.3.3 Social studies (history and geography)

Three competences were selected from social studies and interpreted as competences that promote problem-solving competence. First, reasoning and justifying choices and strategies include questioning, formulating hypotheses, interpreting, and justifying. Second, analyzing and understanding consists of identifying pertinent information and investing acquired knowledge to explain and use critical thinking. The third competence highlights the role of cooperation demonstrated through discussion, argumentation, and defending one's choices. It is again worth noting that argumentation is a competence sought in social studies.

4.3.4 Sciences

The teaching of sciences (biology, chemistry and physics) allows students to develop their curiosity and open-mindedness, question information, and use their errors constructively and positively. Furthermore, it contributes to nurturing capacities such as observing, experimenting, measuring, reasoning, and modeling. The objectives selected in connection to problem solving were derived from two competences, experimenting and conceiving, creating and performing. The former includes identifying questions of scientific nature, formulating hypotheses, experimenting and testing hypotheses, interpreting experimental results to derive conclusions, and communicating them using sound arguments. The latter includes conceiving an experiment to conduct measurements or observations.

In summary, built on the competences of the 'socle', the French program is a competence-based framework that constitutes the underpinning structure for both teaching and assessment. Each discipline contributes to the five domains thus, highlighting the integrated nature of the program. The various disciplines aim to develop in learners' subject-specific competences and cross-curricular competences, such as argumentation. Interdisciplinary projects, mentioned in domain five, are given a significant value, constituting the means to promote cross-curricular competences.

4.4 American program

Two main references, the Common Core State Standards (CCSS) and the Next Generation Science Standards (NGSS), were consulted to examine the requirements of the American program. Considering the Common Core State Standards, two public documents were explored to select the objectives that promote problem-solving competence: ELA (English Language Arts) and the Common Core State Standards for Mathematics.

4.4.1 English language arts standards

Standards, described in the introduction of the Common Core Standards for English Language Arts and Literacy in History, Social Studies, and Technical Subjects, are described as rigorous, research and evidence-based, meet college and work expectations, and are framed by international benchmarks. They aim to develop College and Career Readiness (CCR) standards in the areas of reading, writing, speaking, listening, and language, as well as mathematics. The College and Career Readiness standards form the underlying structure of the Common Core document.

The standards define the understandings and skills students are expected to acquire, highlighting a vision of what it means to be ready for college, the workforce, and life in this technological era. They are expected to enable a twenty-first century literate person to develop the abilities for gathering, comprehending, evaluating, synthesizing, reporting, and conducting original research with the ultimate goal of answering questions and solving problems. The teaching of reading, writing, speaking, listening, and language is not limited to English language discipline but encompasses a range of other subjects such as history/social studies, sciences and technical subjects. Developing a literate person is a shared responsibility among teachers of different disciplines. In this respect, Pellegrino and Hilton (2012) note that the standards for English Language Arts and Literacy, in History/Social Studies, Science, and Technical Subjects (CCSS-ELA) translate an integrated approach to reading, writing, speaking/listening, and language. This integration reflects a vision of language practices as best taught when they constitute means for acquiring knowledge and skills within literature, sciences, technology, and history. Such an integrated view of standards considers reading, writing, and oral language as means of acquiring knowledge, effective argumentation, and clear communication in literature, sciences, and social studies (Pellegrino & Hilton, 2012). Interestingly, this approach to literacy mirrors to a large extent domain one, languages to think and to communicate, of the French program's 'socle'. In both American and French programs, the emphasis is placed on the integrated approach to literacy. In addition, argumentation which occupies a central place in the French program is also stressed in the American program. Standards targeting the ability for argumentation are embedded in many disciplines and reflected in processes such as building an understanding, criticizing, and constructing arguments.

4.4.2 Common core standards for mathematics

The Common Core State Standards for Mathematics emphasizes the conceptual understanding of key ideas which determine the organization and generation of knowledge within this discipline. Similar to ELA (English Language Arts) standards, mathematics standards frame what students should understand as well as what they are able to do. Eight standards define what mathematics teachers should seek (Common Core Standards for Mathematics, p. 6-7). They are as follows:

- Make sense of problems and persevere in solving them.
- Reason abstractly and quantitatively.
- Construct viable arguments and critique the reasoning of others.
- Model with mathematics.
- Use appropriate tools strategically.
- Attend to precision.
- Look for and make use of structure.
- Look for and express regularity in repeated reasoning.

When it comes to argumentation, standard N.3, 'construct viable arguments and critique the reasoning of others', reflects a form of argumentation constituting an area which overlaps with other subjects. Being considered a standard, it occupies a valuable place, as is the case in the French program. Generally, there are two prominent areas of overlap between the Common Core mathematics learning goals and twenty-first century skills, namely argumentation, reasoning and problem solving (Pellegrino & Hilton, 2012).

4.4.3 Science practices

The Next Generation Science Standards (NGSS) was referred to for identifying science practices underlying the teaching of sciences. NGSS is anchored in the Framework for K-12 Science Education, which expresses a vision that places the learning of disciplinary core ideas in the context of science and engineering practices. 'Practice' as stated in the document, is used as a term to replace 'skill' putting emphasis on the role of knowledge and not exclusively the skills in defining each practice. There are eight practices of science and engineering (NGSS, Appendix F) students are expected to learn. They are listed below:

- Asking questions (or science) and defining problems (for engineering)
- Developing and using models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations (for science) and designing solutions (for engineering)
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating information.

Again, argumentation reappears in "engaging in argument from evidence", highlighting its role and presenting an area of similarity between the American and French programs. The NGSS practices show that they do not function independently from each other but are closely interconnected. Moreover, science core ideas are linked to engineering procedures and cross-cutting concepts such as using mathematics and computational skills and communicating information. The areas of overlap with literary and mathematical skills reflect an integrated approach to learning (Comfort & Timms, 2018). Even more importantly, the science and engineering practices overlap with twenty-first century skills, particularly non-routine problem solving and complex communication, central to science and engineering disciplines (Pellegrino & Hilton, 2012).

Before bringing to a close this section, it is important to mention the substantial difference in the nature of the American and French programs. Standards and Practices define what students are expected to acquire in terms of knowledge and skills; nevertheless, they are general and do not dictate what teachers should teach. Consequently, a comprehensive, content-rich curriculum must be developed within these fundamentals. This is where the difference lies. The French 'socle' is compulsory, constituted of well-defined competences dictating the requirements for both teaching and assessment. From this presentation of the three programs' objectives pertaining to problem solving, the next section describes how the observation templates, and the means to conduct classroom observations, were developed based on these curricular objectives.

4.5 Development of the observation log templates

In order to develop unified templates for comparative purposes, it was deemed necessary to structure and categorize the curricular objectives of the Lebanese program, the competences of the French program and the standards and practices of the American program. To facilitate categorization and at a later stage the analysis of observation data, resorting to PISA 2012 cognitive problem-solving processes strands served this purpose. The four strands or dyads include "Exploring and Understanding", Representing and Formulating", "Planning and Executing", "Monitoring and Reflecting". This is illustrated in the table below, which displays the four strands, the American program CCSS and NGSS, and the French competences of the 'socle'. Since the objectives of the Lebanese program are simpler than the American and French programs' objectives and covered by these programs, the focus was placed on the American standards and practices and the French competences in the developing of the observation templates. Based on the table below, two templates were constructed: the first included general objectives constructed based on the competences, practices and standards and used to identify the focus of the lesson observed. The template was developed based on the similarities identified between the requirements of the French and American programs. The second template, the observation log, consisted of concrete, specific, observable students' behavior derived from the PISA 2012 four strands of cognitive processes. The two templates (Appendices D and E) served as the base for structured observations, the topic of the next chapter.

Table 4.1 American and French program objectives classified in concordance with PISA 2012 strands of cognitive problem-solving processes.

PISA 2012 four strands	*American program Standards/ Practices* of CCSS and NGSS	*French program competences of the socle*
Exploring and understanding -Exploring the problem situation: observing it, interacting with it, searching for information and finding limitations and obstacles -Understanding given information and information discovered while interacting with the problem situation; demonstrating understanding of relevant concepts	-Read closely to determine what the text says explicitly and to make inferences from it; cite specific evidence when writing or speaking to support conclusions drawn from text -Make sense of problems and persevere in solving them -Reason abstractly and quantitatively -Ask questions and define problems	-Understand and interpret complex oral messages -Interpret literary texts -Question one's self and others on historical and geographical situations -Extract pertinent information -Identify questions of scientific nature -Explore by **e**xtracting from a document the relevant information, reformulate, organize and compare it to prior Knowledge) - Explore (test and try different ways to solve a problem)
Representing and formulating -Representing the problem using graphs, tables, symbols, verbal representations and shifting between the different formats -Formulating hypotheses; organizing and critically evaluating information	-Present information, findings and supporting evidence -Model with Mathematics -Develop and use model (development of questions and explanations, generating data that can be used for predictions and communicating ideas to others)	-Construct notions that permit the analysis and the elaboration of texts and speeches -Propose one or two hypotheses to answer a scientific question -Identify a mathematical concept/construct and solve a problem using this conceptual framework/ analyzing this construct to solve a problem)
Planning and executing -Goal setting (clarifying the goal, setting sub goals if necessary); -Devising a plan or a strategy to reach the set goal (including steps) and executing	-Prepare for and participate effectively in a range of conversations, building on others' ideas and expressing their own clearly and persuasively. -Construct explanations and design solutions -Use appropriate tools strategically -Plan and carry out investigations	-Debate in a constructive manner -Choose and establish a relationship between convenient conceptual frameworks to solve a problem…) -Demonstrate, using logical reasoning and referring to mathematical rules (properties, formulas and theorems) to reach a conclusion -Design and create a measuring tool and an observation protocol -Set a plan for an experimental task
Monitoring and reflecting -Monitoring progress (checking intermediate and final results, detecting unexpected events and taking remedial action when needed) -Reflecting on solutions considering different perspectives, critically evaluating assumptions and alternative solutions, identifying needs for additional information or clarification and communicating progress in a suitable manner.	-Delineate and evaluate arguments and specific claims in a text, including the validity of the reasoning, the relevance and sufficiency of the evidence -Construct viable arguments and critique the reasoning of others -Analyze and interpret data -Engage in argument for evidence -Obtain, evaluate and communicate information	-Move from an intuitive approach to a well-elaborate argumentation, using acquired knowledge and critical thinking. -Formulate hypotheses to interpret historical and geographical phenomena -Justify a method or an interpretation -Interpret experimental results to derive conclusions and communicate results with a justification -Reason by solving problems, analyzing, reflecting on errors, and testing different solutions

4.6 Concluding thoughts

The document review of the three programs, American, French, and Lebanese, provided an in-depth exploration of the curricular requirements for each program. The different documents gave way to identifying programs' objectives linked to problem solving and, even more importantly, to examining the areas of similarities and differences between programs. American and French programs stress an integrated approach to teaching observed in the five domains underpinning the French 'socle' and the overlapping areas between the US, Common Core State Standards, and the Next Generation Science Standards. The broadening term of literacy opens the way to new concepts encompassing reading literacy, mathematical literacy and science literacy, beyond its old narrow meaning restricted to reading and writing (Csapó, 2010). Furthermore, this integrated approach emphasizes the role of transversal or cross-curricular competences. In particular, argumentation is not limited to the realm of languages but underpins other disciplines such as mathematics, sciences, and social studies. As for the Lebanese program, it remains compartmentalized into subject-specific objectives. In connection with the nature of the programs, French and Lebanese programs' requirements are compulsory and mandated by the Ministry of Education in their respective home countries, whereas the American program provides a framework of general standards, offering relative flexibility for curriculum developments. With these final highlights on document review, the next chapter deals with structured observation findings to discern how the array of curricular objectives is concretized into teaching practices. Followed by the analysis of post-observation interviews aiming to uncover underlying beliefs and understandings, the three instruments, according to Flick (2007), can potentially show the different facets of the phenomenon under study, either by complementing or contradicting each other.

Chapter Five

Analysis and Discussion of Structured Observations

5.1 Introduction

This chapter presents the analysis of the observation sessions conducted in nine different schools. The analytical work was carried out to investigate the following research question:

How does the teaching of problem-solving competence reflect each of the curricular requirements in middle school?

A total of 81 teaching sessions, nine in each school, were observed. In general, three classes per grade level were attended, in subjects which included languages, mathematics, sciences, and social studies. The first three sections of this chapter provide an analysis of the observation data per category, collected from three different sources: the lesson objectives template, the observation schedule, and the anecdotal notes. Afterward, the results are discussed in depth. Then, in the sections that follow, a cross-category analysis is addressed. The chapter closes with a discussion of the findings derived from this comparison across the three categories of schools. A reference to PISA (2012) four dyads of cognitive problem-solving processes was done when describing the findings. These strands, as described in chapter four helped construct the observational templates (observation schedule and program objectives template) by categorizing the various curricular objectives from which the components of the observation schedule were derived.

5.2 Category 1: Schools with the Lebanese program

The analysis of the data derived from observations was based on 27 class visits conducted in three different schools which exclusively cater to the Lebanese program. These K-12 schools prepare students for the Lebanese baccalaureate, their passport to higher studies. Two of these schools have English language as the main language. This means English is the vehicular language utilized to teach various disciplines, such as mathematics, sciences, and social studies. In the case of the third school, French is the main language of instruction used to deliver the different disciplines. The three schools abide by the procedures mandated by the Ministry of Education and Higher Education. They are entitled to follow the Lebanese curricula in the various subjects and ultimately, prepare their students for two national exams, the Brevet, end of year 9, and the Lebanese baccalaureate, end of year 12.

5.2.1 Observation schedule data analysis

Table 5.1 presents the data driven from the observation of 27 classes (45-minute periods each). The 27 classes were spread over the three grade levels of the middle school, with a well-balanced distribution among the various disciplines (sample visit schedule in Appendix F).

Table 5.1 *Frequency of observation of cognitive processes manifested by students' behavior in category 1 of schools with the Lebanese program. Low (L), Moderate (M), High (H)*

Cognitive processes	Total: 27 teachers	L (1-2 times)	M (3-4 times)	H (more than 5 times)
Understand a text, diagram, formula, tabular information	19	8	11	0
Draw inferences	6	4	2	0
Relate information from various sources	8	5	2	1
Demonstrate understanding of relevant concepts	22	4	16	2
Use information from students' background knowledge to understand the information given	20	11	0	9
Identify the variables in the problem & note the interrelationships	15	8	7	0
Retrieve, organize	6	3	2	1
critically evaluate contextual information	1		1	0
Construct tabular, graphical, symbolic, and verbal representations	6	1	5	0
Apply a given external representation to the solution of the problem	1	0	1	0
Shift between representational formats	3	1	2	0
Construct hypotheses	3	3	0	0
Analyze a system	4	5	2	0
Examine solutions & look for additional information or clarification	2	1	1	0
Evaluate solutions from different perspectives	2	1	1	0
Justify solutions	8	5	3	0

The compilation revealed that most teachers (19 to 22 out of 27) based their lessons on helping students show their understanding, demonstrate understanding of relevant concepts related to lessons, as well as establish links with prior knowledge. Many teachers made attempts to help their students identify the variables and try to establish links between these variables. Few teachers, however, carried their students' understanding beyond the exploration phase to draw inferences, relate information from different sources, and retrieve and organize ideas. For instance, only six teachers dealt with drawing inferences, and eight addressed relating information from various sources. In both cases, teachers seldom targeted these objectives as illustrated by the low frequency. Furthermore, only one of the participants encouraged students to make contextual, evaluative judgments as part of the learning process. The rest of the participants rarely gave their students the opportunity to do so. In addition, few teachers were involved in the construction of different representations and formulation of hypotheses categories, two learning practices that can classified under "Representing and Formulating" strand of the PISA (2012) for problem solving. Only six teachers for the former and three teachers for the latter, with a total constituting 33% of the teachers observed. The lowest number of participants revealed by the compilation was related to the examination of solutions and evaluation from various perspectives which may be classified under "Monitoring and Reflecting" strand of cognitive problem-solving processes. Interestingly, 'justifying solutions' category was addressed in 30 % of the observed classes (8 out of 27 teachers).

In general, most frequency ratings ranged between low and moderately observed. Only 14 teachers demonstrated high frequency ratings in specific areas such as 'Relate information from various sources', 'Demonstrate understanding of relevant concepts', 'Use information from students' background knowledge to understand the information given' and finally, 'Retrieve and organize'. Exceptionally, nine teachers showed a high frequency rating for item 'Use information from students' background'. This particular cognitive process was sought by 20 teachers out of the 27, reflecting an important effort placed into helping students make connections with prior knowledge, yet with varying frequencies.

In summary, findings pointed, at one end, to a predominance of teaching practices and activities focusing on students exploring and showing understanding, thus promoting cognitive processes such as understanding, demonstrating, using prior knowledge, identifying variables, and noting interrelationships; and on the other end, little integration into instruction of practices conducive to students developing capacities for representing and formulating, analyzing, sharing multiple perspectives, examining various solutions, and reflecting. In direct link with this observation log compilation, the next section addresses program objectives.

5.2.2 Curricular objectives findings

The curricular objectives identified during the 27 class observations and displayed in Table 5.2 were primarily addressing the exploration of literary texts (Arabic and foreign languages), images and documents (sciences and social studies), and mathematics concepts. Organizing information and establishing connections with prior acquisitions were the focus of many lessons as well. In addition, in subjects like mathematics and science, working on demonstrations by following step-by-step instructions was sought.

Table 5.2 *Compilation of category 1 program objectives addressed in the 27 lessons observed.*

Lesson Objectives	Number of lessons
Explore literary and non-literary texts, images, and documents.	7
Explore by extracting from a document the relevant information, reformulating, organizing, and comparing it to prior knowledge.	5
Identify questions of scientific nature.	4
Explore by testing and trying different ways to solve a problem.	3
Construct concepts that permit the analysis and the elaboration of texts and speeches.	2
Identify a mathematical model and solving a mathematical problem using this model.	4
Choose and establish a relationship between convenient conceptual frameworks to solve a mathematical problem or study a model.	1
Develop and use a model (development of questions and explanations, generating data that can be used for predictions and communicating ideas to others).	1
Debate in a constructive manner.	2
Demonstrate by reaching a conclusion using logical reasoning & referring to mathematical rules (properties, formulas and theorems).	3

Preparation for a debate did have its share amongst the participants' group, with two teachers targeting this curricular objective. Identifying a mathematical model and working on problem-solving application exercises were significantly more targeted than choosing and establishing relationships between various models to solve mathematical problems. Moreover, elaborating an interpretation as well as making justifications were seldom targeted. Similarly, developing explanations and making predictions received little attention. Objectives that were not emphasized in any of the 27 classes were: 'Elaborating an interpretation of literary texts' (for languages,) and 'Setting an experimental task' for sciences. With the former, language lessons primarily targeted the level of understanding. With the latter, activities involved hands-on experiments. Generally, there was a focus, across the various disciplines, on objectives at the level of exploration and identification of concepts, thus relatively limiting the range of objectives addressed. The next section presents the findings derived from the written notes taken along with observation log ratings and lesson objectives checks.

5.2.3 Anecdotal record findings

The written notes rotated around four axes: the nature of the teaching activities, questioning and discussion, teaching approaches, guidance and feedback. The display in Table 5.3 shows the data structured around these focus points for each observed class. In general, teachers tended to launch their teaching session without clarifying to students the objectives of the lesson and in the absence of a brief introduction. In the case of new lessons, the approaches adopted ranged from video projections to student presentations of short research projects given as homework and briefly discussed during class. Moreover, in classes where discussions took place, the nature of questioning could be described as unidirectional, i.e., question -answer type (teacher to student); only one encounter out of 27 was noted where interaction took place between teacher-student and student-student. Very little pair or group work occurred during these sessions. Records revealed that 12 teachers (44%) built their lessons around a provision of exercises that students were required to undertake on their own. The striking finding was related to the teaching approach in the various classes. In 16 observed sessions, observations showed a tendency towards a relatively teacher-centered approach. That was manifested through teachers monopolizing the explanation, solving the exercises given during application and practice sessions, and generating themselves questions in the quasi-absence of students' involvement. The other prominent finding concerned the provision of feedback. Only five teachers helped students by giving prompts, advice, and guidance when students were on task. Those teachers were observed circulating and offering individual help. Finally, out of the 27 teachers observed, only one teacher gave the opportunity to students to work in groups on a multi-step task with clear step-by-step procedures. It consisted of an experimental activity performed in the laboratory.

Table 5.3 *Compilation of data derived from anecdotal notes taken during 27 class visits.*

	L1 A1 SC	L1 A2 MA	L1 A3 EN	L1 A4 SC	L1 A5 EN	L1 A6 SC	L1 A7 AR	L1 A8 SS	L1 A9 SS	L2 B1 SS	L2 B2 EN	L2 B3 AR	L2 B4 SC	L2 B5 MA	L2 B6 SS	L2 B7 MA	L2 B8 SC	L2 B9 SC	L3 C1 AR	L3 C2 FR	L3 C3 MA	L3 C4 FR	L3 C5 MA	L3 C6 AR	L3 C7 SC	L3 C8 SC	L3 C9 SS
Objectives shared with students			X								X	X		X													
New lesson through exercises	X																										
New lesson through videos								X												X	X					X	
New lesson through homework									X										X								
Discussion					X					X	X				X								X				
Application / Practice		X									X	X	X			X				X	X	X	X	X	X		X
Multi-step task			X	X	X																						
with clear instruction				X																							
Question T …..S	X					X	X	X	X	X				X	X				X	X	X	X		X	X	X	
Question T--S--S---T																							X				
pair/group	X		X	X	X						X																
Feedback			X	X	X						X												X				
Frontal teaching	X		X				X			X		X	X	X		X	X	X		X	X			X	X	X	X
Wrap up by teacher	X					X			X						X							X					

5.2.4 Summary of findings of category 1, schools with the Lebanese program

The collective findings from the three sources of data presented the following prominent trends across the three schools of category 1:

- Strong reliance on instructional practices focusing, under the umbrella of exploration and understanding strand, on promoting students' cognitive processes such as 'Demonstrating an understanding', 'Establishing links with prior knowledge', 'Identifying variables and noting relationships'. Nevertheless, in spite of the common usage of these practices among teachers, it remains that the frequency ratings ranged between low and moderate. Exceptionally, the item 'Use information from students' background knowledge to understand the information given' received high frequency ratings for many teachers (nine teachers out of the twenty who promoted this cognitive process).

- Heavy dependance on a whole-period session of application and practice exercises.
- Preponderance of individual students' work, with very few occasions, when prompt, individual feedback is provided.
- Very low usage of teaching practices conducive to sharing multiple perspectives, reflecting on errors, establishing interpretations, and evaluating various solutions.
- Unidirectional type of questioning, predominantly answering teacher-posed questions.
- Rare students' exposure to multi-step tasks and complete absence of complex, authentic tasks experiences.

The overall findings leaned towards a traditional, teacher-centered approach with whole class instruction, very little group work, scarce feedback, and teacher-led discussions guided by teacher-oriented questioning.

5.3 Category 2: Schools with the French and Lebanese programs

Observations were conducted in three different schools, accredited by the French Ministry of Education. This means that these schools are entitled to offer the French program and lead their students toward earning the French baccalaureate diploma. The observed classroom sessions were distributed among grades 7, 8 and 9 in middle school, with a fairly well-balanced distribution of subjects, French and Arabic languages, mathematics, sciences and social studies (sample visit schedule in Appendix G). A total of 27 classes were observed, nine in each school.

Before proceeding with the analysis of the observations' findings, an essential clarification concerning the programs needs to be made. An important feature of these schools is the delivery of the two programs, French and Lebanese, at the middle school. The two programs are simultaneously offered with certain disciplines strictly following the French curricular objectives of the Official Bulletin of the Ministry of Education, and relatively few addressing the Lebanese curricular objectives. This situation applies to grades 7 and 8. In grade 9, it is even more pronounced due to the need to cover the national brevet examination requirements while satisfying the French program requirements. During this stage, program objectives are filtered in some form, especially for the Lebanese program, with priority given to the objectives targeted by the national brevet exam. In grade 10, French and Lebanese tracks totally diverge, with students either opting to follow the French baccalaureate track ending with the French baccalaureate diploma or the Lebanese baccalaureate track and finishing with the Lebanese baccalaureate diploma. With this brief yet necessary background description of the curricular requirements covered in grades 7, 8, and 9, the next sections present the findings for this category 2 schools with the French and Lebanese programs.

5.3.1 Observation log analysis

Table 5.4 shows the compilation of observational findings derived from 27 class visits. One very obvious remark when looking at the frequency count compared to category 1 schools, is the shift towards moderately (M) and highly observed (H) instances of the itemized students' cognitive processes, with very few low (L) ratings (three teachers). Such a drift in ratings reflects the variety of practices, activities, and means utilized by teachers as revealed in the anecdotal notes displayed in section 5.3.3, table 5.6. A closer look into the itemized cognitive processes shows four areas that were mainly addressed by a large number of teachers. These areas included 'Understanding a text….' and 'Demonstrating understanding of relevant concepts' with respectively 22 and 24 teachers out of 27 targeting these areas during their lesson. Next in importance were two other objectives, 'Identifying and noting relationships between variables' and 'Using students' prior knowledge to understand the given', respectively addressed by 17 teachers for the former and 15 teachers for the latter. These objectives were grouped under the "Exploration and Understanding" strand of PISA 2012 cognitive processes. In addition, the construction of various representations and formulation of hypotheses classified under "Representing and Formulating" strand were noted as well. Raising critical evaluations within a specific context, and beyond through examining solutions, evaluating, and reflecting were observed, thus addressing the last strand of PISA 2012 cognitive processes, "Monitoring and Reflecting".

Table 5.4 *Frequency of observation of cognitive processes manifested by students' behavior in category 2 of schools with Lebanese & French programs. Low (L); Moderate (M); High (H)*

Cognitive processes	27 teachers	L (1-2 times)	M (3-4 times)	H (More than 5 times)
Understand a text, diagram, formula, tabular information	22	0	15	7
Draw inferences	10	1	4	5
Relate information from various sources	8	1	3	4
Demonstrate understanding of relevant concepts	24	0	14	10
Use information from students' background knowledge to understand the information given	15	1	7	7
Identify the variables in the problem & note the interrelationships	17	0	12	5
Construct hypotheses	3	0	3	0
Retrieve, organize	6	0	3	3
critically evaluate contextual information	2	0	1	1
Construct tabular, graphical, symbolic and verbal representations	3	0	2	1
Shift between representational formats	1	0	1	0
Analyze a system	3	0	1	2
Examine solutions & look for additional information or clarification	3	0	3	0
Evaluate solutions from different perspectives	3	0	1	2
Justify solutions	7	0	5	2

An important observation not displayed in the observation log but in direct connection with problem-solving processes was the provision of complex tasks. The anecdotal notes discussed in section 5.3.3 reported on the usage of complex tasks in many classes observed, with students collaborating through the stages of planning and executing.

In summary, the observation log for this category 2 of schools showed a clear shift of frequency ratings varying between moderate and high, with very few in the low range. Furthermore, teachers addressed the four strands of cognitive problem-solving processes, "Exploring and Understanding", "Representing and Formulating", "Planning and Executing" and finally, "Reflecting and Monitoring".

5.3.2 Program-related objectives analysis

It is clear from lesson objectives (Table 5.5), that language teachers moved beyond exploration. They led their students to elaborated interpretations of literary texts, hence, carrying the discussion in class to a deeper level of understanding. Five language teachers, as the table shows, addressed this objective. Moreover, in mathematics, objectives were not limited to application; in six math classes observed, solving problems was not restricted to students using their prior knowledge, establishing links and analyzing, but encompassed reflecting on errors and testing alternative solutions. Finally, it is important to point out that the three schools with a French program sought a larger variety of program objectives, 15 in total, compared to 10 in total in category 1 schools with the Lebanese program.

Table 5.5 *Compilation of curricular objectives addressed in the lessons observed.*

Lesson objectives	Number of lessons
Explore literary and non-literary texts, images and documents.	10
Explore by extracting from a document the relevant information, reformulate, organize, and compare it to prior knowledge.	4
Identify questions of scientific nature.	2
Explore by testing and trying different ways to solve a problem.	3
Construct concepts that permit the analysis and the elaboration of texts and speeches.	3
Choose and establish a relationship between convenient conceptual frameworks to solve a mathematical problem or study a model.	1
Develop and use a model (development of questions and explanations, generating data that can be used for predictions and communicating ideas to others).	1
Elaborate an interpretation of literary texts.	5
Design and create a measuring tool and an observation protocol.	1
Set a plan for an experimental task.	1
Demonstrate by reaching a conclusion using logical reasoning & referring to mathematical rules (properties, formulas and theorems).	3
Justify a method or an interpretation.	2
Interpret experimental results to derive conclusions and communicate results with a justification.	1
Reason by solving problems using acquired knowledge, analyzing as well as reflecting on errors, and testing alternative solutions.	6

5.3.3 Anecdotal record findings

As previously mentioned, notes taken during the observation sessions centered around the activities proposed, the type of questioning and the nature of the discussion, the teaching approaches, and the presence or absence of guidance and feedback. The teaching practices commonly observed among the 27 classes are the following:

- Sharing learning objectives with students at the beginning of the lesson.
- Checking for understanding.
- Inquiry-based learning, with feedback and guidance provided during suggested activities or tasks.
- Multi-directional questioning and answering type (teacher/student; student/teacher; student/ student).
- Peer discussion with students voicing opinions, commenting on each other, and reflecting on their mistakes.
- Prevalence of pair and group work.
- Students' exposure to complex tasks, accompanied by clear instruction and prompt feedback.

An interesting finding concerned the number of complex tasks suggested to students during the scheduled visits: five of these tasks were proposed to students, one in sciences, two in mathematics, and three in languages. While the nature of the task and how it was tackled could not be examined in depth in one observation session, especially since each task required more than one period, it was noted that they were first presented to students, explained, and then required to be performed in groups. A complex task, according to Fischer & Neubert (2015) is a problem situation that generally brings forth many interrelated goals. Typically, it requires dealing with an overwhelming amount lot of information, considering the multiple effects of actions, while expecting that the process is happening with typically incomplete knowledge of the effect of the various interventions. Consequently, it necessitates a dynamic adjustment of the course of action. Students have to actively engage, make decisions, monitor the results of their decisions, and benefit from teachers' feedback during the process.

Table 5.6 *Compilation of data derived from anecdotal notes taken during the 27 class observations in category 2 schools, with French and Lebanese programs.*

	F1 A1 SS	F1 A2 AR	F1 A3 LA	F1 A4 MA	F1 A5 MA	F1 A6 FR	F1 A7 SC	F1 A8 SC	F1 A9 FR	F2 B1 MA	F2 B2 MA	F2 B3 SC	F2 B4 SS	F2 B5 SC	F2 B6 FR	F2 B7 FR	F2 B8 AR	F3 C1 SC	F3 C2 SS	F3 C3 MA	F3 C4 FR	F3 C5 AR	F3 C6 SS	F3 C7 SC	F3 C8 FR	F3 C9 MA
Objectives shared with students	x	x	x		x	x	x		x			x						x	x	x	x		x		x	x
Recalling checking for understanding	x	x	x	x	x	x	x			x		x	x	x								x	x	x		
variety of tools and activities	x		x			x	x						x		x					x					x	
Discussion	x	x							x						x	x						x	x		x	
Application / Practice								x	x	x	x										x			x		
Task with clear instruction			x		x				x									x			x					x
question T__S								x		x	x	x		x			x		x					x		
question T--- S----S---T	x		x	x		x	x			x			x		x	x				x	x	x	x		x	
pair/group work						x	x					x						x		x	x			x		x
individual work											x			x												
Frontal teaching														x			x									
Student centered teaching	x		x	x	x	x	x	x	x	x			x		x	x		x		x	x	x	x		x	
Feedback			x		x	x	x	x	x	x	x		x					x			x					x
Students' reflection on error				x		x	x		x	x	x							x								

5.3.4 Summary of findings of category 2

The general findings of category 2 of schools with Lebanese and French programs demonstrated the following trends across the three schools:

- Instructional practices promoting cognitive processes covering the four strands, "Exploring and Understanding", "Formulating and Representing", "Planning and Executing", and finally "Reflecting and Monitoring", with the prevalence of moderate and high frequencies.
- Interactive, instructional discussions.
- Opportunities for students to reflect on their learning.
- Inquiry-based learning, with a strong tendency towards guided inquiry and discovery.
- Students' exposure to complex tasks with prompt feedback and continuous guidance.

Overall, these findings pointed to a relatively student-centered approach to teaching. Instruction was interactive with widespread group work, discussions moderated by teachers during which students had the opportunity to reflect on their learning, and the sharing of multiple perspectives and thinking with peers.

5.4 Results of observations conducted in schools with the American and Lebanese programs

Classroom observations were conducted in three different schools, with a fair and balanced distribution of attended classes among the three levels, grades 7, 8, and 9, and in different subjects (sample visit schedule in Appendix H). Similar to the other two categories of schools, 27 observations were conducted, nine in each school. The curricular structure in these schools with two programs is very close to the structure in schools with French and Lebanese programs. At the middle school, the two programs are offered, yet with more emphasis on the American program, especially in grades 7 and 8. In grade 9, the pivotal level, emphasis is put on covering the requirements of the Lebanese brevet examination, while respecting the standards and requirements of the American program.

5.4.1 Observation schedule data analysis

While the three schools in category 1 and the other three schools in category 2 presented similar trends of findings within each category, this was not the case for category 3 schools. One of the schools within this category 3 showed findings that contrasted with the other two schools. In order to clarify and illustrate this point, the results derived from each school were separately presented. The school with distinct findings was referred to as A1. The other two, named A2 and A3, presented similar trends in the data. Table 5.7 displays data for each school (A1, A2, and A3) and per individual teacher. For example, A1A1 was the first teacher observed in school A1, A1A2 was the second teacher observed in school A1, etc. This detailed display sought to show the clear differences noted between A1 and the other two schools A2 and A3. It should be mentioned at this stage that when students were working on complex tasks and were not necessarily demonstrating one of the itemized observable behaviors for documentation in the observation log, anecdotal notes were primarily recorded. This explains why in the table below, there are empty columns such as A3C1, A3C4, A3C5, A3C8, and A3C9, in reference to five teachers in school A3.

Table 5.7 *Frequency ratings of observed behavior in the three schools of category 3, referred to as A1, A2 and A3.*

	A1 A1 MA	A1 A2 SC	A1 A3 SS	A1 A4 EN	A1 A5 EN	A1 A6 LAN	A1 A7 MA	A1 A8 SC	A1 A9 SC	A2 B1 EN	A2 B2 LAN	A2 B3 MA	A2 B4 EN	A2 B5 SC	A2 B6 SC	A2 B7 SS	A2 B8 SC	A2 B9 MA	A3 C1 SC	A3 C2 MA	A3 C3 SC	A3 C4 SS	A3 C5 SS	A3 C6 MA	A3 C7 MA	A3 C8 EN	A3 C9 EN
Understand a text, diagram, formula, tabular information	M	M	L	M	H	L	M	H					H	M	M	M	M	H		H	H						
Draw inferences					H			H		M	M							H		M	H						
Relate information from various sources	L	L		L						H				M		M				M				H			
Demonstrate understanding of relevant concepts	M	M	L	M	H	L	M	H	M	H	M	H		M	H		M	H			H			H	H		
Use information from students' background knowledge to understand the information given	L	L	L		H			H		H				M	M	M	M			M	H			H	H		
Identify the variables in the problem & note interrelationship		L	L		M		M		M	H			H		H					H	H			H	H		
Construct hypotheses		L																									
Retrieve & organize													H								H			H			
critically evaluate contextual information													H														
Construct tabular, graphical, symbolic & verbal representations						L						H			M			H						H			
Shift between representational formats								H																			
Analyze a system									L			H	H														
Examine solutions, look for additional information or clarification																		H							H		
Justify solutions							M		L			H															

Data showed that none of the observation log items were rated low (L) in A2 and A3. That was not the case for A1, where many items received low frequency ratings. For example, considering the commonly rated items among the three schools, such as 'understand a text, diagram, formula, tabular information', 'draw inferences', 'demonstrate understanding of relevant concepts', 'use information from students' background', 'identify variables and note the interrelationships', none received low (L) in A2 and A3. All of the ratings in these two schools varied between moderate (M) and high (H). Whereas, in A1, low ratings were attributed to all of the above-mentioned items, not without some variations among the participants, where moderate and high frequencies were recorded as well. For instance, the first item in Table 5.7, two participants out of seven received a low rating, while for the other five participants, ratings varied between moderate and high. Item 'relate information from various sources' had predominantly a low rating. As for 'using information from students' background to understand the information given', three out of five teachers had a low rating. These results mirrored, to a certain extent, the ones of category 1 schools with the Lebanese program. Another differing pattern in frequency rating was related to 'retrieving and organizing information', 'critically evaluating contextual information and examining solutions and looking for additional information for clarification' items. The three itemized cognitive processes were reflected in the teaching practices of A2 and A3 participants with ratings varying between moderate (M) and high (H), none of which was noted in the observed classes in A1. In summary, data derived from class observations did not display similar trends across the three schools, as was the case for the other two categories.

5.4.2 Program objectives data derived analysis

Similar to the findings of the observation schedule, the lesson objectives of A1 presented trends that diverged from the other two schools, A2 and A3. The objectives noted in A1 were mostly distributed among exploration objectives ('exploring literary texts, images and documents'; 'exploring by extracting information'; 'identifying scientific questions'; 'exploring by testing different ways to solve problems'). Whereas in A2 and A3, in addition to the exploration objectives, a variety of other objectives were targeted, such as elaboration and interpretation of literary texts, hypotheses formulation in sciences and in social studies, debating in language, and justifying a method in social studies. Teachers in both A2 and A3 covered a bigger variety of curricular objectives. In particular, objectives such as 'formulating hypotheses', 'elaborating an interpretation', and 'debating', were not tackled in A1. In total, eight different objectives were sought in A1 compared to 10 in A2 and 10 in A3 as well. Hence, A2 and A3 data showed close similarities in terms of the lesson objectives that were addressed.

5.4.3 Anecdotal record results

Notes taken during the observational sessions showed an even sharper divergence between A1 and the other two schools. As displayed in Table 5.8, notes revealed clear differences when it came to questioning, activities proposed, feedback, group work, and lastly, students' reflection. While similar trends in data were demonstrated in A2 and A3 related to the nature of question-answer discussion (teacher/student, student/student), they contrasted with the unidirectional type of questioning (teacher/student) observed in A1. Clear divergence was demonstrated in group work activities in A2 and A3, as opposed to individual work in A1, in providing feedback and prompt guidance when tasks were given, and finally, in creating opportunities for students to reflect on their learning, when none was observed in A1. Another important difference was the usage of a variety of activities and means in teaching practices, clearly noted in classes observed in A2 and A3. One commonality among the three schools that data displayed was the reliance on recalling and checking for understanding. For instance, in A1, six out of nine teachers used strategies to check for understanding and help students recall information; in A2, it was five out of nine. It was less significantly observed in A3, two out of nine, due to the provision of tasks when classes were observed, necessitating other practices.

Looking into tasks suggested to students, out of the nine classes visited in A1, none of the teachers gave a complex task. In only one class in A1, an experimental laboratory session was observed with students provided with detailed, step-by-step procedures to follow. It was a reminder of schools with the Lebanese program, where a similar finding was noted. This contrasted with school A2 and was an even more pronounced difference with school A3. In school A2, two teachers out of nine proposed a complex task to students to be performed collaboratively. In school A3, six out of the nine teachers planned for complex tasks where students were also observed working in groups.

Table 5.8 *Compilation of anecdotal notes taken during the 27 observation sessions in category 3 schools.*

	A1 A1 MA	A1 A2 SC	A1 A3 SS	A1 A4 EN	A1 A5 EN	A1 A6 LA N	A1 A7 M A	A1 A8 SC	A1 A9 SC	A2 B1 EN	A2 B2 LA N	A2 B3 M A	A2 B4 EN	A2 B5 SC	A2 B6 SC	A2 B7 SS	A2 B8 SC	A2 B9 M A	A3 C1 SC	A3 C2 M A	A3 C3 SC	A3 C4 SS	A3 C5 SS	A3 C6 M A	A3 C7 M A	A3 C8 EN	A3 C9 EN
Objectives shared with students								X	X	X			X	X	X	X	X	X			X			X			
New lesson through videos																				X				X			
Recalling Checking for understanding	X	X	X	X	X			X				X				X	X							X	X		
Variety of tools and activities												X	X			X	X			X	X			X	X		
Discussion		X	X		X					X										X			X				
Application / Practice	X					X					X	X					X								X		
Task with clear instruction						X				X			X	X	X	X			X		X		X			X	X
Question T----S	X	X			X	X	X	X																			
T--S---S---T										X			X					X		X			X				
Pair / groupwork			X						X	X	X	X	X	X	X	X		X	X		X		X				
frontal teaching	X		X				X																				
Feedback								X	X	X		X	X	X	X			X	X	X	X		X	X	X	X	X
Students' reflection on error								X				X	X		X			X	X							X	X

5.4.4 Summary of findings for category 3

Findings derived from school A1 showed a relatively traditional, teacher-centered approach to instruction. Discussions were primarily teacher-led, with occasional pair or group work. One possible reason to explain the divergence of school A1 findings from the other two schools, A2 and A3, within category 3, was that instruction in A1 was not sufficiently imbued with teaching practices instilled by the American program, despite the mixed program approach adopted in the middle school. With regard to A2 and A3, general findings suggested a student-centered approach to instruction, with opportunities for students to work collaboratively, interact in teacher-moderated discussions, share perspectives and reflect on their learning and the learning of others. Moreover, students benefited from continuous feedback to guide their work. They were given authentic, complex tasks to complete, putting them in real-life situations.

5.5 Comparative analysis of cross-category findings

Findings presented for each category of schools revealed important similarities mainly between categories 2 and 3 -schools with two programs- but also exhibited differences across the three categories. Generally, instruction in Category 1 schools with the Lebanese program tended to be teacher-oriented, with emphasis on structured discussions and activities in the absence of complex tasks exposure. Some practices observed in category 2 and schools A2 and A3 of category 3 were totally absent in category 1. These teaching practices included clarifying lesson objectives to students by way of introducing the lesson, giving feedback, providing opportunities for students to work in pairs and groups, sharing their perspectives in discussions, and reflecting on their work as well as on the work of others. Moreover, discussions generated through multi-directional questioning and answering could be described as rare in category 1, with more focus on the unidirectional type of questions.

One contrasting finding and rather striking difference was the total absence of whole class sessions dedicated to application and practice exercises that prevailed in many classes of various disciplines, observed in category 1. Application and practice exercises in addition to discussions were carried out in category 2 and schools A2 and A3. Students were presented with ample opportunities to share their thinking strategies and procedures and comment on each other's work. Furthermore, an evident process of reflection observed in category 2 and schools A2 and A3 of category 3, was absent in category 1 as well as in school A1. A richer range of objectives was targeted in schools with two programs compared to category 1 where a predominance of objectives targeting the exploration of concepts was noted.

In lieu of a closer examination of data across the three categories of schools, cognitive problem-solving processes that were mostly addressed and the ones least addressed were considered. The calculation of the percentages of teachers targeting specific cognitive processes per program revealed highly interesting patterns across the three categories of schools. These percentages are displayed in Tables 5.9 and 5.10. Since observations in school A1 of category 3 showed data trends relatively different from the other two schools A2 and A3 within the same category, and rather close findings to the ones of category 1, separate calculations were conducted in order to avoid skewing category 3 results.

Table 5.9 *Percentages of observation log items targeted by more than 50% of teachers,* irrespective *of frequency ratings.*

	Lebanese program (3 schools)	Lebanese & French Programs (3 schools)	A2 & A3 (2 schools) Lebanese & American programs	A1 (1 school) Lebanese & American programs
Understand a text, diagram, formula, tabular information	70 %	81 %	61 %	89 %
Demonstrate understanding of relevant concepts	81 %	89 %	77%	78 %
Use information from students' background knowledge to understand the information	74 %	56 %	69 %	56 %
Identify the variables in the problem & note the interrelationships	56 %	63%	54%	56 %

Calculated percentages revealed that irrespective of the program's offerings, the same cognitive processes had percentages higher than 50% across the nine schools. This could mean that during the 81 class observations and throughout the different disciplines, languages, mathematics, sciences or social studies, teachers sought to promote most of the same cognitive problem-solving processes. Hence, this emerging pattern across the nine schools was demonstrated in the similarities of targeted problem-solving processes across the three categories of schools. These cognitive processes primarily fell under Exploring and Understanding strand of the 2012 PISA strands.

Calculated percentages lower than 50%, with their corresponding targeted cognitive problem-solving processes items, are displayed in Table 5.10. Interestingly, another pattern emerged from the calculation, showing percentages less than 50% for the same cognitive processes, across the three categories of schools. These cognitive processes were categorized under Representing and Formulating, Planning and Executing, Reflecting and Monitoring of the 2012 PISA strands.

Table 5.10 *Percentages of observation log items targeted by less than 50% of teachers, irrespective of the frequency ratings.*

	Lebanese program (3 schools)	Lebanese & French Program (3 schools)	A2 & A3 (2 schools) Lebanese & American programs	A1 (1 school) Lebanese & American programs
Draw inferences	22 %	37 %	38 %	22 %
Relate information from various sources	30 %	30%	38 %	33 %
Critically evaluate contextual information	3.7 %	7 %	8 %	0 %
Construct hypotheses	11 %	11%	0 %	0 %
Retrieve and organize	22 %	22 %	23 %	11 %
Analyze a system	15 %	11 %	15 %	11 %
Examine solutions & look for additional information or clarification	7 %	11 %	15%	0 %
Evaluate solutions from different perspectives	11 %	11 %	0 %	0 %
Justify solutions	26 %	26 %	8 %	22 %

Hence, two significant patterns were implied from percentage calculations. Irrespective of the curricular objectives of the three programs under study, the first pattern pointed to teaching practices focusing on promoting problem-solving processes, such as exploring, understanding and demonstrating understanding of concepts, establishing links with prior knowledge, as well as identifying and making connections among variables. The second main pattern indicated teaching practices that fell short in catering to cognitive problem-solving processes, which allow learners to infer, plan, hypothesize, analyze, justify, and critically reflect on their learning. Creating opportunities for students to construct arguments, raise claims and warrants, evaluate evidence, synthesize, make connections between information and arguments, analyze and evaluate various and alternative points of view presented low percentages across the three categories of schools. Before turning to the discussion of these percentages and interpretating the emerging patterns, another even closer examination of the log finding observations targeted mathematics and sciences disciplines.

5.5.1 Contribution of mathematics and sciences

A further cross-category exploration sought to examine the contribution of mathematics and science subjects in developing cognitive problem-solving processes, primarily to connect with the TIMSS results where the national performance has been consistently low for the last ten years. This closer examination focused on the processes that were not sufficiently promoted across the three categories (percentage less than 50% displayed in Table 5.10).

Table 5.11 *Mathematics and science contribution to the development of students' cognitive problem-solving processes per category, in school A1, and in the total number of classes observed.*

	Category 1 Lebanese program		Category 2 Lebanese & French program		Category 3 A2 & A3 Lebanese & American programs		Category 3 A1 Lebanese & American programs		Weighted percentage per total number of observed mathematics and sciences lessons	
	Math 5 lessons	Sciences 8 lessons	Math 6 lessons	Sciences 6 lessons	Math 5 lessons	Sciences 5 lessons	Math 2 lessons	Sciences 3 lessons	Math 18 lessons	Sciences 22 lessons
Draw inferences	1 20 %	2 25%	1 17 %	2 33 %	2 40 %	1 20 %	0 %	1 33 %	22 %	27 %
Relate information from various sources	1 20 %	1 13 %	1 17 %	2 33 %	2 40 %	1 20 %	1 50 %	1 33 %	28 %	23 %
Critically evaluate contextual information	1 20 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %	6 %	0 %
Construct hypotheses	0 %	3 38%	0 %	3 33 %	0 %	0 %	0 %	1 33 %	0 %	27 %
Retrieve and organize	1 20 %	1 13 %	0 %	1 17%	1 20 %	1 20 %	0 %	0 %	11 %	14 %
Analyze a system	1 20 %	3 38%	0 %	1 17 %	1 20 %	0 %	0 %	1 33 %	11 %	23 %
Examine solutions & look for additional information or clarification	0%	0%	2 50%	0%	2 40 %	0 %	0 %	0 %	28 %	0 %
Evaluate solutions from different perspectives	2 40 %	0%	0 %	2 33 %	0 %	0 %	0 %	0 %	11 %	9 %
Justify solutions	3 60%	2 25 %	2 33 %	3 50 %	1 20 %	0 %	1 50 %	1 33 %	39 %	27 %

The table displays the percentage contribution per subject and category of school. For instance, considering the item 'draw inference', out of the five mathematics classes attended, drawing an inference as a practice was only observed in one mathematics class, contributing to 20%. For the same item and in the same category of schools A1, out of the eight sciences classes observed, in two classes this practice was noted, making 25%. The weighted percentages (the last two columns in red) revealed that the contribution of either mathematics or sciences was generally low, with areas showing percentages as zero. For instance, constructing hypotheses was not addressed in any of the mathematics classes observed across the three categories of schools, irrespective of the program offered. Considering mathematics and sciences percentages together per item, the lowest pair of percentages (6 % ; 0%) concerned the item 'critically evaluate contextual information', while the highest pair (39 % ; 27%) was related to the item 'justify solutions'. Items such as 'drawing inferences' (22 % ; 27 %) and 'relating information from various sources' (28 % ; 23 %) as a pair came next in terms of high percentages. Generally, the calculations demonstrated that even within their respective domain specific disciplines, mathematics and science teachers did not sufficiently address the different cognitive problem-solving processes, notably when it was related to "Representing and Formulating" strand and the various forms of critical evaluation which touch on "Monitoring and Reflecting" strand. Added to this deficiency in addressing the two strands was the scarcity of exposing students in these two subjects to performance tasks and experimental activities, as demonstrated by the various observational data. This lack of opportunities for students to devise a plan, experiment, and put a plan into action showed an additional weakness in connection with planning and executing. Consequently, the low contribution of both mathematics and sciences in promoting many facets of cognitive problem-solving processes, as revealed by the data, may shed light on TIMSS national performance.

5.6 Summary

In this chapter, the findings derived from 81 class observations conducted in nine different schools were presented, and described. They were treated by considering, at the first stage, each category of school, then through drawing a comparison across the three categories. Emphasis was placed on the examination and discussion of trends that developed from the findings per category, before turning to pursue the analysis and interpretation of emerging patterns resulting from cross-category data analysis. Generally, the analytical findings derived from observations category 1 of schools with the Lebanese program demonstrated a significant reliance on application and practice, essentially addressing curricular objectives under "Exploring and Understanding" strand of PISA (2012) cognitive processes for problem solving. In contrast, for category 2 schools with Lebanese and French programs and category 3, A2 and A3 schools with the Lebanese and American programs, emerging data presented similarities between these two categories in addressing the four strands of cognitive processes for problem solving. The cross-category comparison revealed emerging patterns which showed, across the three categories of schools, a noticeable weakness in addressing specific cognitive problem-solving processes essential to prepare students to develop problem-solving competence as a twenty-first century competence. The next chapter deals with post-observation interviews. It explores teachers' perceptions, and understandings thought to play a primordial role in shaping their teaching practices.

Chapter Six

Interview Analysis

6.1 Introduction

Chapter six presents the findings derived from the thematic analysis of post-observation interviews. The 71 interviews, lasting 15 to 20 minutes, sought to elicit teachers' understanding and conceptualization of problem-solving by addressing the last research sub-question underlying this study, namely: *How are the teaching practices of problem-solving competence influenced by teachers' understanding of the requirements of the different curricula in middle school?*

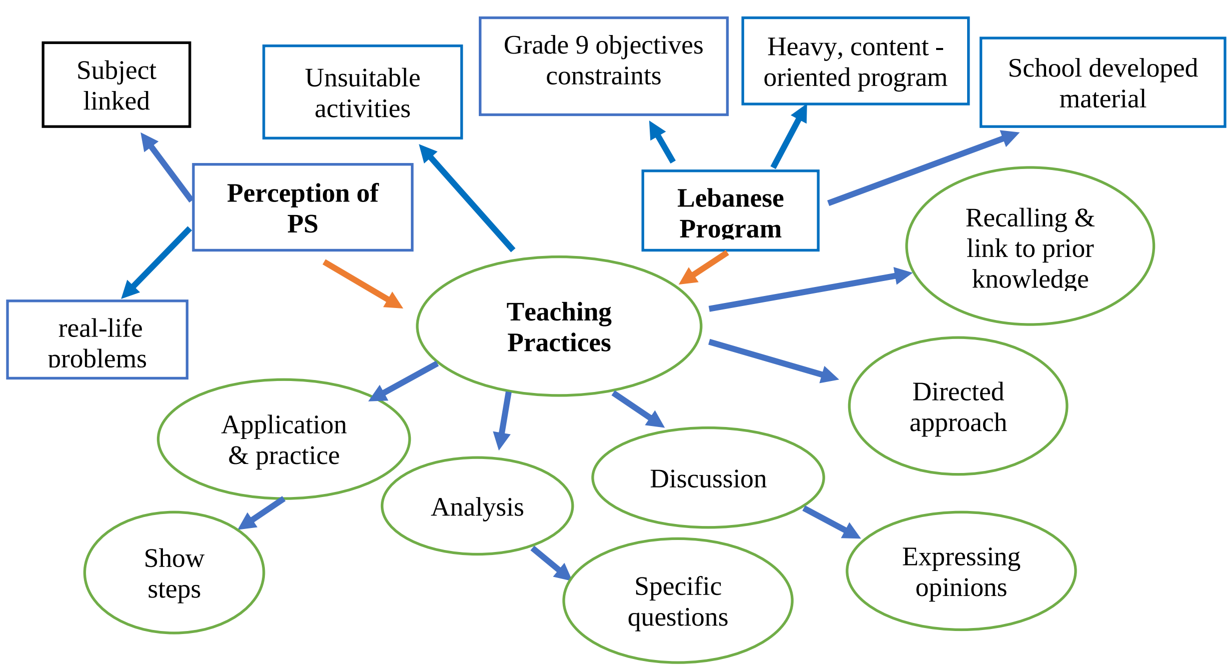
These short, semi-structured interviews were conducted with teachers whose classes were attended for observation. While the interviews were framed around four main questions, unstructured prompts and improvised follow-up questions were also used. They helped keep the conversational aspect of the interviews, seek clarification of meanings and explore emergent areas of interest. The first question was related to the teaching practices and activities used in the pre-observation session and their relationship with problem solving. The second question broadened the scope of the interview, exploring the interviewee's understanding of problem solving. The third and fourth questions prompted the interviewee to reflect on the program itself and the extent to which it facilitated the integration of problem-solving competence. The interview concluded by enquiring about additional resources and means, other than the program requirements, that supported instruction. The interview protocol is displayed in Appendix I. In the forthcoming three sections (6.2, 6.3 & 6.4), emerging themes per category are described using thematic maps. The analytical process consisted of following the six stages of Braun and Clarke's (2006) thematic analysis, as presented in chapter three (section 3.7.2). Themes were developed by iteratively engaging with the data. This was performed through revisiting transcripts to gain an in-depth understanding, grouping and regrouping codes (based on the frequency of their recurrence), and refining themes in order to identify their prevalence across the whole data set. Searching for themes entailed a building-up process. This means that themes were generated through several revisions of the codes looking for overlapping areas between codes, and general topics emerging from clustered codes. This process is illustrated through the initial and intermediary thematic maps that are displayed for each category of schools. These maps show how the generated codes were clustered or regrouped to generate the main codes leading to the identification of themes. The final thematic maps constitute the emerging themes that prevail across the whole data set. A detailed Excel list of all identified codes was exported from NVivo and posted in Appendix J. Section 6.2 below deals with the first within-category thematic analysis, exploring and interpreting interviews conducted in category 1 schools that solely offered the Lebanese program.

6.2 Themes derived from category 1 schools with the Lebanese program

6.2.1. Main themes construction

Figure 6.1 displays the production of initial codes generated from data derived from 26 transcribed interviews. The generation of codes consisted of identifying the initial codes, clustered around three main axes which oriented the four questions of the interview guide namely, teaching practices, perception of problem solving, and the nature of the Lebanese program (in bold in the figure). The axes were used to facilitate the grouping of codes, but they were not considered themes. As illustrated in Figure 6.1, five categories or codes were connected to teaching practices, two others described teachers' understanding of problem solving, and four were linked to teachers' insights and observations concerning the Lebanese program in facilitating problem-solving.

Figure 6.1 Initial thematic map representing developing codes.



Codes of lesser recurrence, such as expressing opinions, specific questions, and show steps, eventually formed the collapsed or clustered codes. The arrows in brown color indicate the areas that affected, in interviewees' opinions, their practices. The process of sorting codes into potential themes is illustrated in Figure 6.2. Three main themes (program's constraints and remedies, directed approach, and subject-specific, real-life problems) emerged after reviewing and modifying the seven potential themes as represented in Figure 6.3.

Figure 6.2 Intermediary thematic map with seven themes.

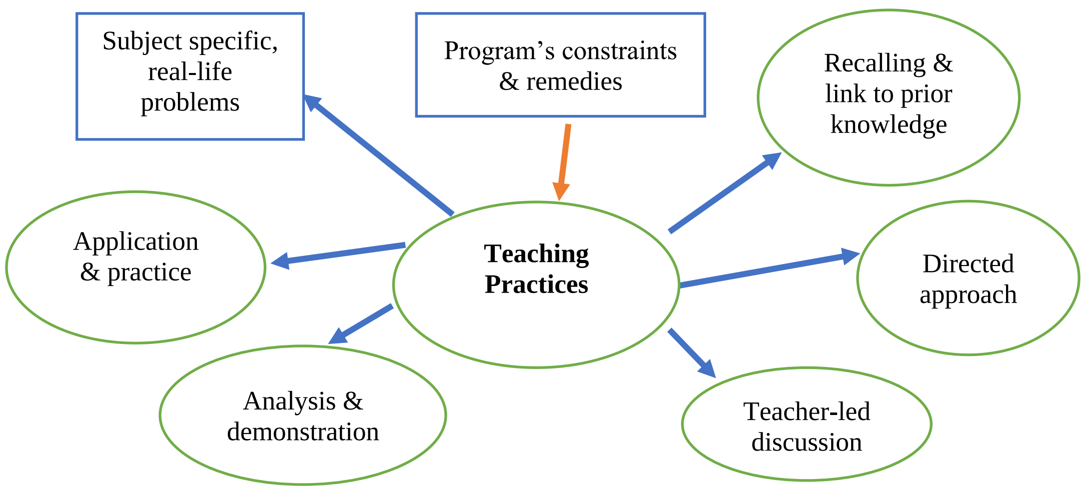
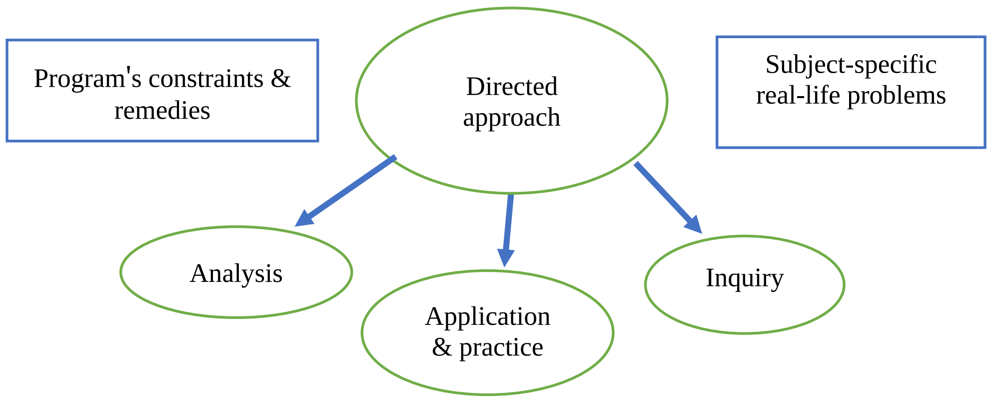


Figure 6.3 Final thematic map with the three developed themes: directed approach, subject-specific, real-life problems, and program's constraints and remedies.



The three final themes, directed approach, subject-specific, real-life problems, and program's constraints and tentative remedies are discussed separately.

6.2.2 Theme one: Directed approach

In order to facilitate the display of quotes derived from transcribed interviews, teachers were referred to by the initials assigned to them on NVivo. For instance, L1A1 Language referred to a language teacher, Lebanese program (L), school A, and as the first teacher interviewed. Theme one was derived from the responses to question one of the interview protocol which inquired about the teaching practices and activities teachers deemed conducive to promoting problem-solving competence. This first question was descriptive, focusing on teachers' practices during the observation session. Starting with such a question served as an icebreaker seeking to dispel any interview-related unease and prompting a colloquial interviewing style to elicit spontaneous and rich responses (Brinkmann & Kvale, 2015).

In general, interviewed teachers irrespective of their discipline, highlighted the role of analytical processes in promoting problem-solving. The theme analysis occupied the highest frequency of occurrences, (35 references on NVivo), with 21 out of 26 interviewed teachers considering analysis as a key thinking process that helped students develop problem solving. Teachers connected this reasoning skill with students' capacity to apply acquired concepts, present justifications, and derive conclusions. A selection of quotes reflects this recurrence:

L1A7 Arabic language: *I push them to analyze and justify their answers, whether in grammar or in reading. I mainly ask students questions to analyze and justify.*

L1 A8 social studies: *Students should be able to understand a document, analyze it, and then make deductions and be able to find solutions. Using the document give students more information through the analysis of this document and help them assimilate the information.*

L2B5 mathematics: *They have to use their analytical skills and relate the data.*

L2B9 Sciences: *So here we get to the analysis part, and now we are problem solvers.*

L3C4 English language: *To solve a problem, is to push students to analyze the situation. Analysis is central to daily work. In every selection, there is this type of question, where students have to analyze.*

In tight connection with the analysis, interviewed teachers emphasized the role of application and practice sessions to train students to develop their analytical skills and consequently, to acquire problem-solving skills. Application and practice ("drilling") came next in the order of importance given by teachers with 12 teachers alluding to it. Below are some quotes relevant to application and practice:

L1 A6 Sciences: *By teaching it through drilling, practicing, it will be easier for students to reach a solution for any problem.*

L2B4 Sciences: *By practice mainly, through exposing students to different exercises, and different strategies.*

L2B8 Sciences: *About how I can promote problem solving in my students, first of all, through practice, subjecting students to several situational problems, to practice various situations.*

L3C1 Arabic language: *Student discovers with me through direct communication the goals.*

Interviewees' replies emphasized the importance accorded to the specificity of problem situations as well as to modeling when students are exposed to these practice sessions. Moreover, many interviewed teachers stressed the necessity for students to follow step-by-step procedures when analyzing a problem situation. The examples below illustrate how interviewees highlighted specificity, modeling, and demonstrating through step-by-step procedures.

L2B6 social studies: *We put the student in a position to solve a specific situation, by rephrasing the main key phrases in different ways.*

L2B7 mathematics: *Through modelling, so I solve the exercise and discuss it with students.*

L3C7 Sciences: *Conduct a session of application exercises so students can approach specific tasks.*

The insistence on guiding students to use specific strategies to solve a problem was met with persistence to instigate students to recall subject-specific knowledge. This suggests the importance given by interviewed teachers to the acquisition of subject-specific knowledge (factual and conceptual knowledge) and subject-specific strategies to deal with problem situations which appeared to be closely intertwined. Demonstrating this understanding through recalling and following modeled procedures was essential to instruction. The sample of quotes below exhibit the importance given to the acquisition of subject-specific knowledge.

L1 A2 Sciences: *Problem-solving, dealing with a problem situation, based on pre-requisites. We always base on the pre-requisites.*

L2B7 Mathematics: *They relate to what they have learnt to help them solve a problem, they have to relate things to the concepts they acquired.*

L2B8 Sciences: *Usually it's given based on pre-requisites, so we would later provide them with either a graph or a table on blood analysis.*

L3C3 mathematics: *Giving students handouts with supplementary exercises. They are direct application exercises, with prerequisites on prior properties learnt.*

The strong reliance on application and practice put to question the place of discovery and inquiry in instructional procedures and activities and the extent to which it is embedded in instruction. Interviewees' responses, as reflected in the quotes below, suggest a tendency toward closely guiding students when put in front of new situations.

L1A4 Sciences: *We had steps and there were things that students had to figure out by themselves, they estimate.*

L2B8 Sciences: *Approach is more or less inquiry-based. I always like them to start wondering about something, asking questions. In every session, I usually start with a little bit of lecturing concerning the points to be explored.*

L3C1 Arabic language: *The student can discover the information required with the help of examples.*

Many interviewees clearly pointed out to the importance of leading questions:

L1A8 Social studies: *Asking questions with specific target and prepare students with simple steps to put them in a problem situation. I rely heavily on directed questioning to involve all students in the discussion.*

L2B7 Math: *I give them leading questions to help them solve the problem.*

L3C1 Arabic: *The more it's new, the more I activate the process of direct communication with the student.*

L3C7 Biology: *The activity has a global question, through specific questions, students can write a conclusion.*

According to teachers' comments, so-called inquiry activities consisted primarily of research projects assigned as homework, PowerPoint presentations, and the projection of videos for students to explain at a later stage. Some interviewees believed that varying those means promoted problem-solving skills.

L1A9 Social studies: *We focus a lot on the research and how to analyze and link the findings to the real life.*

L2B1 Social studies: *We rely a lot on PowerPoint. and in the PowerPoint, there is also figures and graphs and questions that need to be solved.*

L2B4 Sciences: *I usually send them a video via google classroom before starting the lesson, where they have to observe and take notes*, *and a list of questions where they need to inquire about the topic. In general, they observe the experiments presented in the link and discover.*

L2B5 Mathematics: *I try to use ways or tools related to real life; most students like to watch videos or short films and presentations*.

L2B7 Mathematics: *Problem-solving exercise that relates to the content of a lesson or maybe a project that we have seen and found it can be interesting for the students to be engaged in. It could be a video where they show a performed project.*

L2B9 Sciences: *I like to think outside the box. I don't like to use something traditional. I always like to have something new. I use PowerPoint or videos.*

L3C8 Sciences: *It depends on the problem, either I give documents or videos.*

L3C2 French Language: *I ask them to do some research work in preparation for a new lesson. I also give them a selection to prepare ahead of time. I always ask students to do some research before starting a new selection.*

The selection of quotes shows that discovery learning was associated with the use of documentation, PowerPoint presentations, and video projections, followed by class discussions. The role of complex tasks (open-ended, with real-life links) appeared inexistent in discovery learning practices. It was only when questioning about the use of complex tasks that some interviewees shared their opinions. Only one teacher mentioned the open-endedness characteristic of a complex task, whereas the rest of the interviewees associated the concept of task with multi-step problems, or a project given once a term, as reflected in the quotes below:

L1A3 Mathematics: *Complex problem is when you have the steps to solve a problem. It can be by a single step, or two. The more you have steps, the more it is complicated. In every single lesson, I give two to three.*

L2B1 Social studies: *Activity combining everything the student went through, being able to analyze, link information, and make deductions.*

L2B7 Mathematics: *We don't always have the time to give a complex task, once in the term maybe.*

L3C3 Mathematics: *It is an open-ended problem that requires many competences. It is given every two months involving students working in groups.*

L3C5 Mathematics: *It is an exercise with five or six questions with links to move from one question to the other.*

In summary, the various responses collected from 26 interviewees concerning the teaching strategies and activities they used to promote problem solving highlight an approach heavily reliant on subject-specific problem situations. Analysis processes were tightly associated with problem solving. Students put their acquisitions into application following specific strategies their teachers modeled. Moreover, discussions were primarily teacher-led through direct questioning. Limited inquiry-based activities were embedded into instruction, with instances reserved for assigned research projects and audio-visual means such as videos and power point presentations.

6.2.3 Theme two: Subject-specific, real-life situations

Theme two was generated from responses to the first two questions of the interview guide which linked instructional activities to teachers' perception of problem solving. Making connections to students' lives dominated the responses, with 18 interviewees commenting this aspect. Interviewees stressed the importance of making these connections for students' learning and developing problem-solving competence. Below are samples of quotes reflecting the emphasis teachers had put on this connection in their responses:

L1A7 Arabic language: *I always ask why so we can help them deal with their problems, confront a problem, as it may happen in their lives. They don't know how to solve the problem, so I always try to link to their daily lives.*

L1A9 Social studies: *Because it is geography and civics, students are making links with daily life. We should always let the students feel that what they are learning is related to something they are living. This content will be used later on in life.*

L2B2 English Language: *So maybe relating the conflicts to an experience they lived and asking them how they dealt with it, they will be able to come up with a kind of solution that is appropriate and acceptable.*

L2B5 Mathematics: *Problem solving is a situation that we all can be in, it's a problem from real life. Problem solving is a need in their lives. It is very important to relate what we learn to real life, to make it meaningful for them.*

L2B8 Sciences: *I want them to be able to problem solve in life. I give extra information with real life applications.*

Whilst there was a tendency to highlight the link with real-life situations across the various subjects, some comments pointed to a certain perception connecting mathematics and sciences with problem solving or perceiving problem solving as a literary genre. This suggests that in subjects like languages, problem-solving is not perceived as an integral component of teaching, or as a goal to be pursued. Rather, it is a skill connected to a specific content objective. Moreover, the association of problem solving with mathematics and sciences restricts problem-solving processes to particular subjects, thus taking away from problem-solving competence its transversal or cross-curricular aspect, as displayed in the comments below:

L1A3 Mathematics: *Problem solving is the soul of math and sciences.*

L1A6 Sciences: *We have problem solving in math, and in biology. I think basically I am talking about sciences where it is addressed to a high extent.*

L1A9 Social studies: *Problem solving in civics subject is not given as much importance as in math or physics.*

L2B8 Sciences: *I teach a scientific subject matter where problem solving is a big part. We want them to be scientific thinkers, problem solvers in real life.*

L1A5 English Language: *It is a genre, writing genre, it is covered in grade 9.*

L1A7 English Language: *It depends on the lesson, in general, when dealing with a story, it is possible to put the students in a situation to solve a problem. It depends on the literary genre. This genre pushes them to justify using proofs, and solve the problem, it is integrated in the teaching practices.*

As a summary of theme two, teachers generally considered it important to provide students with problem situations linked to real-life situations. Their responses suggested that a concerted effort was made to help students relate concepts to real-life situations. However, these situations, as gathered from their responses, remained limited to real-life examples and were perceived as tightly linked to their subject matter. While the usage of open-ended tasks seemed to be absent, multi-step problem situations were commonly used in daily practices.

6.2.4 Theme three: Lebanese program's limitations and remedies

Theme three was derived from responses to questions four and five related to program requirements and the extent to which the program facilitated the integration of problem solving in instruction. The majority of interviewees raised concerns about the appropriateness of the Lebanese program to the demands of the twenty-first century. This program did not undergo any modifications for at least three decades. Three main issues were identified, which presented obstacles to the integration of problem solving. The first was the long list of content objectives to be covered per year, making the content per discipline relatively heavy. The second issue was the unsuitability of the suggested activities, and the third one was the grade 9, end-of-year brevet national exam. These concerns are addressed separately starting with the long, content-oriented program.

L1A3 Mathematics:	*You have to follow the objectives, in grade 7 the objectives are too many, basically content skills*
L1A5 English language:	*I do have a big problem with the Lebanese program, it is an impediment. It is old fashioned, rigid and doesn't address the needs of students.*
L1A8 SS:	*The program is very limited, with lots of repetition. It is too long.*
L2B5 Mathematics:	*It's a big program, we are trying our best but time is limiting us, so we are facing obstacles.*
L2B7 Mathematics:	*The program is mainly concentrating on content objectives more than competences. My only problem is lack of time, we have a long curriculum that I have to cover and follow.*
L3C6 Arabic language:	*Because our time and schedule are limited, so finishing a curriculum on time plays a big role in not varying activities.*
L3C7 Sciences:	*The Lebanese program as content gives lots of details, may be because of the brevet exam.*

Interviewees considered that the lengthy content objectives prevented them from varying activities and exercises as they felt pressured by time. Moreover, the nature of the exercises presented another important obstacle to addressing problem solving, as illustrated in the comments below.

L1A3 Mathematics: *Lebanese program doesn't give you the way to go further. It doesn't give importance to problem solving.*

L1A6 Sciences: *The exercises in the book are direct questions.*

Hence, limited by time and by the lack of appropriate examples and application exercises in textbooks, teachers regarded these two constraints as putting major obstacles to introducing variation into their teaching. In direct connection with the time factor, interviewees raised concerns about the lengthy content objective requirements of the national brevet exam that students take at the end of the middle school cycle. Teachers of lower grade levels, namely grades 7 and 8, considered that they were under pressure to cover all content objectives to prepare students for grade 9. Interviewees did not take this source of stress lightly. At all stages of the interview, there was a kind of an insistence on considering the brevet examination as a major hindrance, depriving teachers at all grade levels in the middle school of any flexibility to alleviate the pressure resulting from the demanding, content-oriented program. The various quotes below reflect the stressful and worrisome preparation for the brevet examination.

L1A3 Mathematics: *Objectives of the Lebanese program are always related to grade 9. Students have to reach grade 9 and sit for official exams.*

L1A4 Arabic language: *In grade 7, since it is close to grade 9, where there is an official exam, we try our best to cover all the requirements.*

L1A5 English language: *Our aim goes definitely beyond the Lebanese program, but because we have the official exams, we need to train them on mechanical content like grammar. Instead of doing activities in grade 9, with brilliant students, I have to teach them grammar.*

L1A8 Social studies: *Unfortunately, they have to sit for official exam and answer questions in a specific way. We as teachers are obliged to follow this way, even if we are not convinced of the way.*

L2B2 English language: *It is all guided towards a main target, the official brevet exams.*

L2B8 Sciences: *I teach grade 7 and I need to train students for certain skills, since they are going to be tested in grade 9 official exams. I want to feel comfortable that they are ready to approach grade 9.*

L3C5 Mathematics: *In grade 9 we have the official exams and we need to train students to the type of exam questions of the brevet. In grade 10, we have the flexibility to go beyond and vary activities.*

These comments clearly reflect a perception that can be described as negative toward the brevet national examination. The resentment exhibited by interviewees was primarily caused by the pressure resulting from the lengthy list of required content objectives on the one hand and the nature of the brevet assessment on the other hand. To remediate this difficult situation, certain interviewees mentioned that teachers developed school materials to compensate for the lack of a variety of exercises and examples in the national textbooks. Moreover, there were initiatives taken within schools to redistribute content objectives and alleviate the pressure caused by the heavy content, as illustrated in the quotes below:

L1A3 Mathematics:	*The book we are using is not the official one. It is done by the school.*
L1A4 Sciences:	*Objectives are the ones of the vertical progression at school.*
L1A5 English language:	*I follow the system at school which is explore, apply, develop and then extend.*
L1A6 Sciences:	*It is an enrichment to the actual program. We have booklets.*
L2B2 English language:	*It's like scope and sequence, you get it at the beginning of the year, there are specific skills depending on the grades being taught.*

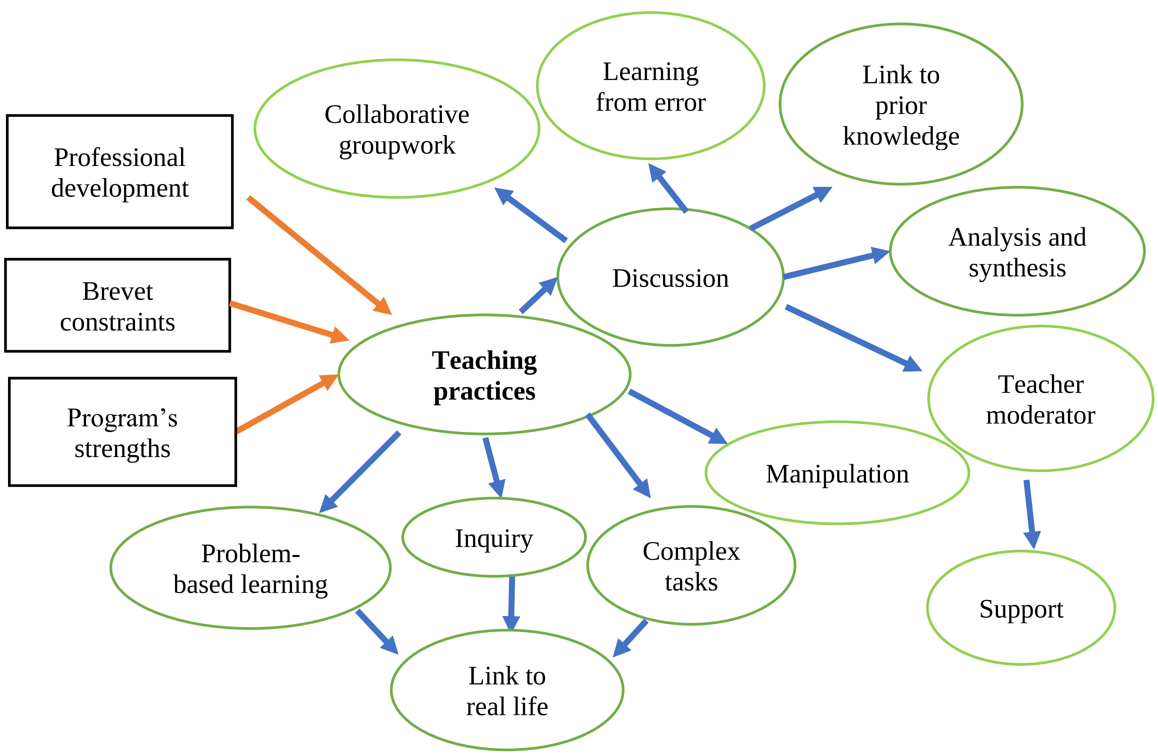
As a close to this first part of the interview analysis, the general understanding of problem solving among the 26 interviewed teachers was subject-specific, with links to real-life situations. Teachers perceived problem solving as heavily reliant on strategies that sought to promote students' analytical skills, driven by teaching strategies anchored in teachers-led procedures. Interviewees did not hesitate to show their frustration about the nature of the Lebanese program, and the brevet national exam. They considered both as an impediment to teaching and learning. In the next section 6.3, 23 interviews conducted in three schools with French and Lebanese programs, classified under category 2 are analyzed.

6.3 Themes derived from category 2 schools with the French and Lebanese programs

6.3.1 Thematic maps for generating the main themes

The forthcoming three figures 6.4-6.6, illustrate the gradual development of the main themes, resulting from the transcribing and coding of 23 interviews with approximately an equal distribution of interviews among the three schools (8, 7, 8). Looking at Figure 6.4 representing the first order of developed codes, the instantaneous observation that can be made is the richness of the identified codes (in red), representing the various components of instruction compared to the first cycle coding of category 1. More than ten interviewees discussed these various codes during interviews, giving them a relatively substantial weight in terms of recurrence.

Figure 6.4 Preliminary thematic map of developing codes.



The arrows in brown color represent the areas that affected, in the interviewees' opinions, their teaching practices.

Figures 6.5 and 6.6 present the development of the main conceptual themes for this second category of schools.

Fig 6.5 Intermediate thematic map with themes under development.

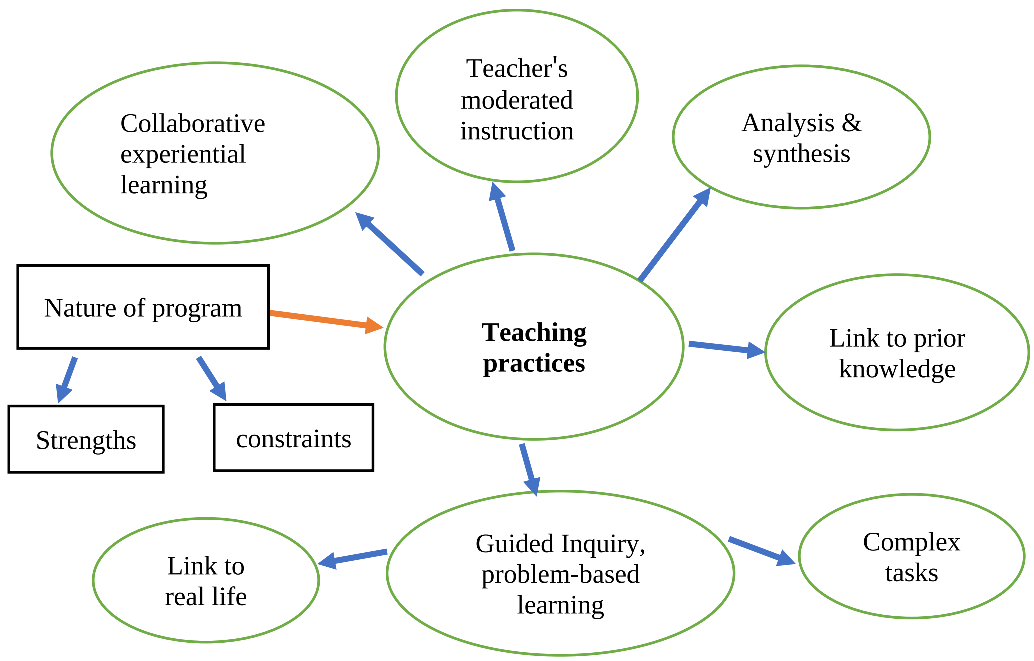
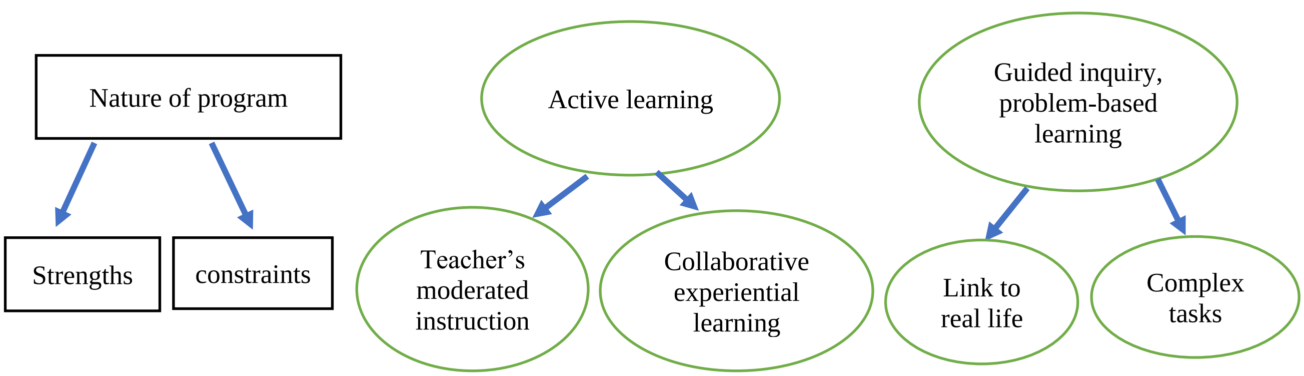


Fig. 6.6 Final three main themes: active learning, guided inquiry and problem-based learning, and program's facilitation.



The next three sections separately discuss the main themes resulting from the coding process. The various quotes were translated from French into English, as most interviews were conducted in French.

6.3.2 Theme one: Active learning

Two sub-themes underpin students' active learning theme: teachers' moderated instruction and students' collaborative and experiential learning. The presentation and discussion of interviewees' responses aimed to answer the following two questions: What does active learning mean based on the interpretation of interviewees' responses, and how does active learning, in teachers' understanding, promote problem-solving?

18 out of 23 interviewees (51 references quoted from transcribed interviews) emphasized the necessity of students being actively involved in their learning. Recurrent terms in teacher quotes included students discovering, producing, constructing, synthesizing, and being the "architects" of their own learning. An interesting shift from "I" in reference to the teacher in most of the transcribed interviews in category 1 (schools with the Lebanese program) to "them" referring to students in category 2 was observed. The quotes below translate this point.

F1A3 French language: *They produce by themselves so they don’t get bored by merely receiving information.*

F1A4 Mathematics: *We prepare the activities in such a way students can by themselves discover the new information, and work by themselves.*

F1A7 Sciences: *Nowadays, in this century, we speak of the learners as at the center of their own learning. They have to discover by themselves. Discovering is the best way to learn. They have to look for everything when exploring documents.*

F1A8 Sciences: *Students need to experiment, formulate hypotheses, find the strategies. We always make use of the investigation method where the child is the architect of her/his learning.*

Irrespective of the discipline they taught, interviewees insisted on the importance of creating opportunities for students to develop autonomy and work independently through exploring, questioning and reflecting. While interviewees in category 1 concentrated on analytical skills in their conversations as necessary skills to promote problem solving, interviewees in category 2 discussed a large array of reasoning skills. More quotes reflect this point.

F1A9 French language: *They question things, start from their own difficulties and try to find solutions. When we give them the solution, students will stop looking.*

F2B4 Social studies: *They have to learn how to think, we push them to reason and analyze and learn how to use a given to analyze it and make deductions.*

F2B6 French language: *They have to look for what is invisible!*

F3C1 Sciences: *I prefer to give as many situations when students are in action. This is the essence, for example, having 6 groups coming up with 6 different experiences, share their results. This sharing nourishes the general problem situation or the challenge.*

F3C8 French language: *When the student is capable of questioning things, this triggers a process to question, investigate, and understand the hidden. There is reflection, and giving opinion.*

These various quotes represent a specimen reflecting what was considered primordial in teaching: the learner at the center of her/his learning, the learner as the "architect" of her/his own learning. This suggests a strong drive toward developing students who are actively involved and responsible for their own learning. It might also explain why another area received great attention from interviewees and was frequently mentioned during interviews. There was a clear emphasis on discussion, analysis, and synthesis, as 16 out of 23 interviewees elaborated on this point.

F1A3 French language: *Participation, interaction and involving them in situations as if they were in real situations.*

F2B1 Mathematics: *They work in groups and together, they derive the synthesis.*

F2B5 Sciences: *It is an interactive practice; this means discussion and interaction among students.*

F2B7 French language: *When we debate, they listen to each other, reconsider their positions may be unwillingly or without necessarily knowing.*

F3C5 Arabic language: *Everyone has something to say, and it's important to know how to let them express themselves.*

Further comments explained the predominance of discussion and interaction, which were conducive to synthesizing the lesson. The lesson was perceived as constructed by students.

F3C6 Social studies: *This is not just a dialogue; it is a shared lesson*.

F3C8 French language: *I can just ask the question directly. But this is not the case. I work a lot on discussion. It is a way to function in general, whereby students find the links by themselves. This is how reflection is constructed.*

Another element interviewees associated with active learning was a reflection on errors. The selected quotes focus on the place of reflection on error as a necessary learning tool.

F1A6 French language: *Error is like a lever; it is a source of learning.*

F2B3 Sciences: *We work on gaps and recurrent mistakes. The importance of groupwork is to allow students to exchange ideas, clarify their thoughts, and correct each other. Yes, we learn by making mistakes.*

F2B7 French language: *When students start listening to each other, they start to criticize, judge and consequently, they are going through an auto construction in their reasoning that may lead them to find the solution.*

F3C3 Mathematics: *They identify the mistake and work backward to make corrections.*

The quotes above show that collaborative work was an inherent component of teaching activities and practices. While putting students in groups was occasionally mentioned in category 1 interviews (schools with the Lebanese program), emphasis on collaboration within groups was noted in this category 2 interviews. Collaborative work, as described in the different comments, was about interacting, sharing ideas and perspectives, and correcting each other. More examples with focus on collaboration are mentioned below:

F1A3 French language: *Students were helping their classmates, trying to recapitulate, to refresh their friend's memories with the essential points or the learning outcomes that we covered.*

F2B3 Sciences: *The importance about groupwork is the exchange between students which allow them to reconsider their perspectives, correct wrong ideas, or reflect on ideas that are not clear in their minds.*

One more quote highlights the importance given to the role of group reflection in creating opportunities for students to reconsider their wrong ideas.

Manipulation and experimentation were two additional aspects of learning raised primarily by science and mathematics teachers. This feature was completely absent in the conversations of category1 interviewees. Below are two comments reflecting this point:

F1A4 Mathematics: *We construct our activities based on platforms such as GeoGebra to allow students to manipulate and discover by themselves.*

F3C1 Sciences: *Students will take the time to invent an experimental protocol, go through the steps, reformulate, etc.*

From the above collection of quotes which focused on students' learning, it was natural to inquire how teachers saw their role in the classroom. 15 out of 23 interviewees commented on their role and its effect on learning, presenting a sharp contrast with category 1 where only two interviewees mentioned the facilitation role they assumed in their classes. Interviewees perceived that emphasizing the moderator role was closely intertwined with the development of autonomous learners who were actively engaged in their own learning and benefited from the guidance and support provided. The following examples reflect this inherent relationship between autonomous learning and support systems.

F2B3 Sciences: *The student can find the solutions; the teacher is present to guide but not to give the answers.*

F2B6 French language: *The lesson is much more interesting when they raise the questions, instead of me soliciting them. This helps them go deeper into reflection about the topic.*

F3C8 French language: *I can help them, through questions, through guidance, to reformulate, question, and find by themselves the solutions, the explanation to think, and solve an issue or a problem. Then we bring help and support in vocabulary, concepts…* ***If we guide them very closely, they will be able to reproduce a scheme, but not to approach a new situation.***

This last statement (in bold) suggests a perception that promotes guided inquiry. Proceeding to how interviewees related to inquiry leads the discussion to the second main theme, the subject of the next section.

6.3.3 Theme two: Guided inquiry and problem-based learning

Many interviewees considered problem-based learning as an integral component of the French program. While it was an aspect of inquiry absent in category 1 conversations, it was frequently referred to during the different interviews conducted in category 2 schools. The various quotes below depict an understanding of problem-based learning closely linked to providing feedback. They show how the two are interlinked in a teacher-moderated environment.

F1A8 Sciences: *It is always a problem situation, students have to formulate the hypothesis, and put the procedures. It is up to them to discover the experiment.*

F1A9 French language: *I intervene but only at the beginning. We need to give them the opportunity to work alone and explore.*

F2B3 Sciences: *Physics is based on practice, when I launch a lesson, I display material and ask students how we can assemble the different instruments.*

F2B6 French: *What is important is to put students in front of a text and ask them to discover, to push them towards the invisible, and gradually, to try to guide them. There is a big difference between asking students to find the solutions and to give them the solutions. We should help them get to a point to ask the right sort of question and, by using the text, to answer this question.*

F3C3 Mathematics: *It is about putting students in front of a challenge, a new situation that resemble reality, when not all elements of the problem are given. This pushes them to think and explore.*

F3C8 French language: ***This is why balance is important**. If we give students everything, they will acquire new information but will not acquire the capacity or the competence to think, reflect and progress. On the other hand, if I leave them to discuss on their own exclusively, in the absence of any guidance, what is constructed is not as efficient as when there is no closure at various stages of the process.*

This last quote highlights the importance of a balanced teacher's intervention when students are given a new task. It is about the type of support, timing, and frequency provided to students while they are working on a task. It is neither the specific and ongoing feedback, cues and clues nor the complete absence of guidance and support. Rather, it is about giving the students the space to discover and experiment while offering timely guidance. Furthermore, it is about putting students in front of new problem situations to use their knowledge acquisition to discover new concepts, as reflected in the comments below.

F2B4 Social studies: *Whatever we do, we try to go backward to the concepts they have acquired.*

F3C8 French language: *I systematically start from what they derive irrespective of the grade level. I start from what students perceive, their understanding… trying to establish a chain, a link which echoes what was covered before. I try to choose texts which allow to establish links with pre-requisites and help students reinvest what was acquired.*

Establishing links was not limited to prior knowledge but involved making connections to real-life situations, as shown below:

F1A5 Mathematics: *We always try to connect what we are learning to our daily problems. This requires putting students in situations where they have to research to find the answers.*

F2B2 French language: *If the information stays in the abstract, it will not touch them. It is when there is connection with their real, daily life issues that they will better understand and grasp the information presented to them.*

F3C7 Mathematics: *Students tend to ask the question about the usefulness of the concepts taught. I have to show them the link to the reality.*

Hence, it is about helping students connect their acquired knowledge to reality and apply knowledge when faced with new situations. This exposure included putting them in front of complex tasks. Interviewees perceived complex tasks as an inherent component of the French program. Consequently, it is important for the sake of the analysis to explore at this stage how interviewees defined a complex task.

F1A5 Mathematics: *It is a problem situation which requires from students to make use their acquisitions which are not directly related to the chapter we are dealing with.*

F1A8 Sciences: *For every theme, we have at least two complex tasks. A complex task is problem-based, with an open-ended question. It is not about answering by yes or no. It is about analyzing and justifying, by going through the investigation method.*

F1A9 French language: *It is problem-based task that is relatively open-ended whereby students are not guided at each step, they start with an initial situation, and it is up to them to discover the whole process in order to reach the final situation.*

F2B5 Sciences: *It is complex because we are giving the students new documents to use in order to deal with the problem-based task.*

F3C1 Sciences: *A complex task is when there are many steps to perform but the students have to find these steps, put them in order. Hence, there is a creative work*

F3C3 Mathematics: *It is up to the students to find the appropriate information. This is why it is a complex task. It involves analysis, reasoning and calculation as a last step.*

From the comments above, it could be gathered that the commonalities were the open-endedness of the problem task and its novelty. The two components associated with a complex task brought two characteristics that differentiated them from the multi-step tasks mentioned in category 1 (schools with Lebanese program) interviews.

With this last comment, the next and final theme considered is the effect of the program requirements on teaching and learning. The discussion center on how the program facilitated the integration of problem-solving into instruction.

6.3.4 Theme three: Nature of the program

What was interesting to explore was the effect of the Lebanese program content on instruction. Many interviewees in this category 2 taught both the Lebanese and the French programs. As it is described in section 6.2.4, Category 1 interviewees unanimously commented on the various constraints resulting from the old-fashioned and rigid Lebanese program. Consequently, it was necessary to investigate whether teachers juggling the two programs exhibit similar reluctance vis-à-vis the Lebanese program. Interviewees offered interesting insights on the differences they experience when dealing with both programs. They highlighted the relevance of the French program to the age group they were dealing with, namely middle school students. They believed that the activities' relevance to reality, the richness of the proposed themes, and the emphasis on investigation and inquiry paved the way for developing problem solvers. The quotes below mirror this point.

F1A4 Mathematics: *The Lebanese program is heavily based on techniques; we teach students the way and they have to follow. Whereas the exercises in the French program are always in relation with students' reality. It gives more meaning to learning.*

F1A8 Sciences: *The French program is based on the investigation method. Hence, there is always a complex task, a problem situation. Whereas this investigation method is not present in the Lebanese program, where we are limited to exercises to solve and a frontal lesson to give.*

F2B6 French language: *I believe the French program facilitates problem solving because it pushes the students to explore, and investigate.*

Being confronted with two divergent, sometimes antagonistic approaches to teaching, interviewees leaned toward the French program's instructional approaches. The "archaic" Lebanese program, as described by an interviewee (F1A6 below), and the brevet examinations put grade 9 teachers under the obligation to respect the content objectives of the Lebanese program to prepare their students to sit for the national, high-stake exams at the end of the academic year. This was not the case for the other grade levels (7 and 8), where teachers had the flexibility to imbue the Lebanese program with the French program teaching approaches. More importantly, as teachers of these two grade levels pointed out, even if they were obliged to cover the content objectives of the Lebanese program, they approached them using teaching practices and activities such as inquiry and active learning, two characteristics of the French program. Hence, they evaded the rigidity of the Lebanese program in grades 7 and 8 and thrived to bring variety into approaches in grade 9 to prepare students to take the end-year brevet exams. Nonetheless, despite the teachers' efforts to alleviate the difficulties that the Lebanese program posed due to its nature, such a situation remained a source of frustration to grade 9 teachers, as reflected in their comments below:

F1A5 Mathematics: *In grade 9, we have a problem as we cater to the two programs and we are always pressured by time. Then, it is not possible to give complex tasks which are demanding in terms of time.*

F1A6 French language: *We have to train students to the question type of the brevet exams which are different from the French program approaches to assessment. In addition, the themes proposed are archaic.*

F2B4 Social studies: *Unfortunately, we have this "cut" at the end of grade 8 because of the brevet at the end of grade 9. We cannot cover all the requirements for the Lebanese program in grade 8, we choose the skills that cater to the brevet.*

While commenting on the stressful situation resulting from catering to two programs, mainly in grade 9, interviewees considered that the ongoing professional development was beneficial and a source of growth and enrichment. It prepared them well to incorporate French program methodologies into their practices. More importantly, while professional development was frequently discussed in this category 2 of schools, it was totally absent in category 1 conversations. Aside from the coordination meetings during which teachers developed teaching material, category 1 interviewees did not tackle professional development during interviewing.

As a way of closing of category 2 interviews' analysis, the interpretation of the 23 transcripts indicates a perception of problem solving rooted in active, problem-based learning. Teaching practices were perceived as centering around inquiry, investigation, and manipulation within a support system of feedback and guidance. Teachers primarily considered themselves as the moderators of this learning. Although the teaching of two programs, French and Lebanese, presented many difficulties, mostly due to the preparation of students to sit for the Lebanese brevet exams at the end of grade 9, interviewees seemed comfortable catering to the requirements of the two programs. As derived from the different conversational interviews, the advantages the French program offered in terms of resources and professional development kept teachers abreast of the latest approaches to teaching and learning. These favorable conditions allowed them to create suitable learning environments to cater to the required competences of the 'socle' among which, problem-solving competence.

The following section, 6.4 deals with the interpretation and analysis of transcribed interviews performed in three schools of category 3. These schools deliver two programs at the middle school, the American and the Lebanese ones. The structure of the discussion is similar to the preceding two categories starting with three thematic maps illustrating the development of the main theme.

6.4 Themes derived from category 3 schools with the American and Lebanese programs

6.4.1 Themes generation

The three stages of meaning naming, meaning condensation, and meaning interpretation was performed on 24 interviews conducted in three different schools (A1, A2 and A3), with nine interviews in A1, seven in A2 and eight in A3. The analysis of category 3 transcribed interviews revealed a clear discrepancy between A1 on the one hand, and A2 and A3 on the other hand. Whilst the three schools catered to the two programs, American and Lebanese, teachers' understanding of problem solving and how it was translated into teaching in school A1 were noticeably divergent from teachers' understanding in the other two schools A2 and A3, thus calling for a separate categorization of codes and themes. It should be noted that a similar divergence within category 3 was also observed when analyzing observational data. A1 observational findings, analyzed in chapter 5, section 5.4, differed from the other two schools and converged with category 1 schools with the Lebanese program. The three forthcoming figures 6.7-6.9 report on the development of themes for schools A2 and A3. They respectively display the stages in the development of the main themes starting with the identification of codes, followed by the mid-stage of code clustering and ending with the emergence of three main themes.

Figure 6.7 First stage thematic map representing developed codes.

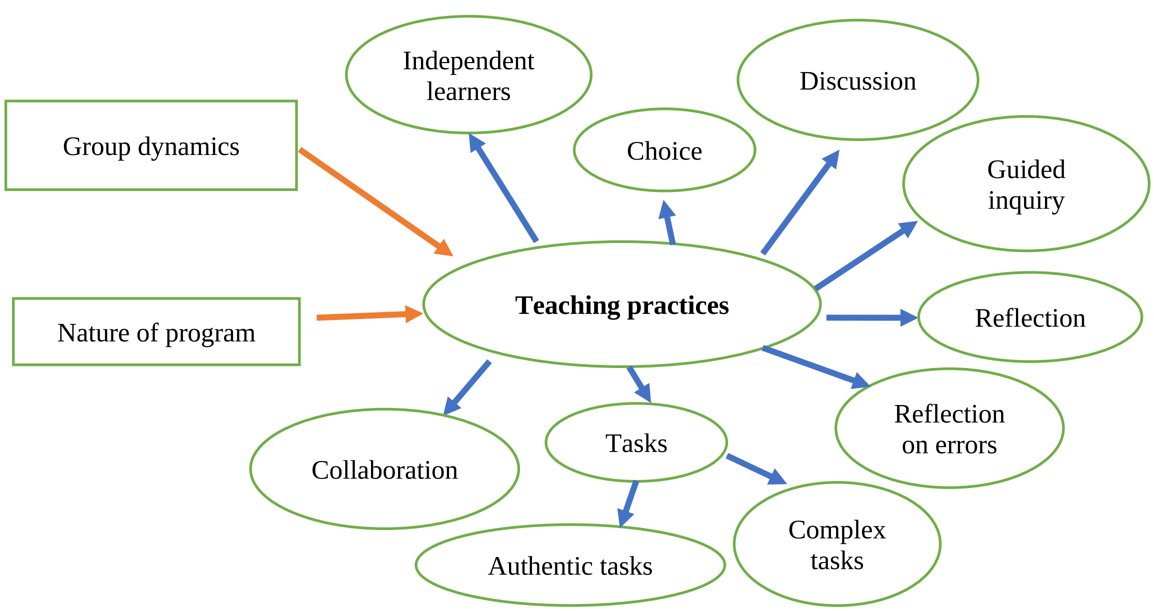
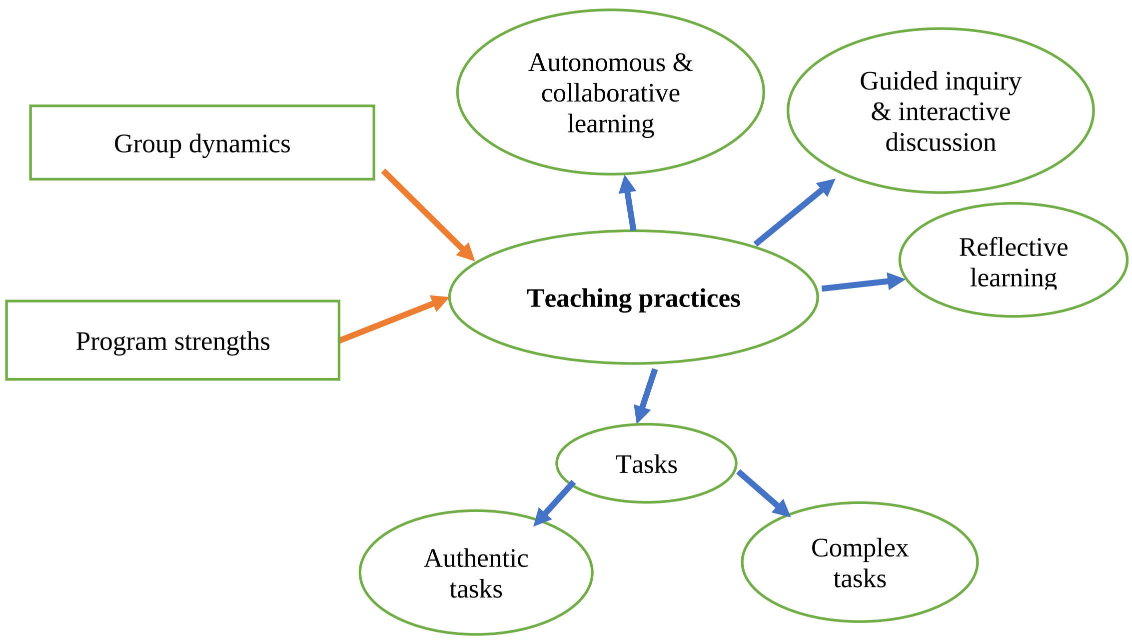
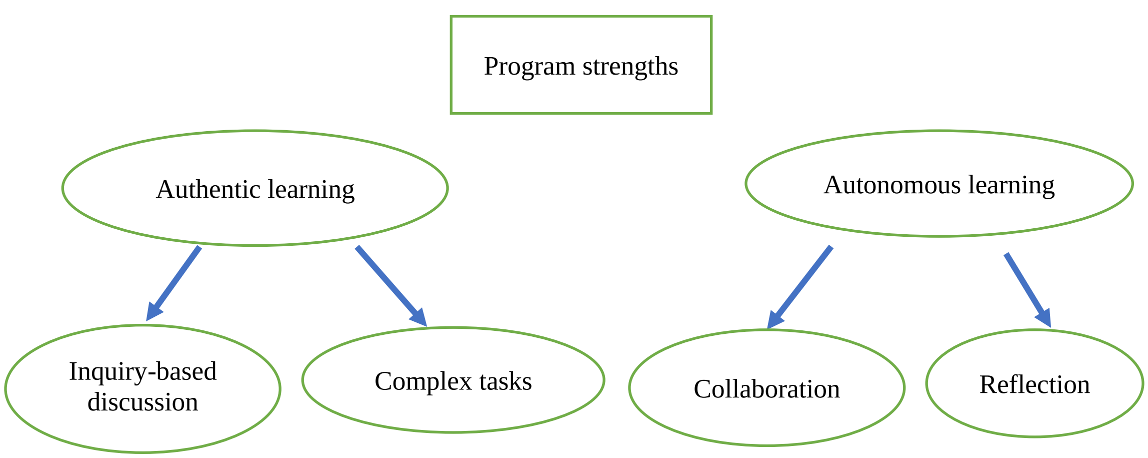


Figure 6.8 Mid-stage thematic map with groupings of codes.



The arrows in brown show the factors that affect teaching practices.

Figure 6.9 Final three themes: autonomous learning, authentic learning and program strengths.



Considering the six interviews conducted in A1, the identified codes led to developing themes similar to the ones derived in category 1 schools with the Lebanese program. These themes included teacher-led approaches, subject-specific real-life problems and program constraints. Two separate discussions of themes, supported by interviewees' quotes and comments follow, starting with A2 and A3, and ending with A1.

6.4.2 Analysis and discussion of schools A2 and A3 findings

6.4.2.1 Theme one: Autonomous learning

It turned out to be relatively hard to conduct a discussion separating the two identified themes, autonomous learning and authentic learning, because of their closed, intertwined relationship as it appeared in the various interviewees' quotes and comments. However, the equal importance given to each necessitated dealing with the two themes separately, and hence avoiding merging them into one major theme. Raising independent, autonomous learners possessing "voice and choice" as one interviewee commented, was considered a primordial goal developing problem solvers. This position was shared by the majority of interviewees in A2 and A3 schools, as reflected in the quotes below:

A2B1 English language: *Lots of discussion that make them rethink of their own ways, so this is how they try to overcome problems. They have to know that there are certain topics or certain things that have no answer. Every time you do something new you are kind of scared, you think it's a challenge, so it's the ways you develop as strategies to combat those problems. They are given voice and choice.*

A2B3 Mathematics: *I give them hints and they think of it. They spend the time to think of the solution and they take the time to do it. it's not that we solve it on the board they know the solution, and then they go home. We learn in class more than they do at home actually.*

A2B6 Sciences: *It is a learner-centered school. We focus on our learners, we are facilitators, we help them, we guide them but we are helping them to be more independent.*

A3C4 Social studies: *I most of the time let them take charge. Instead of dictating what they should do or what path they shouldn't do I prompt them with ideas, and let them think about it. I don't necessarily give them the* *strategies, I help them find them, because I might not know the strategies, and I might need to find the strategies with them.*

The various quotes not only highlight the importance of active and autonomous learning, but also stress the collaborative aspect of learning in an environment where teachers perceive themselves as moderators. The comment below introduced "agency", which clearly brought to the fore the priority given to raising independent learners.

A3C9 English language: *They do the discussion, I try to lead them through different topics, different ideas, but they're the main agents. Agency belongs to them. I want them to be critical about what is surrounding them, I want them to be critical of the information they receive.*

Promoting autonomous learning was tightly connected to a high level of collaboration among students. Interviewees insisted on the importance of collaboration in the learning process, as displayed in the following two comments.

A2B5 Sciences: *Because one of the aims here in science middle school is to enhance the collaborative skills between the students and it's very important for them to know how to work in teams, not only to work one by one.*

A3C6 Mathematics: *When you pose a certain question, students need to be given a wait time to think, then time to collaborate with each other (pairing); each one had time to think alone, then pairing, collaborating, thinking together.*

Another aspect of learning that interviewees thought as essential in raising independent learners is choice. They considered that it is necessary to provide learners with opportunities to make their own choices and share their own perspectives, as reflected in their comments.

A2B9 Mathematics: *they have the option to choose, especially in math, because each one can see the problem from his own perspective. Each one can use a different strategy or a different method to use to reach his Solution.*

A3C2 Mathematics: *They are decision-makers and they are trying to decide do I need a tool, a calculator, can I do it by hand.*

A3C3 English language: *The way to help them develop this competence is to expose them to different sides of an argument, through disagreeing with each other and giving different and conflicting arguments. I focus a lot on debate in an actual formal debate.*

Turning to reflection, the second subtheme, its meaning took a wider scope in A2 and A3 schools compared to category 2 schools with the French and Lebanese programs. Interviewees' perspective on peer reflection not only consisted of reflecting on one's and others' mistakes, as was the case with category 2 schools with French and Lebanese programs, but encompassed reflection on the process of learning itself, as described in the following comment:

A2B1 English language: *I take every group aside and I interview the members in the group to see their perspectives, how each one of them learned, how they think they learn, what they faced, what they think worked as a way to overcome the problems that they faced.*

Such reflective work takes learners to a metacognitive level, allowing them to reflect on their thinking processes rather than just the end-result of a problem task. It involves the element of self-regulation, only mentioned by this particular teacher. In the quote below, the interviewee made an interesting analogy associating peer reflection with problem solving. As perceived, peer sharing and reflection carry the learners to a deeper level of understanding.

A3C3 Sciences: *Reflection is a very powerful tool. It helps students deal with the problem, understand the problem and try to find solutions. If they don't have that much of deep understanding, it is not going to happen. So, when they are reflecting on what they do, it helps them go deeper. Peer sharing and peer reflection is very important, it is a kind of problem solving, because you are helping the other students to solve issues they are facing.*

In conclusion, the presentation of this first theme describes a perception of teachers that gave significant importance to autonomous and collaborative learning, where the element of choice occupied a predominant place. Students' exposure to authentic situations, the subject of the next section, engaged in a process of on-going reflection, was highly valued and sought after. Undoubtedly, interviewees had a shared understanding of the necessity to create learning environments where students had opportunities to freely express themselves, collaborate together, and reflect on their learning and the learning of others.

6.4.2.2 Theme two: Authentic learning

While interviewees in A2 and A3 shared similar views with category 2 schools with the French and Lebanese programs concerning the necessity to involve students in interactive, inquiry-based activities and reflective discussions, they distinguished themselves by conversing about authentic tasks. Their narratives were rich in information about the nature of authentic tasks and the importance allocated to them relative to others. The various comments first allow to shed light on what interviewees meant by an authentic task and second, to perceive the significance they gave to this type of task in nurturing problem-solving.

A2B1 English language: *It's all about encountering something new and how to deal with those challenges. There's an action, there is an end product and then you can choose how to present that product.*

A2B6 Sciences: *They have to promote their product and they have to choose the best product for the community or the problem that they wish to solve. It's a learning process I mean they have to do the research, develop ideas about their product. As a group of students, I made them sit in teams and choose their own teams in order it to imagine or find the problem as a group of engineers would do.*

A3C4 Social studies: *In this debate, we discussed migration and I have them interview people who migrated and this gave them a personal connection.*

A3C8 English language: *They need to understand that what they are doing is connected to something practical to do later. I try to bring in role modelling in this unit which focus on graphic novel. We are going to be cinematographers. They are associating real life tasks with what we are doing,*

Each of the comments above describe a task situation where students were taking a role that they could assume later on in their lives. For instance, taking the role of engineers or cinematographers, conducting interviews on a current issue such as migration puts learners in front of authentic situations. Students were exposed to complex, open-ended tasks, as well described in the comment below.

A3C3 Sciences: *I like the kids to design, to plan, to run, write the procedure, collect the data, fail! Design a solution that did not work and reflect why they failed in designing the product. It is going through identifying the problem, going through designing the solution.*

The nature of authentic, complex tasks entailed, from the interviewees' point of view, an approach to teaching that promoted inquiry-based practices, where trial and error was an inherent component. Moreover, it rested on discussions and debates where sharing multiple perspectives was an integral element. The selection of quotes below displays this point.

A2B1 English: *We try to address a certain topic from a different point of view. This is what or this is the starting point for problem solving…. We discovered that it is through discussions, through Socratic seminars that students develop certain skills make them learn for life.*

A2B9 Mathematics: *We go into debate and discussion and we relate our objective to real life situations.*

A3C8 English language: *It is more about how you take the information, how you explain the fact how you argue for it. So critical thinking is key for problem-solving.*

In all three comments, there was an insistence on discussion, argumentation, and debate which interviewees considered key practices to promote problem-solving. To create such a climate, interviewees made it evident that their role was to facilitate the learning process and guide students where necessary. The inquiry approach they described suggests a tendency toward guided inquiry with emphasis on the moderating role they assumed. The following quotations highlight the nature of the inquiry, the guidance provided, and the role of teachers as moderators.

A2B1 English language: *I elicit answers and instructions from them, but in the end, I always tend to be guiding each and every one. Whatever problems students encounter they have to think out of the box and find varied solutions for that with the help of their teachers through linking it within our lesson.*

A2B5 Sciences: *I guide them, but I try not to give them the answer. I try just to give them hints because I really want them to think.*

A3C9 English language: *I want them to feel like this is their space where they can make mistakes and try to ask as many questions as possible and they have the tool right in front of them in case they need any support or any maybe if something is not clear enough, they can come to me for an answer.*

A3C6 Mathematics: *I am a facilitator. I have to give time before giving the right answer. I should not give the answer straight away. This is what stops them from analyzing, thinking, trying to get to solutions, trial and error, making mistakes. Freedom, giving them some space to think together, not feed them. To build good problem solvers in life, we have to give students the freedom to explore and not inhibit their thoughts.*

This last comment provides a well-articulated description, putting together interviewees' perceptions of the factors that promoted problem solving. It was a perception that stressed the moderator role of teachers, the autonomous and active role of learners, and associated problem-solving with the provision of opportunities for inquiry and exploration. The presentation of this second theme put to the fore a type of complex task that was not observed in category 1 nor category 2 schools. Authentic tasks exposed students to situations where they were required to take roles and actions as in real life. The nature of these tasks, according to interviewees, prepared students to become problem solvers.

6.4.2.3 Theme three: Program strengths

As an emerging theme, program strengths were examined from two perspectives: first, by looking into the factors which favored the integration of problem solving namely, program requirements, and second, by considering the difficulties interviewees encountered and the strategies they adopted to overcome them. The subsequent discussion begins by looking into the areas which facilitated problem-solving integration followed by the perceived obstacles and the means to surpass them. Conversing with interviewees about program requirements spontaneously prompted the interviewees to compare the two programs, Lebanese and foreign. Interviewees' comments stressed the difference between the two as shown below.

A2B3 Mathematics: *The American book we're using always ends with problem solving, that’s what is interesting about the book. It's always related to real life, like the problems we did today in class. With American books, they take the sections starting with the basics and move forward. It’s flexible. Lebanese program is tougher somehow. They take the material and then directly move to the tough problems. They don't do the practices that they have to do before moving to the tough problems.*

A2B4 English language: *It gives the students steps and it guides them smoothly and easily, whereas the other program is twisted and students tend to get lost.*

A2B1 Sciences: *The American textbooks have a wide choice of texts and lots of connections and you know with the availability of technology, this also allows students to have a wider perspective on things so it's not only that they're exploring something from one point or and another point, there are several ways and several texts and several resources.*

A2B6 Sciences: *In the Lebanese program, students are exposed to problems which are directly related to formulas given by the book or definitions from the chapter, which is very direct. It's not actual problem. There's no space for creativity or for analysis*

These points of view are reminders of similar opinions expressed by interviewees in category 2 schools (with the French and Lebanese programs), especially regarding the appropriateness of the program objectives to develop problem solvers and their relevance to students' age groups. Nevertheless, interviewees emphasized the importance of planning their lessons and prioritizing group dynamics. From the interviewees' comments, it could be suggested that there was relatively greater flexibility compared to the other two categories of schools. Ten out of 13 interviewees gave priority in the planning of their lessons to the group class as shown below.

A2B4 English language: *In my planning, I give priority to student's needs to students' welfare and I cater to these.*

A2B6 Sciences: *When I get to problem solving, I give examples, which are not always from the book. Sometimes it's from my own choice It's from what I need my group to know and what prepares them for the coming years.*

A3C6 Mathematics: *We have the flexibility but we have standards to follow, objectives as well. With the activities, I might plan and then make changes. So my students direct the activities. We at school are flexible, as long as covering the objectives of the Common Core.*

This flexibility was also noticeable when interviewees tackled the issue of the Lebanese brevet exam. While interviewees in the other two categories perceived this end-of-year national exam as posing important difficulties, Interviewees in A2 and A3 exhibited a more relaxed attitude. Their comments stressed the need to abide by the requirements of the brevet while adopting teaching practices and assessment tools that respected the school mission statement as illustrated below.

A2B1 English language: *In my class, I'm using the American program because the selections themselves have a lot of depth. However, at the same time we have some skills that are focused upon taken from the Lebanese program, because some of those students are going to be in year 9 next year. And this is more when it's comes to grammar.*

The above comment describes how this English language teacher (A2B1) was catering to the requirements of the Lebanese program while simultaneously respecting the objectives of the American program. The themes that were chosen and the approaches to teaching were adapted to address the content objectives of the Lebanese program. More comments further insinuated the integration of student-centered approaches to teaching and learning to cater to the Lebanese program requirements.

A3C1 Sciences: *But we don't teach like brevet. We use student- centered approach. We have a lot open of resources.*

A3C2 Mathematics: *The Lebanese brevet is very much focused on the procedural understanding while the American program is very much focused on the conceptual understanding, with real life situations.*

A3C6 Mathematics: *Whether we are covering the Lebanese program or the American one, this should not affect the practices, of course not!*

The ease teachers seemed to possess in dealing with the two programs was probably related to the nature of the American program. Interviewees' responses highlighted the American program's flexibility concerning the distribution of objectives across grade levels. With this last point, the thematic analysis of A2 and A3 interviews comes to a close. The remaining thematic analysis of interviews conducted in A1 is discussed in the following section.

6.4.3 Analysis and discussion of school A1 findings

The development of codes of the nine transcribed interviews conducted in school A1 revealed a great similarity with the codes generated from interviews of category 1 schools with the Lebanese program. As previously mentioned, the divergence of A1 codes required a separate analysis. In order to avoid redundancy with category 1 analysis, the description of A1 interview findings is done in a succinct way. The three main themes developed from the various codes were identical to the ones of category 1, namely, directed approach, subject-specific real-life problems and program constraints. In terms of teaching approaches, interviewees' narratives revealed a tendency toward directed instruction and close teacher support through leading and directing activities, as reflected in the following comments.

A1A1 Mathematics: *I want them to discover by themselves. I lead them, and then they will go by themselves and find out the answer. And I want to be able to solve alone, I give them the tips,*

A1A2 Sciences: *I guide them until they are able to extract the information from any document presented.*

A1A9 Sciences: *If some students need help, I would direct them, guide them to stay on the right track.*

A1 interviewees also placed a strong emphasis on application and practice which were deemed essential to teaching and learning in category 1. Seven out of nine interviewees conversed about the importance of students performing application exercises to refine their problem-solving skills. Furthermore, interviewees considered that the analytical processes underpinning the various activities were valuable in promoting problem solving. The samples of quotes below expresses how practice was considered a powerful tool to promote problem solving.

A1A1 Mathematics: *By practicing more, they will discover how to use the concepts taught. It helps them discover whether they did understand or did not understand what we were talking about in the discussion.*

A1A5 English language: *After we finish the story, I usually ask some questions related to this story, which are the direct questions because they knew the story, and as you noticed, I exploit every detail, but later it would be maybe on a quiz or simple activity. I give them a new passage which has not the same idea, but nearly the same skills.*

While there is an insistence on repetition, the above comment suggests that students are exposed to a new situation in assessment.

A1A8 Sciences: *With practice you will find many ways to solve the problem. With the first problem we will find it hard and go through our notes, when solving the second we will feel it's much easier, so you refer less to the notes but the procedure is clearer. The third problem will be even better, and so on.*

Interestingly, practice and repetition were not given importance in any of the interviews conducted in category 2 or A2 and A3 schools. Instead, there was more focus on the significance of complex tasks in nurturing problem solving. Looking into the nature of the program, interviewees showed their strong frustration concerning the requirements of the brevet, an accentuated frustration observed as well with interviewees in category 1.

A1A5 English language: *In grade 9 specifically, we are really out of time because we have the official exams requirements.*

A1A7 Mathematics: *I need to make sure that they will acquire all the needed information before they go to the official exam, so there are a lot of challenges.*

A1A8 Sciences *Because they don't train the brain to make this procedure or this systematic process, they just memorize and apply in the exam, there is no creative thinking, or the option to think outside the box. It's always the same questions, you follow the steps and you are there.*

Hence, the nine interviews conducted in A1 suggest an understanding which favored teacher-led approaches to teaching and learning to promote problem solving. Instruction was characterized by directed approaches to activities and discussions, as well as a heavy reliance on application and practice. Addressing the requirements of both programs seemed to raise serious obstacles that have yet to be overcome to reach a certain level of flexibility to better cater to both programs.

6.5 Zooming into teachers' conceptualization of problem solving

Comments from the three categories of schools were selected as responses to the second question of the interview protocol. This question specifically sought to explore how interviewees perceived, understood, or, to put it simply, how they defined 'problem solving'. The various quotes were particularly chosen because, when put together, they nicely summarized, in the interviewees' own words, the thematic analyses of each of the three categories of schools. More importantly, they revealed the degree of similarity between the various definitions within and across categories.

6.5.1 Quotes selected from category 1, schools with Lebanese program

L1A5 English language: *Problem solving is promoted through* ***campaigns that students have to work on, it is not graded.*** *It is something we discuss at all times, when we are in meetings, but I don't think we use it as a title.*

L1A8 Social studies: *We may not always be able to integrate problem solving, but I try to do it as much as possible* ***through videos or power points.***

L3C7 Sciences: *May be through giving* ***many problem situations,*** *the first time, the student will not know how to solve, the second time, somebody helps, the third time, he will do his best. Gradually, you decrease support.*

L3C8 Sciences: *When there is a very* ***difficult situation*** *to be able to directly reach the answer. I have to push my students to find by themselves the answers and deal with the problems. It can be an individual work such* **as research,** *or* ***classwork based on documents****.*

Descriptions that perfectly matched what was derived from category 1 thematic analysis are highlighted in bold. Putting the pieces together, some interviewees perceived problem solving as conducting a research project, a school campaign, or simply a class activity. For others, it was associated with a difficult situation, requiring close feedback and help from teachers, and promoted through repetition and practice. Across the three schools within category 1, it is obvious that interviewees did not share common grounds on how to define problem solving.

6.5.2. Quotes selected from category 2, schools with the Lebanese and French programs

F1A5 Mathematics: *Problem solving is a situation which require the student to think on his own, using the* ***bank of acquired knowledge*** *in order to answer the question that is not necessarily directly related to the chapter we are dealing with.*

F2B3 Sciences: *It is to find a solution to a situation, understand this situation* ***which is not common to them, a new situation they haven't been exposed to*** *before. Simply it is an unknown situation.*

F3C8 French language: *It is primordial for a language teacher to help students* ***reflect*** *and think about what they read, and not to stop at things that are evident. It can be in class,* ***but also in life****, to be able to question what is given, to understand it. So,* ***the most important competence linked to problem solving is to learn how to question things.*** *When a student is capable of questioning things by himself, he will trigger a process, to question, is to search, to understand what is hidden. There is a* ***reflection, giving an opinion.***

The pieces of the puzzle that fit what was derived from category 2 thematic analysis are in bold. They define problem solving as the ability to make connections, face novel and "unknown" situations, raise questions, share perspectives, reflect and be able to transfer this reflection capacity to deal with real life situations. Across the three schools within category 2, there seems to exist a homogenous understanding of problem solving.

6.5.3 Quotes selected from category 3, schools with the Lebanese and American programs

A2B6 Sciences: *When you're teaching sciences and problem solving you cannot just tell the learner this is* ***how this problem is solved.*** *You have to* ***challenge*** *him first. You have to see his capabilities. You have to* ***listen to his point of view*** *on how to solve the problem and then help him. Maybe he will* ***find his own solution*** *when he's given the time.*

A3C6 Mathematics: *There* ***isn't one way****. To build good problem solvers in life, we have to give students the* ***freedom to explore*** *and not inhibit their thoughts.*

A3C9 English language: *Problem solving would be the* ***irregular process*** *of finding meaning in the world through* ***different means, options and possibilities.*** *It seems a bit of a broad answer, however, I think this is what we implement and in our language courses. And it's very irregular in my opinion, so it's not one way and one strategy that should go from A-Z very directly It might have its ups and downs It might be very unusual It might fall into.*

The highlighted sections together reveal a homogenous description of problem solving across A2 and A3 schools. It associated problem solving with challenging situations that students delt with using their own ways to reach the end goal. It was about the learner finding her or his own processes, "irregular" processes, while benefiting from enough autonomy and support.

It was through this purposeful selection of quotes that a comparative description of interviewees' understanding of problem solving was drawn. Interestingly, this selection of interviewees' definitions brought together not one unified perception but varied perceptions of problem solving across the three categories of schools, with varying degrees of convergence as well as divergence.

6.6 Concluding thoughts

This chapter dealt with the analysis of the post-observation interviews that were conducted right after class observations. While these interviews were relatively short, nevertheless, by taking a conversational collegial aspect, they resulted in rich findings, revelatory of insightful information about interviewees' understanding of problem solving and how this understanding was translated into practices.

In general, except for one school namely A1, the thematic analysis of interviews conducted in schools with two programs -categories 2 and 3- reflected an understanding of problem-solving teaching embedded in an inquiry-based approach, in a class environment moderated by teachers, with emphasis on exposing students to complex tasks. Teaching activities put students in front of real-life problem situations engaging them in reasoning processes conducive to raising active, collaborative, and autonomous learners. Although there were nuanced differences between A2, A3 schools and category 2 schools, teaching practices showed a close resemblance between them, primarily in terms of the strong reliance on approaches to teaching and learning which underpinned their respective foreign programs (American in A2 and A3 and French, in category 2). Teachers' responses and points of view reflected a strong conviction to imbue practices, when catering to the Lebanese program objectives, with student-centered approaches and activities characterizing foreign programs. Interviewees seemed to be relatively at ease dealing with the binding requirements of the Lebanese brevet national exam and accommodating to the objectives of both programs at different levels of middle school (grades 7, 8, and 9). This was done without jeopardizing the requirements of the Lebanese program nor the student-centered practices of foreign programs which allowed them to address problem-solving competence. Reaching this kind of balance was made possible due to various reasons. Among them, was professional development emphasized by interviewees of schools with French and Lebanese program. Another reason was the flexibility of the American program. Based on the general standards that did not dictate a specific sequence of objectives, the American program gave teachers the freedom to develop their yearly progressions, thus making it possible to introduce adjustments and modifications when deemed necessary. Considering A1 school, which had contrasting findings compared to the other two schools in the same category 3, it could be suggested that teachers have not yet developed the means to reach the level of flexibility to cope with both programs, Lebanese and American, and eventually move toward a more student-centered approach to better integrate problem-solving competence into instruction. Insofar as category 1 is concerned, the actual Lebanese program was perceived as posing severe obstacles to addressing problem solving as a twenty-first century competence. The presentation of an array of definitions of problem solving offered not only a description of the practices associated with each category but highlighted a level of heterogeneity in defining problem solving across the three categories.

Chapter Seven

Discussion and Conclusion

7.1 Introduction

This chapter begins with a summary of the main findings resulting from the data analyses derived from the research instruments used for data collection. Then, syntheses of within-category and cross-category findings are presented. A discussion based on these syntheses is elaborated. In addition, the significance of the results and limitations of the study are considered. The chapter concludes by depicting future implications on research and practice, followed by final and concluding thoughts.

7.2 Summary of main findings

This project examined how problem-solving competence was incorporated into teaching practices at middle school (grades 7, 8, and 9) in nine different schools in Beirut. These schools were selected based on the program they offer: three schools with the Lebanese program in category 1, three schools with the French and Lebanese programs in category 2, and three schools with the American and Lebanese programs in category 3. This categorization aimed to build a comparative study on the instructional practices and the underpinning beliefs and understandings concerning the teaching of problem-solving competence. This was achieved through (a) reviewing curricular documents to identify program objectives targeting problem solving, (b) conducting structured class observations to describe problem-solving processes, and (c) exploring teachers' perceptions and beliefs on problem-solving competence. Before endeavoring into the comparative analytical phase across the three categories, the schools within each category were thoroughly examined to look for consistency, search for meaning through patterns, and describe divergences. Miles, Huberman, and Saldana (2014) well describe this process, considering that "each case must be understood in its own terms, yet we hunger for the understanding that comparative analysis can bring" (p. 101).

Within-category syntheses presented in section 7.2 constituted the building blocks for a comparative synthesis across the three categories of schools seeking to address the overarching question underpinning the study research: *How does the teaching of problem-solving competence-*

at the middle school level- in Lebanese private schools compare across different curricula? Before proceeding with a synthesis per school category, keys findings emerging from the study are summarized below.

Structured observations conducted in 81 classes across the nine schools (nine in each school) revealed similarities in derived data within category 1 (schools with the Lebanese program) and category 2 (schools with the French and Lebanese programs). However, category 3 (schools with the American and Lebanese programs) did not exhibit similar trends across the three schools, with one of these schools (referred to as A1) presenting significant differences with the other two, while presenting similarities in approaches with category 1 schools with the Lebanese program. Within-category analysis of observation findings displayed approaches to teaching ranging from teacher-led environments, characteristics of category 1 schools, to teacher-moderated environments in category 2, and in two schools out of three in category 3. Regarding the comparison of findings across the three categories, it showed that teaching approaches stressed cognitive processes related to exploration, understanding, and demonstrating understanding, while less emphasis was placed on processes such as planning, monitoring, reflecting, and evaluating. This underlying similarity allowed for the advancement of propositions, described and discussed in section 7.5, concerning the teaching of problem-solving competence across the nine schools. Another important finding relates to open-ended problem tasks, only noted in categories 2 and 3 (in two schools out of three). Though exposure to these tasks was occasional, they presented opportunities for students to deal with problem-based, real-life situations and were considered by teachers as fertile grounds to nurture problem-solving competence. One last point worth stressing is linked to interdisciplinarity, highlighted in both the American and French programs. Findings showed that this curricular component was mostly addressed through interdisciplinary projects. Nevertheless, these projects were planned sporadically and upon need.

Regarding post-observation interviews, 71 in total were performed across the nine schools. They were revelatory of an understanding of problem-solving competence as essentially developed within subject-specific domains. Nevertheless, analysis did not discern a clear perception regarding the integration of the transversal component or domain-general feature of problem-solving competence. Generally, teachers' beliefs and understandings displayed a range of definitions showing consistency between categories 2 and 3 and divergence with category 1 schools. Teachers in category 1 schools with the Lebanese program, perceived problem-solving competence as promoted through research projects and school campaigns linked to a theme in languages or a difficult problem task in mathematics and sciences. Whereas in the other categories, 2 and 3, teachers' perceptions reflected an understanding that associated the development of problem-solving competence with students' exposure to challenging situations, ranging from simple problem tasks to complex, open-ended, and authentic tasks.

This summary of general findings opens the way to the next sections 7.3 and 7.4 which present within-category followed by cross-category syntheses. These syntheses seek to provide a comprehensive and holistic description of the integration of problem-solving competence into teaching practices.

7.3 Within-category data syntheses

In this section, a synthesis is developed for each category of schools, bringing together the key findings from structured observations, semi-structured interviews, and documentary review of curricular requirements.

7.3.1 Synthesis of findings of category 1, schools with the Lebanese program

In this category 1 of schools, interviewees' points of view harmoniously converged with observational data, demonstrating a teachers' perception of problem-solving primarily subject-specific, with teaching practices and activities channeled through three main pathways. The first path was characterized by teaching practices aimed at ensuring students' understanding of the concepts taught. Activities were geared towards translating abstract concepts into practical examples helping students make connections with the real world. The second path promoted analytical skills perceived as essential reasoning skills intimately intertwined with problem-solving processes. Closely connected to the second, the third path consisted of the frequent and regular provision of application and practice of subject-specific problem situations that can be described as well-defined problems within a specific domain. Collaborative work, timely feedback, and interactive discussions were rare. These instructional practices indicate teacher-led instruction with directed approaches to teaching, driven by content objectives and skills. With instruction oriented by the three main channels, areas of cognitive problem-solving processes related to planning, executing, reflecting, and evaluating were less addressed as revealed by both observation logs and anecdotal records. The identified lesson objectives essentially targeted areas of exploration, understanding, and application. As for the nature of the program, the lengthy content objectives and the requirements of the high-stake brevet national exam taken by students at the end of grade 9, were points that were emphasized during interviews. They were regarded as an important source of stress and posed obstacles to implementing varied instructional practices and activities.

7.3.2 Synthesis of findings of category 2 with the French and Lebanese programs

In a teacher-moderated classroom environment, instructional practices and activities in category 2 schools with the French and Lebanese programs promoted guided inquiry and problem-based approaches to learning. Providing opportunities for students to explore and demonstrate understanding, formulate and represent, plan and execute, and reflect and evaluate, mirrored an understanding of problem-solving inextricably intertwined with teaching that fostered active, collaborative, and autonomous learning. Exposure to open-ended complex tasks was perceived as a necessary means to challenge students to deal with real-life problem situations, where collaboration, reflection, and evaluation were considered essential for learning. More importantly, reflection was given particular attention, specifically the detection of errors. As highlighted in various interviews, developing error detection skills was regarded as a powerful problem-solving learning tool, especially in category 2 schools with the French and Lebanese programs. While the learner was described as the architect of her/his own learning, providing support through feedback and guidance was regarded by teachers as an integral component of teaching practices. Finally, interdisciplinarity, emphasized in the French program, remained limited to disparate and occasional initiatives, such as school-wide projects.

7.3.3 Synthesis of findings of category 3 schools with the American and Lebanese programs

When clear trends were identified among the three schools within categories 1 and 2, it was not the case with category 3 schools. The three schools displayed areas of noticeable divergence across observations and interviews. Although the three schools catered to both programs, teaching approaches in school A1, as well as teachers' perceptions and understandings of problem solving, were similar to a large extent to the ones described in category 1 schools with the Lebanese program. As for schools A2 and A3, findings generated clear similarities displayed by both observation and interview-derived data. These findings pointed to a student-centered approach, built on guided inquiry and discovery, in an environment favorable to nurturing autonomous, collaborative, and reflective learning. Exposure to complex, open-ended tasks valued by teachers and reflected in interviews, put students in front of real-life situations to deal with. In this respect, authentic, complex tasks, which were only noted in school A3, involved students in even more challenging situations, such as case studies. Last, interdisciplinary tasks were restricted to school-wide projects. From this panorama of within-category synthesis, the next section presents the core commonalities across the three categories of schools.

7.4 Cross-category synthesis

7.4.1 Structured observation generated patterns

The comparative analysis of observational findings across the three categories of schools revealed, on the one hand, cognitive problem-solving processes promoted by more than 50% of teachers across the nine schools forming the sample, and on the other hand, cognitive processes that were addressed by less than 50% of teachers. Teachers' contribution percentages (Section 5.5, Tables 5.9 & 5.10) exhibited two highly interesting patterns across the three categories of schools.

The first pattern showed that teachers, irrespective of the programs' offerings, gave importance to similar cognitive processes, specifically *'Understand a text, diagram, formula, tabular information'*, *'Demonstrate understanding of relevant concepts'*, '*Use information from students' background knowledge to understand the information'*, and *'Identify variables in the problem and note the interrelationship'*. More than 50% of teachers whose classes were attended targeted these processes, which mainly centered on understanding and demonstrating understanding.

The second pattern indicated that cognitive processes which fell under representing, formulating, planning, executing, monitoring, and reflecting were not as emphasized, with less than 50% of teachers contributing to their integration into instructional practices and activities.

The developed two patterns are significantly meaningful in addressing the overarching question of this study. They suggest an underpinning commonality across the nine schools forming the sample. This commonality is double-sided. One side indicates the centrality of select cognitive problem-solving processes focusing on exploration and understanding and reflected in their widespread integration into instruction. The other side translates a weakness in addressing a range of other cognitive processes, such as planning, executing, monitoring, and reflecting.

7.4.2 Interview-generated patterns

If observations revealed what was happening in classrooms, interviews unveiled the underlying beliefs and understandings. Interviewees' accounts helped develop through teachers' descriptions a deeper interpretation of the meaning of problem-solving competence and how it was integrated into teaching. Interviews, structured along three axes, first identified practices and activities that teachers perceived as promoting problem solving, thus establishing a direct link with class observations. Second, they mined into the problem-solving definition, and third, they explored the nature of the program(s) delivered and how it/they facilitated problem-solving teaching.

The first axis generated a similarity across the nine schools regarding problem-solving conceptual understanding. There seemed to exist a prevailing perception of problem-solving competence tightly linked to its domain-specific nature with rare reference to the transversal or cross-curricular component. Another important similarity concerned open-ended, complex tasks. Although the importance of their role in promoting problem-solving was highlighted in interviews of categories 2 and 3, their application, as reported by interviewees, was not systematic, suggesting a perception considering these tasks as adds-on activities rather than an inherent component of instruction.

The second interview axis, with a focus on the exploration of teachers' perceptions of what problem-solving competence is, displayed an array of problem-solving definitions (Section 6.5). For instance, problem-solving competence was perceived as the ability to deal with an issue through school-wide campaigns, conduct a research project on a specific issue, or link to a theme approached in languages. It was also considered as promoted by putting students in front of novel and unfamiliar situations or giving students the freedom to explore. This sample of definitions entailed an understanding associating problem solving on the one end with a specific activity, theme, or research project, and on the other end, with approaches to teaching and learning built on guided inquiry, problem-based learning, and reflection.

The third axis concentrated on the nature of the program(s) and its role in facilitating the development of problem-solving competence. Irrespective of the school category, interviewees pointed to the necessity to alleviate the pressure put by the overwhelming content objectives and skills of the Lebanese program. Teachers' responses may imply a clear consensus on the urgent need for comprehensive reform. A negative reaction resulting from stress and worry to cover the requirements of a heavily loaded, content-oriented program was very pronounced among teachers of category 1 schools (Section 6.2.4).

While teachers in schools with two programs (categories 2 and 3) shared with category 1 teachers the need for a reform of the Lebanese program, they dwelled on the value of foreign programs in facilitating the integration of problem-solving competence into teaching approaches and procedures (Sections 6.3.4 & 6.4.2.3). Their responses stressed the necessity to infuse the Lebanese program with activities and learning strategies adopted from foreign programs. Furthermore, teachers highlighted the role of professional development in keeping them abreast with the latest approaches that facilitate the integration of twenty-first century competences. It is worthwhile to note at this stage that professional development was not raised in any of the interviews in category 1, suggesting a dearth in this area. Finally, responses from schools with the American and Lebanese programs emphasized the flexible nature of the American program in helping them deal with the requirements of both programs. The general standards underlying the American program permitted the construction of a school progression of programs' objectives that best fit the school's needs. Bringing to a close the presentation of within and cross-category syntheses, the next section turns to the interpretation and discussion of findings.

7.5 Discussion of cross-category findings

The interpretation of findings centers around a discussion on the nature of problems, their relationship with cognitive loads and provision of guidance and feedback, and finally effect on learning.

7.5.1 Nature of problem situations

Considering the nature of problems of category 1 schools with the Lebanese program, the application and practice exercise sessions in the various domains, languages, sciences, social studies, and mathematics indicate a reliance on well-defined problems (Mayer & Wittrock, 2006) or structural problems (Jonassen, 2000). These problems have all their operators given; they have known elements, require predictive and prescriptive ways, and their solutions knowable and comprehensible (Mayer & Wittrock, 2006; Jonassen, 2000). This kind of problem-solving is algorithmic and requires strong methods, which allow solving a specific problem in a certain domain when used correctly and under appropriate conditions (Van Merriënboer, 2013). Being inflexible, they can only be applied to specific situations. The frequent sessions -12 out of the 27 lessons, around 44% - dedicated to application and practice exercises characterizing the three schools in category 1, are expected to allow learners to develop a certain automation, which eventually puts a low load on their working memory. With teaching practices centered on ensuring that students demonstrate understanding of the concepts taught and making a connection with prior knowledge in relation to these concepts suggests a type of instruction seeking to promote primarily factual and conceptual types of knowledge (Mayer & Wittrock, 2006) closely related to retention rather than meaningful learning (Mayer, 2002). Striving to help students reach a kind of automation is probably associated, in teachers' understanding, with expertise. Nevertheless, dealing exclusively with well-defined, well-structured problems remains insufficient. Focusing on well-defined problems denies students from dealing with real problems when real-life problems are ill-defined, necessitating reasoning and decision-making (Mayer & Wittrock, 2006). Emphasizing the application aspects of knowing, as Van Merriënboer, Kester, and Paas (2006) contend, prevents students from developing, at a later stage, interpretive and creative processes. Exposure to both routine and non-routine aspects of problem solving enables students to derive inferences from tentative solutions and make decisions about the strategies to employ in dealing with the problem situation (Van Merriënboer, 2013). The rare exposure of students to complex tasks deprives them of important types of knowledge of Mayer and Wittrock's typology (2006), namely, procedural, strategic, self-regulatory beliefs, and meta-cognitive types of knowledge. The absence of opportunities to learn how to plan, execute, monitor, and self-regulate puts learning closer to rote learning than to meaningful learning and where the place of transfer is questionable.

As Mayer (2002) observes, if the aim of teaching and assessing is the subject content students have learned and retained, then the focus is primarily targeting one class of cognitive processes focusing on remembering, with retention falling under this category.

Turning to category 2 schools (Lebanese and French programs) and A2 and A3 of category 3 (Lebanese and American programs), examining the emerging findings took a different route. This was not the case for school A1 in category 3, where the findings closely resembled those of category 1 schools with the Lebanese program. In category 2 and schools A2 and A3, instruction was characterized by students' exposure to various problem situations in an environment driven by guided inquiry, with students having opportunities to collaborate in groups to deal with proposed activities and tasks. Problem solving encompassed both well-defined and ill-defined problems. The latter, described as knowledge-based problems (Van Merriënboer, 2013), may have multiple solutions and often require the student to make a judgment, and where the learner does not have a ready-made solution (Mayer & Wittrock, 2006). This type of problem requires heuristic methods rather than algorithmic ones as is the case with well-structured problems. Ill-defined problems bring in problem-solving processes, such as critically organizing contextual knowledge, and making inferences, in addition to resorting to strategies, such as analogy with similar encountered cases, to reach end goals. In these schools, ill-defined tasks took the form of complex tasks where students, in groups, collaborated in all steps of the task to reach end goals. For instance, in a science class, this was done by conducting a project related to an actual, real-life situation and in an English class, writing a persuasive essay linked to a current, global issue.

A different type of task, which can be described as an authentic learning task, was only observed in school A3. For example, students in a social studies class worked on a case study where they had to conduct interviews in their community. The end product was a debate where students were observed exposing, discussing, raising arguments, and defending their positions. From a sociocultural lens, such learning goes beyond the boundaries of constructing and acquiring knowledge, as Crossouard (2009) contends, to learning as a process of becoming where the learner identifies with a certain community and fully engages in its practices. Such learning requires the creation of opportunities for students to engage with their peers, alongside their teachers (experts), in dealing with authentic tasks in the communities of practice. Attending to the division of labor is an essential consideration when designing the task. The teacher has the opportunity to draw on a repertoire of pedagogical positions to support learning (observer, assessor, subject expert, or learner) during the different phases of the task. Similarly, students are allocated specific roles which give way to different social positions interplaying in their learning setting. Being challenged by the open-endedness of the task and its complexity, students' joint endeavor makes peer assessment more acceptable, while the extended nature of the task opens the way to deeper individual learning. Hence, these tasks promote student agency, projecting learners into different positions and communities where their work is framed by the rules these positions and communities entail. Van Merriënboer (2013) describes this type of task as necessitating the orchestration of knowledge, skills, and attitudes (competences), and is instrumental in reaching the integration of the three. It is such an integration that describes complex learning (Kirschner & Van Merriënboer, 2008). It involves the coordination of different skills and often leads to the transfer of what was acquired in classrooms to daily life and eventually work.

Building on examining the nature of problems, the next section depicts the underpinning instructional processes with a discussion framed by Cognitive Load Theory (Sweller, 1988).

7.5.2 Cognitive processes, cognitive load and instruction

If students in category 1 schools with the Lebanese program were given opportunities to represent and plan when confronted with a problem, the cognitive process of reflecting and monitoring was not visible. Moreover, teaching practices conducive to helping students make judgments about the appropriateness and effectiveness of the strategies used were not observed. In Cognitive Load Theory (Sweller, 1988), the interplay between short-term and long-term memories is crucial in determining learning. In most of these cases, students in category 1 were resorting to means-end analysis strategies dealing simultaneously with various operators and resorting to backward strategies by starting with the goals. This type of means-ends strategy, though conducive in most cases to the end goal, comes at the expense of heavily using the limited capacity of the working memory. Dealing with the problem state, goal state, and the relation between the various operators and subgoals is overwhelming and does not guarantee schema acquisition, even when the problem approached is solved (Sweller, 1988). In conventional problems, using means-ends analysis allows one to reach a solution but not necessarily to learning because "goal attainment and schema acquisition may be two largely unrelated and even incompatible processes" (p. 283). Furthermore, support must be provided during the knowledge acquisition process, and this support should be reduced only after learners have gained the appropriate level of experience. Putting students in application and practice situations when they are still novices to the concepts introduced, a "disguised learning by doing" as adroitly described by Beckmann and Goode (2014), whereby students are expected to learn while performing, is rarely conducive to effective learning. Resorting to trial and error and unsystematic procedures negatively affect performance and, ultimately, effective learning. It is the lack of systematicity, as Beckmann and Goode assert, that can be detrimental to learning. While exposing inexperienced students to problem-solving based learning might put them at the risk of overloading their working memory capacity resulting in poor learning outcomes, the information required for novice students may gradually turn redundant as their level of expertise increases. Eventually, this redundancy might hinder further learning. Consequently, as Sweller (2010) notes, it is crucial for teachers to take into consideration the different levels of learners' experience when designing their lessons.

Irrespective of the complexity of the information, extraneous cognitive load varies with instructional procedures (Sweller et al., 2019). It can possibly be avoided when prompt feedback is provided to students (Beckmann & Goode, 2014). Under instructional procedures unfavorable to learning, students' performance might be strenuous when it could be facilitated by appropriate support. Task complexity depends on how many pieces of information and interrelationships are needed for processing and understanding. Jonassen and Hung (2008) contend that the higher the number of pieces of information and interrelationships involved in cognitive processing, the higher the degree of complexity. Students in category 1 schools with the Lebanese program did not deal with complex tasks per se. The perceived difficulty students encountered may not be related to the complexity of the task as much as to extraneous, situational factors that could be avoided with appropriate instructional procedures. When confronted with problem situations, the lack of suitable system support could be one of the reasons why students were not successfully performing. Another suggested reason is the direct exposure of students to problem situations instead of gradual preparation. Van Merriënboer et al. (2006) stress the importance of ensuring a smooth transition from low-element interactivity tasks, such as worked examples, to higher-element interactivity tasks. For novices, problem-solving is not an effective educational method. Still, it can be a goal when effective methods are implemented to guide learners toward this goal by developing the needed knowledge in a certain domain (Van Merriënboer, 2013). In the absence of this knowledge, problem-solving becomes a difficult task.

The other two categories portrayed a different class environment that characterized many of the classes observed in category 2 (French and Lebanese programs) and A2 and A3 of category 3 (American and Lebanese programs). Tasks, irrespective of their nature, were approached through guided inquiry, allowing students to construct their own knowledge, collaborate to plan and implement strategies to deal with problem situations, and, most importantly, reflect on their errors. The anecdotal records displayed in Tables 5.3, 5.6 and 5.8, reflect discrepancies between approaches to questioning and discussion in category 1 schools with the Lebanese program compared to the other two categories. Teachers' questions in category 1 were of type student/teacher, meaning that students were asked to elaborate on their own work without building on peers' ideas. Students worked on their tasks and did not or were not required to share, either in pairs or in groups. This was contrasted with the other two categories of schools, where there were interactions of the type teacher-student and student-student as the records show in Tables 5.6 and 5.8.

Such a process of shared reasoning, whether in discussion or when dealing with a task in groups, ultimately aims at helping students reach informed conclusions. If dialogues are led by teachers who should demonstrate openness and adroit management of discussions, they are also students owned (Hennessy et al., 2023). Emphasis is placed on the learning process rather than merely reaching the correct answer. Dialogues help students build arguments and identify flaws in them, instead of immediately falsifying them. Moreover, they promote agency by allowing students to elaborate on their ideas and make their reasoning explicit, as well as acknowledge and respond to the various perspectives of their peers. Students actively engage in establishing connections, reinterpreting, and trying to make meaning of new experiences and ideas (Barnes, 2008). Thus, this kind of teaching seeks to create situations conducive to learning through collective knowledge building (Hennessy et al., 2023). This collective thinking is enhanced by teachers posing open questions which further induce speculations and inquiry, while providing sufficient time for dialogue.

The detection of errors was well emphasized in interviews conducted in category 2 schools. In this respect, Hattie and Timperley (2007) contends when students learn to develop ways to detect their own errors, this leads to a kind of self-feedback. Learning can be further enhanced in an environment where students have the possibility to build strategies for self-assessment and evaluation, develop error detection procedures and build their self-efficacy. Creating such classroom environments, which nurture peer and self-assessment and provide opportunities for learning from mistakes, is primordial for learning. Nevertheless, group discussions should never be built on a "laissez faire" approach (Barnes, 2008, p. 6). Teachers need to provide suitable guidance and supervision which both require appropriate prior preparation in order to lead a successful discussion in group work. Creating supportive environments which encourage students to share ideas with their teachers and peers help students move forward in their learning. Correcting peer errors that characterized many classes in category 2 schools (French and Lebanese programs) could not have been possible if the teaching context was not free from any danger of being aggressively contradicted or even made fun of. While the observation log does not allow the derivation of evidential, numerical data concerning students' responsiveness, the notes taken reported the difference in students' responsiveness to activities and tasks between category 1, category 2, and A2 and A3 of category 3. Passivity in category 1, is contrasted with involvement and readiness to approach activities in many classes observed in categories 2 and 3 (schools A2 and A3). Nevertheless, it is not possible to report accurately on students' participation due to the lack of a specific measuring tool targeting students' participation.

7.5.3 Zooming into cross-category emerging patterns

In a throwback on program requirements, while the Lebanese program did not yet accommodate for twenty-first century competences due to a lack of program reform, both the French and American programs underwent major curricular changes to ensure their integration. These reforms highlighted the role of twenty-first century competences (European terminology) or skills (American terminology), putting on a high pedestal problem-solving competence as both a domain-specific competence and a cross-curricular competence. The calculated percentages displayed in section 5.5 (Table 5.10) show that instruction in the nine schools constituting the sample emphasizes students' understanding and students' demonstrating their understanding, making connections with prior knowledge, and establishing links across concepts, thus highly promoting factual and conceptual types of knowledge. Whereas other cognitive processes, such as constructing hypotheses, retrieving and organizing, drawing inferences, analyzing, justifying, and critically evaluating different perspectives, percentages demonstrate a weakness in promoting procedural and strategic types of knowledge (Mayer & Wittrock, 2006) across the three categories, with calculated percentages lower than 40% (Table 5.11). This means that, generally, instruction in the nine schools placed less emphasis on these cognitive processes, certainly with varying degrees between the different schools and categories.

Three possible reasons may be advanced to explain the insufficiency in addressing these cognitive processes across the schools. The three proposed reasons, familiarity with the context, occasional exposure to complex tasks, and prevalence of guided approaches, with even directed approaches in category 1, could present factors that interpret the low percentages for certain cognitive problem-solving processes.

1. Lack of variety in activities and problem situations and students' exposure to familiar situations.

Familiarity with specific types of problems does facilitate problem solving; however, it does not guarantee either transfer to other types of problems or even to the same kind of problems (Jonassen, 2000). On this point, Beckmann and Goode (2014) note that empirical evidence does not unequivocally support the claim that the knowledge acquisition is facilitated in a familiar context. It is suggested that novelty and abstractness may be more beneficial for acquiring knowledge and learning. This point is more concretized by the concept of semanticity or the learner's level of familiarity with the learning environment in the acquisition of new knowledge. Beckmann and Goode (2014) present the argument that familiarity of a context (e.g., high level of semanticity) does not guarantee the acquisition of new knowledge, a challenge to the commonly held belief that familiarity and concreteness of a context facilitate learning of new concepts. Rather, it is suggested that contextual novelty and abstractness may be even more beneficial. A familiar context may motivate problem solvers to pursue a goal rather than explore and acquire knowledge about the system. A familiar context (with high semanticity) can be detrimental to their learning in the absence of any systematicity. Guidance in problem solving is required for making assumptions and systematically testing. A priori assumptions, as such, do not impede the acquisition of knowledge. It is the lack of systematicity when testing them that can be detrimental to learning. Hence, not only is the provision of guidance crucial, but this guidance should be towards assisting problem solvers in explaining and systematically testing their assumptions. This is highlighted elsewhere by Beckmann et al. (2015), who note that how students approach a task determines the effectiveness of a learning environment. It is the deliberative processing that "contributes to the effective acquisition of mental models that are necessary underpinnings of successful decision-making in complex environments" (p. 22). Putting learners in dyads or groups improves performance during the exploration phase. Nonetheless, it is not sufficient to guarantee effective learning. It may be enhanced in an environment where expectations are communicated, assumptions are explained, and decisions are justified in a structured and systematic manner.

Hence, practice should aim at enabling the learner to acquire routine aspects of problem-solving behavior and non-routine aspects, such as reasoning and decision-making. Novice learners develop "recurrent skills" with repetitive practice. In contrast, "non-recurrent skills" vary from one problem task to another and require that learners be exposed to an array of problems differing on various dimensions (Kirschner & Van Merriënboer, 2008). In highly contextualized learning environments, acquiring knowledge and understanding are tightly linked to context, which renders these two products of learning difficult to be transferred into novel situations (Beckmann & Goode, 2014). Variability is an important factor in complex learning. However, it is necessary to ensure a smooth transition from simple tasks, with low-element interactivity, to tasks with high-element interactivity (Van Merriënboer, Kester, & Paas, 2006). This gradual transition of tasks, ranging from simple to highly sophisticated and authentic tasks, addresses the learner's increase in expertise. Choosing tasks that are as varied as possible, assists learners in reaching a certain level of abstraction and constructing general knowledge from the details of individual tasks. According to Kirschner and Van Merriënboer (2008), linking the task approach to the variability component is crucial for the transfer of learning. Consequently, as the authors contend, by exposing learners to all sorts of skills, knowledge, and attitudes needed to perform the task, they are enabled to build a holistic vision of the task, in a process that is inductive, with stimulating knowledge derived from authentic experiences.

2. Occasional exposure to complex tasks

The inconsistent integration of activities and situations, which puts students in front of complex, open-ended tasks, poses a serious hindrance to students learning how to develop strategies to plan, make decisions, monitor the outcomes of their decisions, and reflect on the entire process with an adequate support system. Out of the 81 observations, students were exposed to 15 complex tasks. Moreover, the calculated percentages lower than 40% (Table 5.11) suggest that students were given occasional opportunities to develop their abilities to organize these five types of knowledge, which is conducive to deeper learning and transfer. For example, inferring tentative solutions for problems requires learners to bring upon their deep understanding of concepts and their interrelationships to apply them in non-routine situations, which according to Mayer and Wittrock (2006), describe what most real-life problems require. Making judgments and decisions, identifying alternative perspectives, and critically evaluating solutions all of which were used less often (as indicated by low percentages in Table 5.11) are fundamental to help students develop arguments. Being reflective and critical entail that every student should be able to take responsibility for raising questions, establishing connections, making interpretations, and finding the relevant evidence to support one or another viewpoint (Barnes, 2008). As described in chapter four under both the French and American programs sections, French competences and American standards targeting the ability for argumentation are embedded in many disciplines and reflected in processes, such as building an understanding, criticizing, and constructing arguments. Cho and Jonassen (2002) note the close relationship between problem solving and argumentation, especially when dealing with ill-structured tasks. These kinds of tasks provide students with richer opportunities to develop argumentation skills than the well-structured tasks. Even more importantly, Cho and Jonassen contend that students dealing with ill-structured problems can produce better arguments when problem solving in groups and individually. Alexander (2020) defines argumentation as the deliberate marshalling of evidence and reasons in the quest of constructing, assessing, or defending a case. It is a complex process that ranges from making a proposition, through testing a case, reasoning from premise to conclusion, to a debate between two opposing standpoints. What is of crucial relevance to this discussion is that argumentation, as Alexander highlights, is an acquired skill and considers that one of the essential tasks of education is to help students move from disagreement to discussion using evidence and reasoning processes.

Thus, well-designed tasks provide students with exceptional opportunities to develop life skills. Planning, identifying priorities, managing group work, self-regulation, communicating effectively with an audience, and grasping concepts and ideas to respond to questions of others are aspects of the task which characterize the outside world.

3. Prevalence of guided inquiry approaches

Notwithstanding the importance of supporting systems when students are exposed to novel tasks, approaching new situations with frequent and immediate feedback may not achieve its ultimate goal, that of nurturing cognitive problem-solving processes. While such feedback directly benefits practicing performance by helping identify and select of information, it nevertheless inhibits information-processing for transfer and hence learning. Providing excessive guidance may improve performance when doing the task; however, it does not necessarily guarantee better performance on tests compared to students receiving less guidance during practice. Van Merriënboer, Kester, and Paas (2006) consider that methods, such as step-by-step guidance and frequent feedback may allow the learner to reach pre-specified objectives; nevertheless, it is conducive to low transfer. Guidance in problem solving is required for making assumptions and testing them. Support and guidance are essential prerequisites for learners to approach any new and more difficult task. For novices, product-oriented support assists learners in understanding givens, goals, and the solutions that take them from the given to the goal. For instance, the regular provision of product-oriented worked examples alleviates the pressure of extraneous cognitive load compared to conventional problems. In comparison, process-oriented support aims at providing assistance with the processes to solve the problem task successfully. Van Gog and Paas (2008) observe that process-oriented worked examples not only help in reducing the extraneous load for novices but also enhance germane load compared to product-oriented worked examples. Though they demand more mental effort during the learning phase, the investment of this effort is expected to increase the efficiency during a performance, especially on tests, by requiring less mental effort investment compared to product-oriented worked examples. However, Kirschner and Van Merriënboer (2008) note that both types of support are expected to diminish in the scaffolding process when learners gain proficiency in solving problems. Consequently, it is important to vary feedback and guidance with the nature of the tasks. Limited guidance and infrequent feedback are suitable for teaching simple tasks. Even delayed feedback can be more beneficial and increase efficiency than immediate feedback. However, both feedback and guidance may have the reverse effect when teaching complex tasks by causing cognitive overload.

Looking into the nature of feedback, Hattie and Timperley (2007) observe that not only the timing of feedback is important, but also how students respond to feedback and, even more importantly, how actively they seek it. For instance, feedback is highly effective when it guides students in identifying their erroneous hypotheses and leads them through cues and advice to develop effective strategies for processing and understanding. For feedback to achieve its goal, that of conducting students to mastery and understanding of lessons, it has "to be clear, purposeful, meaningful, and compatible with students' prior knowledge and to provide logical connections" (p. 104). Teachers must continuously judge when, how, and at what level to provide feedback. It is about finding the right balance between the nature of the task, students' expertise, and guidance and feedback.

Hence, it is essential to provide learners with all the instructional support and guidance to work on new, more complex tasks. However, as Kirschner and Van Merriënboer (2008) contend, through scaffolding, this support should decrease with an increase in learner's expertise. Support and guidance can be placed on a continuum. When starting a new class task, high level of support and guidance is needed to deal with learning tasks. Then, gradually, this level is lowered with other different tasks, until it ends with conventional tasks. In a step-by-step model, the authors introduce two types of support information, procedural and supportive. Procedural information is necessary for the development of recurrent problem solving and takes the form of directed instruction on the how processes and direct feedback. Supportive information is needed for non-recurrent problem solving and aims to help learners develop conceptual, causal and structural domain models.

Last, it is worth commenting on the insufficiency of the regular exposure of students to tasks which carry a cross-curricular element, such as interdisciplinary projects. While the French program values interdisciplinary projects to promote the cross-curricular aspect of problem-solving competence, none of the tasks suggested to students during class observations was built on well-articulated interdisciplinary links. Rather, they were tightly subject-based tasks. Similarly, tasks proposed to students in schools A2 and A3 with the American program did not carry an interdisciplinary component.

In summary, cross-category comparisons suggest a dearth in creating learning opportunities for students to develop a range of cognitive problem-solving processes, such as formulating, planning, monitoring, and evaluating, across the nine schools. The insufficiency in enhancing these problem-solving cognitive abilities could be interpreted as the result of an amalgam of factors: a) approaches to teaching drifting toward contextualized environments, b) seldom to occasional exposure to ill-defined, complex tasks, and c) low variability of guidance and feedback that seem not to take into consideration the complexity of the task and expertise of the learner.

7.6 Significance of the study

This study examined how problem-solving competence is perceived and integrated into Lebanese instruction. Supported by a documentary review of three programs, American, French, and Lebanese, exploring classrooms' reality and teachers' understandings enlarged the exploration lens to encompass programs, practices, and beliefs. This project is presented as a pioneering research study. The elaboration of a comparative analysis performed through a tripartite examination of programs' requirements, teaching practices, and teachers' beliefs on problem-solving competence across three different programs presents an original study in Lebanon. The principal key findings described below touch on three areas: teaching practices, the nature of the program and teachers' beliefs and understandings. They are proposed with the hope that the derived conclusions and suggested propositions would allow educators in Lebanon to reflect on problem-solving practices and possibly improve problem-solving instruction to better prepare Lebanese students for the demands of the twenty-first century.

The first significant finding is demonstrated by two substantial patterns stemming from the cross-comparative analysis of observation-derived findings. The first pattern identifies a tendency across 81 observed classes to promote cognitive problem-solving processes emphasizing understanding and demonstrating understanding. The second pattern points to a weakness in addressing other cognitive processes, such as planning, executing, monitoring, evaluating, and reflecting. Referring to the four strands of PISA 2012, the two patterns suggest an emphasis on the first strand, "Exploring and Understanding", at the expense of the other three strands, "Representing and Formulating", "Planning and Executing", and "Monitoring and Reflecting". This conclusion may present valuable insight into interpreting the low performance of Lebanese students on the PISA and TIMSS international exams. A report from the World Bank (2022) shows that students' performance displays similar trends on TIMSS results, for 2011 and 2015, and PISA results for 2012, 2015, and 2018 pointing to a performance worse than the OECD average. In 2018, for the PISA assessment, Lebanon was 105 points below OECD countries, equivalent to more than three years of schooling. In another report prepared by ECRD (Educational Center for Research and Development) specific to TIMSS 2019 results, it is stated that Lebanon has been facing a drop in academic results, with a significant proportion of students not attaining basic math and science knowledge. According to this report, a noticeable drop in math performance has been observed since 2011. The average math score for 2019 places Lebanon in the 32nd position out of 39 participating countries. As for science, a dramatic drop has been observed since 2007. In 2019, the average result put Lebanon in the 38th position, ranking lowest among the MENA (Middle East and North Africa) countries. Interestingly, the report mentions that regarding the math cognitive domain, except for 'knowing', Lebanese students achieved lower results in other categories compared to the international average and MENA countries. The most prominent differences concern reasoning and applying. As is the case for mathematics, students demonstrate difficulties in science in the two areas: applying and reasoning. There are certainly numerous factors explaining the low performance of Lebanese students on the two international exams. Nevertheless, the findings of this study come to confirm the importance given to the 'knowing' domain as the first main pattern of cross-category analysis reveals. Emphasis is placed across the three categories of schools on 'understanding' and 'demonstrating this understanding' cognitive processes revealed by observation log data analysis (Table 5.9). When the contribution of the two disciplines, mathematics and sciences, is considered (Table 5.11), calculated percentages show a noticeable weakness in addressing cognitive problem-solving processes related to inferring, constructing hypotheses, retrieving, analyzing and evaluating. These percentages match the areas identified by ECRD, TIMSS 2019 report, where there are clear deficiencies, mainly reasoning and applying skills. Hence, it is suggested that the two significant patterns from the comparative analysis of findings across the three categories of schools could offer tangible directions by identifying specific cognitive problem-solving processes to be addressed in the future.

The second important finding indicates that students' exposure of students to complex, real-life tasks, which help students integrate the knowledge, skills, and attitudes (Kirschner & Van Merriënboer, 2008) necessary to prepare them for the real world, was insufficient. While certain schools succeeded in creating more opportunities than others for students to deal with real-life open-ended tasks, in general, the provision remained occasional across the nine schools.

The third key finding is related to the cross-curricular component of problem-solving competence. Interdisciplinarity is still in its infancy, mainly limited to sporadic projects, inconsistently planned across schools. This key finding is reflected in the literature. Jonassen and Hung (2008) comment on this integration, stating that interdisciplinary approaches, unfortunately, do not receive the adequate support. Schools continue to categorize problems in terms of entrenched disciplinary divisions. Anderson-Levitt (2020) observes that Common Core cannot be described as "competency integrated reform," but rather more of "competency added" (p. 7).

Given the nature of the program, the fourth key finding is a strong consensus among teachers from all three categories on the need for an urgent and comprehensive reform of the Lebanese program to prepare students for the demands of the twenty-first century. In this respect, Bou Jaoude (2007) observes that enhancing curriculum quality and relevance requires the MENA (Middle East and North Africa) region, including Lebanon, to ensure alignment between curriculum content, teaching practices, and assessment to enhance quality learning. More importantly, it necessitates reconsidering what constitutes the "basics" in education. These basics include "meaningful use of technology, rigorous content, thinking, problem solving, and life-long learning skills, in addition to the traditional basics" (p. 89).

As for teachers' beliefs and understandings, the fifth important finding is discerned by the array of definitions of problem-solving competence which presented degrees of inconsistencies. This reflects an understanding among teachers' participants that is not always faithful to the concept of problem-solving competence. The relative divergence in opinions puts into question the extent to which teachers possess a clear conceptual understanding of what problem-solving competence entails in terms of instructional practices. Beckmann (2019) points to the serious limitations that problem-solving theories possess in providing a thorough description, explanation, and prescription of real-world problem solving, questioning the lack of understanding of the meaning of complexity in complex problem solving.

The sixth and last key finding is relevant to professional development, which displays salient differences across the categories. While there was a complete absence of any reference to professional development in category 1 schools with the Lebanese program, it was emphasized in category 2 schools with the French and Lebanese programs and occasionally mentioned in category 3 schools with the American and Lebanese programs.

7.7 Limitations of the study

The ultimate goal for conducting this comparative study across the nine schools in Beirut was to explore the present educational scene concerning the integration of problem-solving competence into teaching. One main limitation of this study is that it cannot assess in the best way the prevalence of the phenomenon under study and, consequently, cannot allow drawing conclusions relative to the prevalence of the phenomenon. By definition, in a case study inquiry, the boundaries between the phenomenon under study and its context are not clearly defined. This generates potential variables requiring a large number of cases that are impossible to examine (Yin, 2014). The multiple case study design was sought to evade the particularization (Stake, 1995) of one or two case studies, hence aiming to achieve a firmer basis for generalization. The goal underlying the cross-case analysis is to enhance generalizability or transferability to other cases and to provide an in-depth understanding and explanation of the phenomenon under study (Miles, Huberman, & Saldana, 2014). For this project, it is thought that the repeated findings within and across-categories would better allow the development of working hypotheses about other unstudied cases than a finding emerging from one or two cases (Schofield, 2011). It is not about proving the generalizability of the findings, as Punch (2005) points out, but certainly suggesting some generalizability through presenting propositions for testing in further research. To further enhance the exploratory and comparative nature of the study, opting for a random sampling of cases within each category of schools, instead of 'selecting' the cases was sought to reach a certain degree of heterogeneity of schools. According to Gomm, Hammersley, and Foster (2011), in simple random sampling, the large number of data points and their random distribution across the population increases the probability that the main forms of heterogeneity within the population are more or less accurately reflected. Nevertheless, the random sampling that was performed does not guarantee substantial heterogeneity, especially since the schools were randomly sampled from a small pool, as described in section 3.3.2. In a total of 33 schools that fit specific criteria, three schools were sampled out of 16 in category 1, three out of nine in category 2, and three out of eight in category 3. Despite this limitation, such a random sampling was favored over a purposeful sampling to avoid seeking typicality and considering the study's exploratory nature.

Another limitation is related to the internal generalizations within categories. Relying on information derived from a small number of observations (nine per school) performed over a short period of time (three-day schedule) needed careful considerations related to the degree of generalization from this information to the behavior of all the teachers at school. Observation schedule visits (Appendices F, G and H) sought a relatively fair distribution of classes across the three levels of the middle school, and among teachers aiming for both balance and diversity to address the representativeness of the teachers' sample.

The analysis of observational and interview data from categories 1 and 2 revealed trends in their findings allowing for the formulation of within-category general propositions. This was not the case for category 3 schools with both the American and Lebanese programs. Caution should be taken in assuming within-category patterns, especially since one school's findings presented clear differences relative to the other two schools within category 3. This contrasting finding requires further exploration of schools within this category 3 to be able to present propositions about how the American program's requirements are addressed and translated into teaching practices. Further field research is needed to advance propositions about the way schools are facilitating the implementation of both the American and Lebanese programs and how they are coping with the requirements of both programs. This could present a potential direction for further investigation in the future.

In addition to the above limitations related to the representativeness of the sample, one more important limitation specific to the observation log is worth mentioning. The observation log did not account for the observation of classes where students worked on a whole-period task. Although it included specific criteria under the category 'Planning and Executing', nevertheless, the frequency rating turned out to be inappropriate to account for these criteria, particularly when the task was given over a whole period. Since solving problem tasks is an essential area of interest, specific criteria relevant to a complex task execution should have been foreseen instead of solely relying on anecdotal records.

Finally, it is necessary to highlight that this multiple case study design was built upon a rationale, which included a random sampling of schools within categories, three methods for data collection, and replication logic, which was essentially directed toward increasing the rigor of the design. Such rigor was continuously sought to strengthen propositions and conclusions which can potentially serve for pedagogical change and improvement. Undoubtedly, the research journey is inextricably intertwined with reflection on the purpose of our research and our own standards. As well put by Denzin (2011, p. 653):

> "There is more than one version of disciplined, rigorous inquiry-counter-science, little science, unruly science, practical science-and such an inquiry need not go by the name of science. We must have a model of disciplined, rigorous, thoughtful, reflective inquiry".

7.8 Directions for future research

The main findings of this study may open three important directions for future research.

The first direction touches on the implementation of complex problem-solving tasks. More research could be carried out to translate the different instructional theories and proposed designs into concrete, evidence-based problem-solving instructional strategies transitioning students from simple tasks to real-life complex tasks. More concretization needs to be made when designing training programs with regard to the expertise of the learner and the effect of guidance and feedback when dealing with complex tasks. I have personally experienced, when working with teachers on the design and implementation of complex tasks, that the orchestration, on the one hand, of support and guidance, scaffolding, and students' readiness in terms of expertise to approach complex tasks, with, on the other hand, problem-based learning pedagogical approaches, constituted a serious arena of struggle. Falling into unstructured methods presented a real challenge to their implementation. As Barron and Darling-Hammond (2010, p. 215) clearly put it, "it takes significant pedagogical sophistication to manage extended projects in classrooms so as to maintain a focus on doing with understanding rather than doing for the sake of doing".

Another significant direction to consider is the design of training programs on how to construct interdisciplinary tasks and deal with these tasks in the classroom. At the practical level, it is not evident to teachers what interdisciplinarity involves despite its important place in the French and American programs. Sharing personal insights in connection with the development and implementation of interdisciplinary activities, the design of these activities is a challenging and time-consuming endeavor for teachers. It necessitates a close and prolonged coordination among teachers in selecting cross-curricular themes, identifying the required thinking skills and cross-curricular competences, finding the time to address them effectively with the competing demands of curricular requirements, and developing appropriate criteria for assessment. On this last point, Leat et al. (2012) observe that assessing transversal competences proved to be of particular difficulty, especially that they are neither connected to a specific subject nor assessed in school tests or national exams. Thus, it reduces their implementation to sporadic initiatives, as findings of this project come to confirm. Admittingly, generating such an original and valued product requires creative work, flexibility, and sustained professional reflection and organization. As noted by Barnes (2015), the intention in cross-curricular learning is to connect and combine (p. 273), adding an important element of unpredictability and imagination to the outcomes. Consequently, clarity about the objectives for the disciplines involved and planning for appropriate means for integration is a complex approach which can present its risks of turning counter-productive. While the design of these interdisciplinary activities carries its own difficulties, presenting the task to students possesses its challenges in terms of understanding the interdisciplinary nature of the task, planning, and assessment. In this respect, Jonassen and Hung (2008) describe the double effect the integration of an interdisciplinary component has on problem structuredness. First, by infusing a level of comprehensiveness by including various disciplines, it is not always clear to students, when first exposed to the problem situation, what and how many disciplines are included. Second, the interconnectedness and interdependency of the different disciplines included in the problem situation imply a need to balance between the different components of the problem related to the various disciplines, which can be challenging to students. Thus, it is essential to consider in further research on how to design these interdisciplinary tasks and how to facilitate their implementation in the classroom.

Finally, the third direction relates to teachers' conceptual understanding of problem-solving competence. An operational definition of problem-solving competence in both its domain-specific component and even more in its domain-general one needs to be addressed to permit appropriate enactment of problem solving in the different disciplines.

7.9 Concluding thoughts

"All life is problem solving" (Karl Popper, 1999, p.100).

Undoubtedly, seeking to find answers to the overarching underpinning question was in itself an ill-defined, complex task to problem solve. Exploring classrooms and uncovering understandings about problem-solving competence highlighted how the translation of the requirements of three different programs yielded different approaches but also significant similarities to problem-solving integration in instruction. If divergence reflects the different approaches that underpin programs, the observed convergence suggests context-based, culturally anchored practices. In chapter three, a reference to Alexander (1999) was made to describe pedagogy as a window into the culture to which it belongs. The noted significant similarities across the nine schools draw a portrait of the Lebanese educational approaches to teaching that are still struggling to get deracinated from the legacy of the twentieth century. This study puts to light the existing gap between what curricula preach about the concept of twenty-first century problem-solving competence, and how in practice, it is implemented in classrooms. This gap reflects an ambiguity about the concept of problem-solving competence. Future research needs to identify evidence-based, teachable strategies to address the lack of transparency about problem-solving competence as reflected in the programs. The emphasis put in the French and American programs on the role of cross-curricular or transversal skills has not yet found its way into instruction, as this study revealed. Thus, the ongoing discussions in research studies on domain-general problem solving could be geared first, toward identifying specific skills that fall under this category, and second, how to integrate these skills into teaching. Putting both the definition of complex learning as the integration of knowledge, skills and attitudes (Kirschner & Van Merriënboer, 2008) and bringing back the definition of problem-solving competence by Fischer and Neubert (2015), put in the literature view section of this study, as "a bundle of skills, knowledge and abilities, which are required to deal effectively with complex non-routine situations in different domains" (p.1) gives complex, authentic tasks a fundamental place in ensuring transfer and hence, meaningful learning (Pellegrino & Hilton, 2012). Educational programs have not yet incorporated complex tasks, to ensure an inherent integration into instruction. As long as the concept of a complex task is ambiguous, its translation to teaching will remain an add-on activity. Concerted research efforts should clarify this concept, so that it can be integrated into educational programs in a clear, transparent way, and then find its way into classrooms. Until then, learners are not optimally benefiting from an effective instructional means to prepare them for the unpredictability and uncertainty of the twenty-first century.

As a final thought imbued with the long experience as a practitioner in the educational field, teaching practices cannot and should not be reduced to either/or options with every pedagogical trend and novelty. Polarization, as Alexander (2020) realistically paints the situation in schools, has long "plagued" (p. 18) educational approaches, where traditional vs progressive, instruction vs discovery, teacher-centered vs student-centered among many others, have divided educational practices. "The lure of the binary" (p. 18) ought to be abandoned into a more inclusive both/and. The challenge is well encapsulated by Higgins (2009, p. 13):

"…rather than thinking of progress as a linear measure through the curriculum, the distance travelled, perhaps the breadth of development will also be important, the area of learning as a measure. This would represent a step change in understanding what is important to assess in education, from progress as speed to the idea of acceleration or from distance to area of learning mastered, and a focus on the learner's potential as well as progress."

Eschewing educational dichotomies needs transitions, so as not to turn change into some unattainable ideals and getting rejected by classroom realities with their tensions, compromises, dilemmas, and frustrations which are intrinsic to the teaching profession. Even when innovation is successful, introducing new pedagogies certainly requires a transitioning and an adaptation phase, for both teachers and students.

Appendix A Participant information sheet

November 2021

Title: Comparative, multiple case study into the teaching of problem-solving competence in Lebanese Middle Schools

You are invited to take part in a research study about the implementation of problem-solving competence in the Middle School.

I am conducting this study as part of an Ed.D studies at Durham University, UK. This research project is supervised by Dr. Nadin Beckmann (nadin.beckmann@durham.ac.uk) Dr. Jens Beckmann (j.beckman@durham.ac.uk) from the School of Education at Durham University.
This research project has been reviewed and approved by the School of Education Ethics Sub-Committee at Durham University (date of approval February 2019).
The purpose of this study is to explore the ways in which teaching and learning of problem-solving competence in the Middle School reflect the requirements of the programs implemented in this cycle (either the Lebanese Program, the French Program or the American Program.)
I am hoping to commence the data collection phase in November 2021 and hope to complete it by the end of February 2022.

If you agree to be in this study, I kindly ask you to allow me to conduct one classroom observation session followed by an interview. During the observation session, I will be taking field notes; as for the interview, it will be audio-taped. Your participation in this study requires one period for classroom observation followed by 20 to 30 minutes interview.
You are free to decide whether or not to participate. If you decide to participate, you are free to withdraw at any time without any negative consequences on you.
All data collected and responses you give will be kept confidential. The records of this study will be kept secure and private. All files containing information are password protected. In any research publication, no information will be included that will make it possible to identify you individually. There will be no way to connect your name to your classroom observation data or to your responses during the interview at any time during or after the study.
Durham University is committed to sharing the results of its world-class research for public benefit. As part of this commitment the University has established an online repository for all Durham University Higher Degree theses which provides access to the full text of freely available theses. The study in which you are invited to participate will be written up as a thesis. On successful submission of the thesis, it will be deposited both in print and online in the University archives, to facilitate its use in future research. The thesis will be published open access.
If you have any further questions or concerns about this study, please do not hesitate to contact me via email at d.a.k.aboulebde@durham.ac.uk or to contact my supervisors. If you remain unhappy or wish to make a formal complaint, please submit a complaint via the University's Complaints Process.
I thank you for reading this information and considering taking part in this study.

Yours sincerely,
Diana Aboulebde

Appendix B Declaration of informed consent

Project title: Comparative multiple case study into the teaching of problem-solving competence in Lebanese middle schools

Researcher: Diana Aboulebde
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Supervisors name: Dr. Nadin Beckmann & Dr. Jens Beckmann
Supervisor contact details: nadin.beckmann@durham.ac.uk j.beckmann@durham.ac.uk

This form is to confirm that you understand what the purposes of the project, what is involved and that you are happy to take part. Please tick each box to indicate your agreement:

- ☐ I agree to participate in this study, the purpose of which is to explore how problem-solving competence is integrated into instruction in the Middle School.
- ☐ I confirm that I have read and understand the information sheet dated [---------2022] and the privacy notice for the above project.
- ☐ I have had sufficient time to consider the information and ask any questions I might have, and I am satisfied with the answers I have been given.
- ☐ I have been informed that my participation is voluntary and that I may withdraw from the study without giving any reason.
- ☐ I consent to being observed during one teaching session and gives permission for the researcher to take field notes.
- ☐ I consent to being audio recorded during the interviews and that my words may be quoted in publications, reports, and other research outputs.
- ☐ I have been informed that all data derived from observations and responses from interviews will be kept confidential and secure, and that I will not be identified in any publication resulting from this research.

Participant's signature: ___________________________________ Date_______________

Appendix C Peer coding

Participant	Selection from Interview	Code
SBI0	usually send them a video via google classroom before starting the lesson, …Another way, as you observed I collected an activity sheet. I send them a link, they observe the experiments presented in the link, and discover	Expose students to different strategies
SBI0	where they have to observe and take notes	Student have a role in constructing their knowledge
SBI0	they come to class they will have an idea about the topic in general before starting the class.	Homework
SBI0	One student once came up to me and expressed himself saying that it was very interesting and it encouraged him to watch other videos related to the subject.	Enhance student's curiosity
SBI0	an experiment were they need to discover things	Linking problem solving to discovery/new information
SBI0	Yes, when they know how to think ….. Usually when you follow the scientific procedure. I urge the students to ask why, how, what.	Systematic thinking process
SBI0	In any situation they are, in order to find answers to any problem they face whether in lessons or school or their daily life, or even something they discovered and they need to know more	Skills that extend beyond school context
SBI0	o they need to be asking these questions and doing research. And by following this strategy they can reach whatever they need to know.	Linking problem solving to research
SBI0	specially organizing their thinking, we teach them how to think, when they are found facing a problem.	Systematic thinking process
SBI1	the strategy is the same, either it was chemistry, math, biology or physics.	Transdisciplinary process
SBI1	This is the elementary level strategy, and as you grow to higher levels it will be more complicated and more steps to follow.	Complexity aligned with age group
SB11	these students have a two-year gap, especially in mathematics, which is reflected negatively on their skills.	Challenge: gaps in pre-requisite skills
SB11	But we did not have in our class today something related to problem solving, but it will reflect in the lesson later on. I can go into something a little bit more complex like circuit selection and circuit analysis action….	Perception of problem solving as related to complex situations/topics
SB11	They have to find the way how to find the current in the circuit, so here they should use equations, mainly because we are related to math, so they will use equations to find the solution of the problem. So mainly in the Lebanese curriculum, this is also a problem.	Perception of problem solving as mainly using Math concepts

Participant	Selection from Interview	Code
SBI5	By practice mainly.	Active involvement of students
SBI5	Exposing them to different exercises and different strategies. Even sometimes we flip the classroom, we use different tools to vary…	put student in new situation / vary strategies
SBI5	this will give you an insight on whether they understood or not because you cannot easily know if they don't ask a question or don't reply to you	importance of students' interaction to monitor learning
SBI5	another exercise in a different way	put student in new situation / vary strategies
SBI15	we can use in our teaching approaches lab skills, they can do an inquiry about something and they have to find an investigation, they have to find a conclusion, to build on observations. ... So here we get to the analysis part, and now we are problem solvers	Active role of students/inquirers
SBI16	...here we are talking about real life application, ... So he was faced with this situation where he has to find the equivalent value.	Relating problem solving to real life situations
SBI16	No, they have to find out, and it was a group work, so they help each other, peer education is very important.	Self-learning
SBI16	When you give a student a problem, a new situation. You are giving him a new situation and he has to solve the issues just to get to a new solution, that's it.	Put student in new situation
SBI16	I can see how the student is thinking, ask him what do you want to write, why you are writing this, what is the correct answer, is it correct, is it feasible to say this answer or no? So we always work together, we do discussions which is something also very important to solve a problem.	Monitor the thinking process
SBI16	A concept map is coming up after they finish this chapter, to relate all the ideas together.	Making connections
SBI16	I want to see the link and connections of ideas. And it's very important for the student as a preparation for the tasks to be ready. So he will be ready and comfortable faster with concept maps.	Making connections

Participant	Selection from Interview	Code
SB20	Thinking about different strategies oriented towards the student center not the teacher center.	Students need to have an active role
SB20	the points they have learned on their own regarding the topic	self-learning
SB20	Yes, but we do make some small changes. For example, this lesson is not included in the Lebanese program but we added it.	Curriculum revision to meet specific needs
SB20	Skills regarding experimentation. In terms of the Lebanese program, the skills include (as verbs) how to identify, draw a graph, analyze a graph.	Supporting factor: some skills are already addressed in the Leb. program
SB20	The Lebanese program has a lot of gaps. We are working on the curriculum from elementary till grade 12, and making the vertical progression and the horizontal although we did not yet start with it.	Hindering factor: gaps in the Leb. program
SB20	Problem solving definitely would help when the student knows how to analyze data, compare, come out with conclusions, referring information from documents, all of these may help them think how to reach a certain solution or conclusion	skills to help students become problem solvers
SB20	We do try hard, and we always have this cliché of preparing students to be problem solvers .... but it really needs a lot of hard work and preparation to prepare our students.	Challenge: a lot of preparation to teach problem solving
SB20	We are working on it to a certain extent with all the difficulties Lebanese teachers are facing, but regarding problem solving I think it needs to be highlighted and stressed more in all disciplines not only in one.	Challenge: problem solving is not perceived as a transdisciplinary skill
SB22	Now we are studying resistors, first of all and it's not included in the Lebanese curriculum.	Adding topics to the Leb. Program
SB22	I told them to put their pens down, the entire session was a lecture using videos using knowledge about resistance, what is meant by resistance from the word in English.	interdisciplinary connections
SB22	Extra information where we find the real- life applications of resistors in our homes.	relating problem solving to real-life situation
SB22	I want them to love physics, and this is physics, so we are not studying physics to succeed in the exams only no, this is physics.	Going beyond the program expectations

Participant	Selection from Interview	Code
SB23	I love the nature of science part, the history of development of this idea, how did it come, why we are using resistors, where we can find them in real life, why am I studying this? They don't know this and even in the curriculum it's not mentioned.	Going beyond the program expectations
SB23	And maybe how to think how to use, it's not allowed to teach the students about the notion of resistance or resistors, and they don't know their shapes at home.	extending knowledge to real-life
SB23	Investigation....In the lab, and in the activity sometime the virtual activities like simulations that I give to them	Inquiry/investigation
SB23	They're not left on their own, they are left to try. First of all, I ask them to try to get used to the simulation. Then after getting used to the simulation, build an electric circuit of your choice, but it should be a serious circuit. So then measure the value of the current and different parts in the branch, so you have to find out, find a conclusion, what did you notice? So they will come up with a conclusion.	Guided inquiry
SB23	The students should be thinkers first, they have to think why, why we are seeing this color. They have to get to know what is the phenomenon of observation of these colors, so they have to be thinkers first to be problem solvers	Thinking process
SB24	Teacher: Because it's repetitive, you study you have grades.	Challenge: Nature of Leb. program does not favor developing thinking skills
SB24	If you can make a study about official exams, you can find that the skills are used the same. The same skills are those big questions, same action verbs. They are not changing.	Challenge: Leb. program does not address all the required skills
SB24	I have time to build thinkers, because in the official exams now we are succeeding. So let's work on something else.	Need to enhance thinking skills
SB24	I'm doing some activities and I'm enriching the curriculum with them and they are enjoying it a lot.	Going beyond the program expectations

Appendix D Lesson objectives log

Name of school:
Subject (Languages; Maths; Sc; SS): __________________ Date: November 2021
Session duration: _____________ Gr. level: _________

Exploring and understanding

-Exploring literary and non-literary texts, images and documents. (L) -----------

-Exploring by extracting from a document the relevant information, reformulating, organizing and comparing it to prior Knowledge. (SS) -----------

-Identifying questions of scientific nature. (Sc) -----------

- Exploring by testing and trying different ways to solve a problem. (M) -----------

Representing and formulating

-Constructing concepts that permit the analysis and the elaboration of texts and speeches. (L) -----------

- Identifying a mathematical model and solving a mathematical problem using this model. (M) -----------

-Choosing and establishing a relationship between convenient conceptual frameworks to solve a mathematical problem or study a model. (M) -----------

- Develop and use a model (development of questions and explanations, generating data that can be used for predictions and communicating ideas to others) (Sc) -----------

Planning and executing

- Elaborating an interpretation of literary texts. (L) -----------

-Debating in a constructive manner. (L) -----------

-Formulating hypotheses to interpret
historical and geographical phenomena. (SS) -----------

-Formulating hypotheses
to answer a scientific question. (Sc) -----------

-Designing and creating a measuring tool and
an observation protocol. (Sc) -----------

-Setting a plan for an experimental task. (Sc) -----------

-Demonstrating by reaching a conclusion using logical reasoning
and referring to mathematical rules
(properties, formulas and theorems). (M) -----------
Choose a strategy to find the solution

Monitoring and reflecting

-Moving from an intuitive approach, to a well elaborated argumentation (L) -----------

-Justifying a method or an interpretation. (SS) -----------

-Interpreting experimental results to derive conclusions and
communicate results with a justification. (Sc) -----------

-Reasoning by solving problems using acquired knowledge,
analyzing as well as reflecting on errors, and testing alternative solutions. (M) -----------
Analyze a situation in order to deduce the important elements

Anecdotal observations (Specific type of activities, nature of Q& A, feedback on performance, other…)

Appendix E Classroom observation log

Explore and understand the problem	Number of times observed	Total	L M H
Understand a text, diagram, formula, tabular information,	1. 2. 3. 4. 5. 6.	-----------	-----------
& draw inferences	1. 2. 3. 4. 5. 6.	-----------	-----------
Relate information from various sources	1. 2. 3. 4. 5. 6.	-----------	-----------
Demonstrate understanding of relevant concepts	1. 2. 3. 4. 5. 6.	-----------	-----------
Use information from students' background knowledge to understand the information given	1. 2. 3. 4. 5. 6.	-----------	-----------
Identify the variables in the problem & note the interrelationships	1. 2. 3. 4. 5. 6.	-----------	-----------
Construct hypotheses	1. 2. 3. 4. 5. 6.	-----------	-----------
Retrieve, organize	1. 2. 3. 4. 5. 6.	-----------	-----------
& critically evaluate contextual information	1. 2. 3. 4. 5. 6.	-----------	-----------
Represent and formulate			
Construct tabular, graphical, symbolic and verbal representations	1. 2. 3. 4. 5. 6.	-----------	-----------
Apply a given external representation to the solution of the problem	1. 2. 3. 4. 5. 6.	-----------	-----------
Shift between representational formats	1. 2. 3. 4. 5. 6.	-----------	-----------
Plan and execute			
Design a system	1. 2. 3. 4. 5. 6.	-----------	-----------
Analyze a system	1. 2. 3. 4. 5. 6.	-----------	-----------
Make decisions	1. 2. 3. 4. 5. 6.	-----------	-----------
Diagnose and propose a solution	1. 2. 3. 4. 5. 6.	-----------	-----------
Monitor and reflect			
Examine solutions & look for additional information or clarification	1. 2. 3. 4. 5. 6.	-----------	-----------
Evaluate solutions from different perspectives	1. 2. 3. 4. 5. 6.	-----------	-----------
Justify solutions	1. 2. 3. 4. 5. 6.	-----------	-----------

Appendix F Sample of observations and interviews schedule in a school with the Lebanese program

Tuesday, November 9, 2021		**Wednesday, November 10, 2021**		**Thursday, November 11, 2021**	
7:40 – 8:25 8D	Chemistry One to one 12:30	7:40 – 8:25 7A	Physics One to one 9:10	7:40 – 8:25 7A	Arabic One to one 9:10
8:25 – 9:10 7D	Mathematics One on one: 1:15	8:25 – 9:10 9B	English One to one 9:45	8:25 – 9:10 9A	Geography One to one 9:45
11:15 – 12:00 8B	English One to one 12:00	12:30 – 1:15 9A	Biology One to one 1:15	10:30 – 11:15 8A	Mathematics One to one 11:15

Appendix G Sample of observations and interviews schedule in a school with the French and Lebanese programs

	Mardi 14 décembre	Mercredi 15 décembre	Jeudi 16 décembre
7h30-8h30		SVT 5eme	
8h30-9h30	Maths 5eme	Histoire-géo 4eme	Français 4eme
Pause: 9h30-10h00	Entretien	Entretien	Entretien
10h00-11h00	Maths 3eme		
11h00-12h00		Physique 4eme	Français 3eme
Pause: 12h00-12h30	Entretien	Entretien	Entretien
12h30-13h30	Histoire-géo 5eme	Entretien	Arabe 3eme
13h30-14h30			Entretien

Appendix H Sample of observations and interviews schedule in a school with the American and Lebanese programs

Day	Period	Time	Room	Subject	Grade	Teacher
Tuesday	P1	7:50 - 8:50	405	Physics	Y8	Interview 10:45
	P2	8:50 - 9:45	403	English	G8	Interview 12:30
Wednesday	P1	7:50 - 8:50	302	Math	Y7	Interview 12:30
	P2	8:50 - 9:45	401	SST	G9	Interview 1:30
	P3	9:45 - 10:45	402	Science	G9	Friday at 9:00
Thursday	P1	7:50 - 8:50	402	English	G9	Interview 10:45
	P2	8:50 - 9:45	902	Math	G9	Interview 11:10
	P4	11:30 - 12:25	404	Science	G8	Friday at 11:00
	P5	1:20 - 2:15	304	French	G7	Friday at 9:45

Day	Period	Time	Room	Subject	Grade	Teacher
Tuesday	P1	7:50 - 8:50	405	Physics	Y8	Interview 10:45
	P2	8:50 - 9:45	403	English	G8	Interview 12:30
Wednesday	P1	7:50 - 8:50	302	Math	Y7	Interview 12:30
	P2	8:50 - 9:45	401	SST	G9	Interview 1:30
	P3	9:45 - 10:45	402	Science	G9	Friday at 9:00
Thursday	P1	7:50 - 8:50	402	English	G9	Interview 10:45
	P2	8:50 - 9:45	902	Math	G9	Interview 11:10
	P4	11:30 - 12:25	404	Science	G8	Friday at 11:00
	P5	1:20 - 2:15	304	French	G7	Friday at 9:45

Appendix I Interview protocol

Name of School: _______________ Grade Level: _____________

Subject: _________________________ Date: November 2021

Preface: *Setting the interviewee at rest: explain the purpose of the interview; confirm my commitment to research ethics (checking if all information in the participant information sheet is clear; stressing on the issue of confidentiality and anonymity); ask the interviewee for permission to audio-tape.*

Interview protocol questions

- ✓ Considering your lesson today, can you tell me please what *teaching practices and activities* have you used which help students develop problem solving skills?
- ✓ What is your *understanding* of problem-solving? Or how do you *define* problem solving?
- ✓ When planning for your lesson, what influence your choice of the teaching practices to address problem-solving? What *factors* can influence your choice of the teaching practices?
- ✓ In your opinion, to what extent do *program requirements* facilitate the teaching of problem solving?
- ✓ What *other sources* do you rely upon to integrate problem solving in your teaching?
- ✓ Is there anything else you would like to add that you think might be useful?

Appendix J All generated codes retrieved from NVivo

(V) Schools with the Lebanese program; (W) Schools with the French and Lebanese programs; (Z) A1 school with American and Lebanese programs; (Z1) schools A2 and A3 with American and Lebanese programs

Name		Files	References	Created on	Created by	Modified on
V Analysis, Justification & conclusion		21	35	4/17/2022 12:41 PM	DAL	7/10/2022 12:07 PM
V Debate		3	10	3/31/2022 3:01 PM	DAL	6/30/2022 8:13 AM
V Directed questioning & discussion		3	3	4/7/2022 9:05 AM	DAL	7/10/2022 12:12 PM
V Expressing opinion		12	19	4/8/2022 9:48 AM	DAL	5/4/2022 12:30 PM
V Making errors and correcting each other		6	8	4/8/2022 9:33 AM	DAL	4/24/2022 8:53 AM
V Open ended questions		1	2	4/8/2022 9:52 AM	DAL	7/10/2022 4:48 PM
V Specific questions		10	27	4/8/2022 10:57 AM	DAL	7/10/2022 4:47 PM
V Researching		6	12	3/31/2022 3:02 PM	DAL	7/9/2022 9:53 PM
V Groupwork		8	11	3/31/2022 3:03 PM	DAL	4/13/2022 12:52 PM
V Hypothesis formulation		4	4	4/6/2022 12:14 PM	DAL	4/24/2022 8:54 AM
V Practice & drilling		12	28	4/6/2022 8:30 AM	DAL	4/23/2022 9:28 AM
V Recalling prior knowledge		11	16	3/31/2022 3:55 PM	DAL	7/12/2022 3:15 PM
V Show steps		7	11	4/4/2022 8:50 AM	DAL	6/30/2022 8:15 AM
V Directed inquiry		10	16	4/21/2022 9:49 AM	DAL	7/9/2022 12:45 PM
V Heavy content oriented		14	33	5/4/2022 12:44 PM	DAL	5/4/2022 1:26 PM
V Tied to grade 9 exam		13	21	5/4/2022 12:45 PM	DAL	5/4/2022 1:21 PM
V Unsuitable activities		16	31	5/4/2022 12:48 PM	DAL	5/4/2022 1:26 PM
V Complex task		6	9	4/6/2022 8:35 AM	DAL	4/22/2022 6:19 PM
V Element of choice		3	4	4/4/2022 10:21 AM	DAL	4/21/2022 6:04 PM

V Interdisciplinary approach		5	7	4/4/2022 9:00 AM	DAL	4/22/2022 6:21 PM
V New situation		8	9	4/7/2022 8:13 AM	DAL	4/23/2022 9:27 AM
V Students' frustration and anxiety		5	10	4/8/2022 10:17 AM	DAL	4/22/2022 6:19 PM
V Refer to foreign programs		11	22	3/31/2022 5:11 PM	DAL	5/4/2022 1:20 PM
V Refer to Leb program Objectives		11	12	4/8/2022 7:31 AM	DAL	4/24/2022 8:48 AM
V Refer to school program		15	36	3/31/2022 3:43 PM	DAL	4/24/2022 8:19 AM
V Teachers' ownership		8	13	3/31/2022 3:45 PM	DAL	4/23/2022 8:59 AM
V Teachers' initiative		12	19	4/8/2022 11:26 AM	DAL	6/30/2022 8:00 AM
V Teacher facilitator		2	3	4/6/2022 10:47 AM	DAL	4/22/2022 4:16 PM
V Teacher's definition of PS		9	16	4/6/2022 9:03 AM	DAL	7/10/2022 12:09 PM
V Active learners		12	17	4/21/2022 9:49 AM	DAL	4/24/2022 9:15 AM
V Link PS to varied activities		13	21	4/21/2022 6:17 PM	DAL	4/24/2022 8:58 AM
V Link PS Lebanese situation Teen age issues		7	16	4/6/2022 10:49 AM	DAL	4/23/2022 3:58 PM
Link PS to discovery learning		6	11	4/21/2022 5:28 PM	DAL	4/24/2022 9:06 AM
V Link PS to literary genre		5	9	4/8/2022 11:14 AM	DAL	4/24/2022 8:15 AM
V Link PS to maths & sciences		7	12	4/8/2022 7:59 AM	DAL	4/23/2022 11:59 AM
V Link to real life		18	30	3/31/2022 3:20 PM	DAL	4/23/2022 11:59 AM
W Discussion, analysis & synthesis		16	25	7/1/2022 6:40 PM	DAL	7/8/2022 9:02 PM
W Group work & collaboration		10	14	7/1/2022 6:25 PM	DAL	7/12/2022 4:39 PM
W Interdisciplinary links		6	10	7/2/2022 8:53 AM	DAL	7/8/2022 7:55 PM
W Link to prior knowledge		10	20	7/1/2022 7:08 PM	DAL	7/12/2022 5:08 PM
W Link to real life		15	20	7/1/2022 5:58 PM	DAL	7/8/2022 9:31 PM
W Making connections		6	9	7/1/2022 6:14 PM	DAL	7/8/2022 9:15 PM

W Moderator role		15	20	7/1/2022 6:33 PM	DAL	7/10/2022 10:42 AM
W Reflecting on errors		13	21	7/1/2022 6:26 PM	DAL	7/12/2022 4:38 PM
W Variety of activities & tools		13	23	7/1/2022 6:28 PM	DAL	7/8/2022 9:27 PM
W Active autonomous learning		18	51	7/1/2022 7:18 PM	DAL	7/8/2022 9:06 PM
W Complex task		11	22	7/2/2022 8:31 AM	DAL	7/10/2022 10:42 AM
W Guidance		3	5	7/3/2022 4:15 PM	DAL	7/8/2022 8:14 PM
W Drilling and practice		3	3	7/2/2022 10:16 AM	DAL	7/3/2022 10:02 AM
W End of unit task		2	3	7/1/2022 6:51 PM	DAL	7/5/2022 12:46 PM
W Gr9 official exams constraints		10	15	7/1/2022 7:16 PM	DAL	7/8/2022 8:36 PM
W Group dynamics		8	9	7/2/2022 8:25 PM	DAL	7/8/2022 9:06 PM
W Guided enquiry & discovery		12	22	7/2/2022 8:25 AM	DAL	7/12/2022 5:15 PM
W Leb. vs Fr. Programs		9	15	7/8/2022 7:43 PM	DAL	7/8/2022 9:31 PM
W Manipulation		6	10	7/1/2022 7:07 PM	DAL	7/8/2022 9:13 PM
W New situations		11	16	7/1/2022 6:33 PM	DAL	7/12/2022 5:13 PM
W Problem based learning		8	16	7/2/2022 10:42 AM	DAL	7/8/2022 9:01 PM
W Professional development		11	12	7/1/2022 6:38 PM	DAL	7/8/2022 7:55 PM
W PS definition		5	7	7/2/2022 8:36 AM	DAL	7/11/2022 6:35 AM
W Safe environment		5	6	7/1/2022 6:23 PM	DAL	7/6/2022 9:17 PM
Z Analysis, justification & conclusion		4	10	7/9/2022 12:43 PM	DAL	7/10/2022 6:52 AM
Z Checking for understanding		3	3	7/9/2022 7:44 AM	DAL	7/9/2022 10:00 PM
Z Directed questioning & discussion		5	8	7/9/2022 12:58 PM	DAL	7/10/2022 7:11 AM
Z Groupwork		2	2	7/9/2022 7:56 AM	DAL	7/9/2022 9:50 PM
Z Interdisciplinary links		1	1	7/9/2022 1:12 PM	DAL	7/9/2022 1:12 PM

Z Link to real life		4	4	7/9/2022 1:21 PM	DAL	7/10/2022 10:25 AM
Z Modelling & Teacher centered		4	7	7/9/2022 7:50 AM	DAL	7/10/2022 7:14 AM
Z Recalling prior knowledge		2	2	7/10/2022 6:26 AM	DAL	7/12/2022 3:14 PM
Z Variety of activities and tools		5	8	7/9/2022 9:48 PM	DAL	7/10/2022 10:20 AM
Z Gr 9 official exams constraints		2	3	7/9/2022 10:14 PM	DAL	7/10/2022 6:34 AM
Z Group dynamics		4	5	7/9/2022 9:58 PM	DAL	7/10/2022 7:16 AM
Z Need for teacher's initiative		2	3	7/10/2022 6:37 AM	DAL	7/10/2022 7:16 AM
Z Practice & drilling		7	15	7/9/2022 7:41 AM	DAL	7/12/2022 4:44 PM
Z Professional development		1	2	7/10/2022 7:17 AM	DAL	7/10/2022 7:19 AM
Z PS definition		6	9	7/9/2022 7:54 AM	DAL	7/10/2022 7:13 AM
Z Reflecting on errors		1	1	7/12/2022 4:35 PM	DAL	7/12/2022 4:35 PM
Z Show steps		2	6	7/10/2022 7:05 AM	DAL	7/12/2022 4:43 PM
Z Structured enquiry		4	5	7/9/2022 7:49 AM	DAL	7/10/2022 7:08 PM
Z1 Active & autonomous learning		12	21	7/10/2022 10:26 AM	DAL	7/11/2022 7:26 AM
Z1 Authentic situations		6	9	7/10/2022 10:43 AM	DAL	7/11/2022 7:14 AM
Z1 Complex task		3	7	7/10/2022 5:29 PM	DAL	7/11/2022 6:48 AM
Z1 Discussion, analysis and synthesis		8	12	7/10/2022 10:18 AM	DAL	7/12/2022 3:36 PM
Z1 Groupwork & collaboration		9	10	7/10/2022 11:37 AM	DAL	7/12/2022 3:42 PM
Z1 Interdisciplinary links		5	6	7/10/2022 11:01 AM	DAL	7/11/2022 7:03 AM
Z1 Link to real life		10	16	7/10/2022 11:53 AM	DAL	7/11/2022 7:14 AM
Z1 Moderator role		8	13	7/10/2022 11:27 AM	DAL	7/11/2022 7:36 AM
Z1 Multiple perspectives, choice		9	15	7/10/2022 7:11 PM	DAL	7/12/2022 4:56 PM
Z1 Open ended questions		6	11	7/10/2022 7:06 PM	DAL	7/11/2022 7:26 AM

Z1 Process& procedure		10	16	7/10/2022 10:30 AM	DAL	7/12/2022 3:41 PM
Z1 Variety of activities & tools		9	12	7/10/2022 4:56 PM	DAL	7/12/2022 4:57 PM
Z1Making connections		3	5	7/10/2022 10:19 AM	DAL	7/10/2022 5:47 PM
Z1 End of unit tasks		1	2	7/10/2022 11:00 AM	DAL	7/10/2022 11:03 AM
Z1 Group dynamics		10	11	7/10/2022 5:04 PM	DAL	7/11/2022 7:17 AM
Z1 Guided Inquiry		9	14	7/10/2022 10:39 AM	DAL	7/12/2022 3:41 PM
Z1 Leb. vs American Prog.		11	22	7/9/2022 10:15 PM	DAL	7/12/2022 3:44 PM
Z1 Gr 9 official exams constraints		3	5	7/10/2022 10:52 AM	DAL	7/11/2022 6:33 AM
Z1 Teachers' initiative		5	8	7/10/2022 10:55 AM	DAL	7/11/2022 6:52 AM
Z1 Practice and drilling		1	3	7/10/2022 5:08 PM	DAL	7/12/2022 3:21 PM
Z1 PS definition		7	10	7/10/2022 5:54 PM	DAL	7/12/2022 3:38 PM
Z1 PS in school mission		4	7	7/10/2022 10:49 AM	DAL	7/10/2022 6:14 PM
Z1 Reflecting on errors		5	9	7/10/2022 6:03 PM	DAL	7/12/2022 4:55 PM
Z1 Reflection		4	6	7/10/2022 10:59 AM	DAL	7/12/2022 3:35 PM
Z1New situations		3	3	7/10/2022 10:31 AM	DAL	7/11/2022 7:05 AM
Z1 Recalling prior knowledge		2	2	7/10/2022 5:18 PM	DAL	7/12/2022 3:13 PM

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