AMERICAN UNIVERSITY OF BEIRUT

THE ROLE OF LANGUAGE IN UNDERSTANDING ABSTRACT CHEMICAL CONCEPTS IN MULTILINGUAL CLASSROOMS

by
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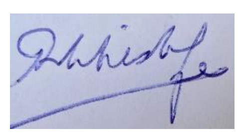

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ABSTRACT
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Based on the sociocultural perspective, an approach to overcome second language learners' challenges in learning science is to embed learning in authentic scientific practices utilizing students' everyday meaning-making and language, particularly home language. In this respect, this study investigated the language practices teachers use to support conceptual understanding in secondary chemistry classrooms. The study also explored how the use of home language (spoken Arabic) facilitated students' understanding in secondary chemistry classrooms. The study adopted a qualitative case study research design. Two naturalistic instrumental case studies were conducted in two Lebanese secondary chemistry classrooms within different contexts. The study sample consisted of two grade 11 scientific section chemistry classrooms adopting the Lebanese curriculum. Data sources for this study were classroom observations and videotapes of the selected Grade 11 chemistry classrooms in addition to informal conversations with the teachers about the language of instruction concerning science and learning. Language practices and participants' meaning making were analyzed by using a multi-level dialogic framework (Mortimer & Scott, 2003; Salloum & BouJaoude, 2019a). Classroom discourse was analyzed based on communicative approaches (authoritative/ dialogic), patterns of discourse, and emerging science knowledge types and cognitive processes in addition to the languages deployed. The findings indicate that teachers used home language for various purposes within the classroom (e.g. affective, linking concepts). Higher levels of knowledge types and cognitive processes often involved the use of the home language. Based on the study findings, the use of the home language promoted more meaningful learning of the science concepts. Recommendations for future research and practice were to employ the home language as a resource within the classroom for meaningful conceptual learning of abstract concepts.

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CHAPTER I

INTRODUCTION

Background and Rationale of the Problem

The importance of language to science learning and the development of scientific knowledge has long been recognized (Rollnick, 2000). Communication of scientific knowledge including presentation of new information and discussion of ideas is facilitated through the specialized language of science which has its distinctive genres, thematic formations, and practical skills (Lemke, 1990). The language of science includes unfamiliar technical words in addition to everyday words that have specialized scientific meanings (Lemke, 1990; Mammino, 2010; Probyn, 2015). This prompted Lemke to argue that learning science is similar to learning a foreign language (Lemke, 1990). Students must integrate the meanings of the words across different contexts with their prior knowledge and experiences. Hence, a poor understanding of the language of science would hinder students' acquisition of scientific knowledge.

For meaningful learning and meaning-making, the teacher engages students in a social process to negotiate understanding of scientific concepts (Mammino, 2010; Mortimer & Scott, 2003). It follows that second language learners (L2) face additional challenges while learning science as they learn science while developing their proficiency in the language of instruction (Mammino, 2010; Rollnick, 2000; Taber, 2015). L2 learners' limited exposure to the language of instruction puts them at a disadvantage in acquiring scientific knowledge. Not only must L2 learners acquire the scientific terms but also, they must reconcile the different meanings across two additional contexts; that of the language of instruction and that of their home language. Consequently, additional tensions between everyday and scientific views are present when the scientific knowledge is administered in a second language (Mammino, 2010; Rollnick, 2000).

Nonetheless, Gabel (1998) argued that the nature of chemistry is complex and includes many abstract concepts. Moreover, chemistry is represented and taught using threefold representations: macroscopic, microscopic, and symbolic (Jaber & BouJaoude, 2012) and thus conceptual understanding of chemistry concepts requires that students understand this threefold representation. Childs, Markic, and Ryan (2015) add that chemistry as a subject includes the "series of facts which are the objects of the science, the ideas which represent these facts, and the words by which these ideas are expressed" (p. 441). Childs et al. (2015), Markic and Childs (2016), and Mammino (2010) propose that teachers often are unaware of the importance of non-technical words, logical connectives, and command words for understanding chemistry. The complex nature of chemistry, the different levels of representation of chemical concepts, and the nature of chemical texts require that students have a high-level proficiency of the language of instruction in addition to that of chemistry to comprehend new concepts. These difficulties are more prominent for second language learners who study chemistry in a foreign language because these students whose relatively low linguistic competence hinders their understanding of chemistry (Childs et al. 2015, Lee, 2001).

Based on the increased attention to sociocultural perspectives on teaching and learning, classroom talk has been a focus of investigation for meaning development in science classrooms (Alexander, 2008; Lemke, 1990; Mortimer, 1998; Mortimer & Scott, 2003; Rollnick, 1998, 2000; Scott, 1998; Scott & Ametller, 2007; Scott, Mortimer, & Aguiar, 2006). The sociocultural theory considers language inseparable from thought. Hence, it regards learning as an ongoing internalization process where concepts are initially rehearsed between people in the social context and then internalized (Vygotsky, 1987). Thus, students would engage their prior knowledge, experiences, and understandings in the learning process. The sociocultural theory also suggests that classroom discourse and teacher talk shape the social life of the classrooms (Bakhtin, 1981, 1986; Vygotsky, 1987). Accordingly, the teacher's role as the mediator of the social and academic language in the science classrooms is emphasized (Mortimer & Scott, 2003).

Through classroom discussions, the teacher helps the students develop scientific understandings in addition to their proficiency in the language of science. Consequently, for meaningful meaning-making, there must be a dialogic exploration of everyday and scientific concepts for understanding of concepts (Aguiar & Mortimer, 2013; Driver, Asoko, Leach, Mortimer, & Scott, 1994; Scott et al., 2006). This exploration, however, must be guided through authoritative guidance by the teacher (Aguiar & Mortimer, 2013; Scott et al., 2006). Through authoritative discourse, teachers emphasize and convey information while with dialogic discourse teachers allow students' exploration of ideas (Aguiar & Mortimer, 2013; Mortimer, 1998; Mortimer & Scott, 2003; Scott, 1998; Scott et al., 2006).

In line with this, an approach informed by sociocultural perspectives argues that everyday meaning-making and discourse would allow students to engage in scientific discourse (Amin, 2009; Warren, Ballenger, Ogonowsky, Rosebery, & Hudicourt-Barnes, 2001; Warren, Rosebery, & Conant, 1994). Warren et al. (2001) suggested that everyday meaning-making resources, particularly their home language, are complementary to scientific meaning-making (Warren et al., 2001). Therefore, there is a need for a dialogue that acknowledges everyday meaning-making resources, and scientific views.

The science education literature highlights the discrepancies between everyday and scientific discourse; specifically, where difficulties in understanding both technical and nontechnical terms were documented even when learning was taking place using the students' home language (Markic and Childs, 2016; Rollnick, 2000; Taber, 2015). Moreover, research results suggest that student's ability to use language to explore existing concepts is pivotal to learning abstract scientific concepts (Curtis & Miller, 1988; Mammino, 2010). Research also demonstrates that adjustments for linguistically weaker students are required for meaningful scientific understandings (Lemke, 1990; Rollnick, 2000). Thus, research results indicate the need for a high level of language proficiency to acquire and develop scientific knowledge (Mammino, 2010).

Furthermore, research findings suggest that L2 learners may bring to the classroom conceptions that are not conducive to science learning (Rollnick, 1998; 2000). In addition, research results show that the teacher and students struggle to express scientific ideas in a foreign language (Amin, 2009; Mammino, 2010; Salloum & BouJaoude, 2019a) and that the home language offers teachers and students a medium to communicate their thoughts more confidently and clearly (Amin, 2009; Mammino, 2010). Accordingly, the home language is found to be effective for teaching and learning science (Mammino, 2010).

But, how is this applied in science classrooms? In multilingual contexts, few case studies were conducted to investigate the language practices within the classrooms. Research into language practices in multilingual settings indicated varying practices among teachers within classrooms. Results showed that some teachers resorted to code-switching that is short switches to the home language for different purposes (Rollnick & Rutherford 1996; Probyn, 2006; 2009; 2015; Salloum & BouJaoude, 2019a; 2019b). For example, code-switching was used to elaborate concepts, give examples from learners' experiences, and for classroom management purposes (Rollnick & Rutherford, 1996; Probyn, 2006; Salloum & BouJaoude, 2019a). Also, one study conducted in Lebanon showed that above half of the observed teachers used their home language more than 50% of the time (Ayoubi & BouJaoude, 2006).

Research findings demonstrate controversy among teachers' views of the use of home language within classrooms (Probyn, 2001; 2009; 2015). Even though some teachers were aware of the stress L2 learners face as they are learning through a second language, they were adamant about the use of the international language as it is the language for testing (Probyn, 2009). On the other hand, some teachers regard using the home language as a means to reduce the stress of learning through a second language (Probyn, 2009). Therefore, in multilingual classrooms, it is essential to further investigate the nature of the classroom talk that is taking place to support understandings.

In multilingual contexts, the debate on the medium of instruction is controversial (Amin, 2009; Rollnick & Rutherford, 1996) partly due to discussions on the quality of education. The international language, especially English, offers access to global scientific knowledge and technological innovations, however, the home language is regarded as essential to preserving the cultural and regional identity (Amin, 2009; Salloum & BouJaoude, 2019a). Hence, even though research findings indicate a preference for the use of home language, several language-in-education policies in multilingual settings have an international language as the language of instruction. The exposure to foreign languages, such as English and French, due to the colonial history of several countries of the Middle East and North Africa (MENA) region influenced the language-in-education policies (Amin, 2009; Salloum & BouJaoude, 2019a).

In the Arab region, the diglossic nature of Arabic adds tensions to the science classrooms as the meaning-making resources of the students reside in the colloquial dialect (spoken Arabic) while the Modern Standard Arabic (MSA) is used to develop literacy (Amin, 2009). Consequently, science education is carried out in a complex multilingual context where several languages interact together (Amin, 2009). In Lebanon, the language-in-education policies reflect the complexity of the Arab region as students are exposed to several languages from a young age. In the school setting, Arabic and English/French are introduced in the first grade and a third language is introduced in the seventh grade (Shaaban & Ghaith, 1999). Additionally, science and mathematics are taught in a foreign language (English or French). As a result, Lebanese science classrooms are multilingual where at least four languages exist: the home language (spoken Arabic), the international language as the language of instruction (English or French), the language of science, and Modern Standard Arabic (MSA) to a certain extent (Salloum & BouJaoude, 2019a).

In summary, different studies have identified classroom talk as one of the essential mediums for meaning-making in science classrooms. Language is an essential medium of communication in the processes of teaching and learning. Research on interactions between students and teachers has been historically significant and dominant patterns were identified (Lemke, 1990). Furthermore, abstract concepts are negotiated through language and thus are the first means of communication to understanding the concepts. Yet, with poor language proficiency students would have an additional concern to master the language of instruction in addition to that of science. While numerous studies have explored the language obstacles faced by students, language practices for second language teachers in science classrooms have been poorly characterized. Furthermore, most research into science classroom talk and interactions was conducted outside the Arab region and was mostly conducted within monolingual settings or with language minorities (Salloum & BouJaoude, 2019a).

Statement of the Problem

Amin (2009) indicated a need for socioculturally framed studies that investigate the characteristics of everyday and school discourse in the Arab region. Moreover, according to Dagher and BouJaoude (2011), there is a need to investigate factors that support or hinder science learning in a foreign language. More specifically, Ayoubi and BouJaoude (2006) pointed out the lack of studies that explored the benefits and burdens of using a foreign language in teaching science in Lebanese classrooms. Furthermore, previous research has demonstrated that the home language, Lebanese colloquial Arabic, is used more than 50% of the time in Lebanese chemistry classrooms where the language of science instruction is English or French (Ayoubi & BouJaoude, 2006). Previous research also showed that inadequate language proficiency was a serious barrier to effective chemistry teaching (Ayoubi & BouJaoude, 2006). However, there is a lack of in-depth studies that investigate how spoken Arabic is used in the chemistry classroom or how it impacts learning.

Among the studies conducted in multilingual settings, to the author's knowledge, only two studies conducted by Salloum and BouJaoude (2019a, 2019b) investigated Lebanese science classrooms' language practices. In the study published in 2019, Salloum and BouJaoude investigated science classroom talk as an intersection between the global influence of high-stakes tests and local teacher talk. Salloum and BouJaoude found that the use of spoken Arabic allowed the teacher to build a partnership with the students towards performing well on their high-stake exams. The second study focused on the language practices of four chemistry teachers and on how and why the native language (spoken Arabic) is used in the classroom. However, the studies were conducted at the intermediate school level while no studies were conducted at the secondary school level in Lebanon where abstract level concepts are taught.

Purpose and Research Questions

In an attempt to address the previously mentioned issues, the purpose of this study was to investigate the language practices teachers use to support conceptual understanding in secondary chemistry classrooms. The study also explored how the use of home language (spoken Arabic) facilitated students' understanding in secondary chemistry classrooms. Consequently, the research questions guiding the study were:

1. How do the existing language practices that teachers use support the conceptual learning of abstract chemistry concepts?
2. How is the home language used across different knowledge types and cognitive processes?

Significance of the Research Study

This study added to the knowledge on language practices in secondary science multilingual classrooms and how they were used to foster students' conceptual understandings. This is significant since limited research has been conducted to investigate classroom practices in the Arab region. In multilingual contexts, science is often taught in an international language; accordingly, the findings of this research study shed light on whether the language of instruction hinders or supports understandings of abstract scientific concepts. It also showed how the different languages interact with one another and whether they're used to help students with the development of understanding. Moreover, it shed light on the strategies teachers use to mediate students' understandings of science concepts. Accordingly, the effective strategies observed were recommended for practitioners to support students to acquire scientific concepts. Furthermore, this study added to existing knowledge on the role of the home language in understanding abstract scientific concepts. More specifically, this research offered an enhanced understanding of the role of spoken Arabic in Lebanese classrooms. This was significant since limited research has been done in the Arab region that investigated how meaning-making resources of spoken Arabic supported students with acquiring abstract scientific concepts. Furthermore, results from this study helped provide recommendations to practitioners on how to utilize everyday home language within classrooms to support abstract scientific concepts understandings. It also helped to inform policy on the role of the home language in learning and developing conceptual understanding.

CHAPTER 2

LITERATURE REVIEW

The literature review presented in this chapter discusses the relationship between language and science, presents the complexity of chemistry as a subject in addition to language's role in chemistry learning. Furthermore, it presents the sociocultural perspective as the theoretical framework for language and learning, provides the rationale for using a multi-level framework to analyze classroom discourse, and presents difficulties second language learners face in learning science. The literature review summarizes relevant empirical studies that explored language practices in multilingual science classrooms. The findings of these studies have been used to develop a clear understanding of using home language as a resource in multilingual classrooms.

Language and Science

The role of language in learning science has long been highlighted in the literature (Rollnick, 2000) since language is an essential component of science and scientific literacy. Individuals require developed scientific understandings to make informed decisions and take informed actions (Yore et al., 2004). Language is used to construct science understandings, in addition, it is a "means to communicate about inquiries, procedures, and science understandings to other people" (Yore et al., 2004, p.348). Moreover, new developments in science involve the communication of the entities and/or phenomena to share the new knowledge (Mammino, 2010).

Lemke (1990) argued that science learning involves learning to talk science. According to Lemke (1990), talking science is not just talking about science but rather is "doing science through the medium of language" (p. ix). Technical scientific terms are used while embedded within common words to generate meanings and engage in scientific discourse (Mammino, 2010). In that vein, Lemke drew a similarity between learning science and learning a foreign language, which has its distinctive genres, thematic formations, and practical skills (Lemke, 1990). According to Lemke (1998), integration and overlap of all the facets of the language, representing the concept is essential for a clear and comprehensive understanding of the scientific concepts (Lemke, 1998). In science classrooms, teachers introduce students to scientific concepts using the language of science. However, communication of scientific knowledge entails that both communicating parties have learned to use language in the same ways. To add to that, teachers utilize familiar words which have unfamiliar meanings under new strange contexts. Therefore, teachers must introduce the language of science to their students for understanding the meanings (Osborne, 2002).

Language and Chemistry

Mammino (2010) noted that language-related issues are particularly notable in chemistry and chemistry education as students often encounter difficulties understanding written and oral communications of the concepts. Several researchers (e.g. Gabel, 1999; Johnstone, 2000; Mammino, 2010; Taber, 2015) suggested that not only the nature of chemistry causes difficulties but also how the chemistry concepts are communicated. The following section illustrates the complex nature of chemistry in addition to the role of language concerning teaching and learning chemistry.

The Complex Nature of Chemistry

Chemistry is regarded as a difficult subject for learners due to its complex and abstract nature. According to Taber (2015), it includes many abstract concepts of conceptualized phenomena, which cannot be simply shown to students such as reaction, oxidation, and reduction. Furthermore, the threefold manner of representing chemistry makes it difficult to learn (Gabel, 1999; Johnstone, 2000). The macroscopic, microscopic, and symbolic levels are needed for the conceptual understanding of chemical concepts. The relationships between the macroscopic and microscopic levels are expressed through the symbolic level (Gabel, 1999). To add to that, within the same conversation, the symbolic representation could be used to refer to both the macroscopic and microscopic representations (Taber, 2015). Furthermore, instruction often takes place at the most abstract level, using symbolic representations (Gabel, 1999; Taber, 2015). Experienced chemists could manipulate all three levels; however, novices would find difficulties in differentiating and simultaneously relating the representations.

However, from the students' perspectives, there is no clear connection between the macroscopic, microscopic, and symbolic levels (Gabel, 1999). Yet, the different modes of representations are required to link what students already know to what is being learned to help them make sense of the information. Thus, students are involved in abstract thinking which requires sophisticated use of language to be able to comprehend and utilize complex sentences to make logical connections (Mammino, 2010). Another challenge students might face is understanding the technical terms used in chemistry that constitute the language of chemistry. Moreover, the language of chemistry often includes terms that originate from everyday life leading students to encounter problems as they try to reconcile the different meanings, a situation which could lead to misconceptions. All this puts a great deal of pressure on the learner who has to negotiate understandings, make sense of the different levels at play, and integrate these understandings to comprehend new concepts while using a foreign language.

Hence, teachers use varied modes of communication to relate the abstract concepts to students' previous experiences (Taber, 2015). Different teaching strategies were suggested to enhance students' understanding of chemistry, such as the use of analogies, metaphors, models, concept maps, and technology (Taber, 2015). Several activities take place in the classroom to facilitate students' understandings that often involve the use of language such as reading, writing, listening, and speaking (Markic & Childs, 2016). Therefore, language plays a fundamental role in chemistry teaching and learning.

Role of Language in Chemistry

Taber (2015) stated that sophisticated means of communication including language are required to teach chemistry concepts that cannot be directly experienced by learners. Similarly, Pyburn, Pazicni, Benassi, and Tappin (2013) asserted that students' language skills are linked to their success in learning chemistry. The students' ability to understand and explain basic chemical concepts in clear language is critical for their understanding of chemistry (Markic & Childs, 2016). Therefore, students require a high level of language proficiency in both the language of chemistry and the language of instruction.

Furthermore, Markic and Childs (2016) noted that even in monolingual contexts where the spoken language and the language of instruction are the same, students still face difficulties in understanding some words. Students would engage their previous knowledge, experiences, and understandings in the learning process. Yet, the lack of comprehension of a few words in a chemistry text may lead to a misunderstanding of concepts. Taber (2015) suggested that the non-technical language of chemistry could be a challenge for many learners; and in particular, second language learners who have limited exposure to the language of instruction.

Second language learners will not only have to learn the language of chemistry but also that of instruction for meaningful conceptual understanding of the chemistry concepts. Through science classroom discussions, students become more proficient in the scientific language. However, accommodations are required for students who are weaker linguistically (Lemke, 1990). This would affect the classroom discourse as both the teacher and the learner will need a high proficiency level in the second language for meaningful discussions and consequently for meaning-making to take place in the classroom. The centrality of language to learning and teaching chemistry is evident. It is thus essential to explore how language and other modes of communication promote the development of meanings in the chemistry classroom (Scott et al., 2006).

Sociocultural Perspective

The link between talking, meaning-making and learning is best framed within the sociocultural theory. The sociocultural theory highlights the role of the social context and semiotic mechanisms such as language as mediators of thoughts and meanings development. This section establishes the theoretical framework for language and learning shaping this study.

Language and Thought Intertwined

The Vygotskian perspectives on teaching and learning influenced the development of the sociocultural theory. According to Vygotsky, activities shared in social contexts play an essential role in cognitive development. He asserted that the individual's cognition is developed on two levels: first in the "interpsychological" plane (the social plane) then in the "intra-psychological" one (Vygotsky, 1987). Individuals develop meanings using language and other semiotic mechanisms presented on the social plane. These semiotic mechanisms acquired in the social context provide individuals with the tools needed for individual thinking. Language mediates relations between people on the interpsychological plane and then is used to internalize the learning within the intra-psychological one. Accordingly, learning and development is a transformation of social processes to individual internalized processes mediated by language.

The importance of the social context was also emphasized in Bakhtin's perspectives regarding his view of language, existence, and thinking as a dialogue (Bakhtin, 1981). Bakhtin (1986) considered an utterance as the real unit of communication that is always expressed from a point of view and responding to another. Utterances, thus, are part of a chain of communication where each utterance replies to previous utterances and predicts others (Bakhtin, 1986; Wertsch, 1991). To understand an utterance, one must orient oneself to it, in addition, to properly placing it in the specific context (Voloshinov, 1973; Wertsch, 1991). Any word is considered to be dialogic or multivocal with its meaning determined largely through the prevailing context (Wertsch, 1991).

Furthermore, Bakhtin (1981) distinguished authoritarian discourse from internally persuasive discourse. He deemed the authoritarian discourse as one that demands acknowledgment and owning it, independent of any power to persuade us internally; it is encountered with its authority already fused to it. On the other hand, internally persuasive discourse is personal; it is also interactive with other internally persuasive dialogues within oneself and with others (Bakhtin, 1981). In addition, the internally persuasive discourse is creative as it produces new and independent words organizing the masses of words from within (Bakhtin, 1981). Bakhtin (1981) also suggested that internally persuasive discourse facilitates generations of new meanings and ideas.

Moreover, Bakhtin (1986) asserted that an utterance is always produced through a specific social language which shapes what is being said. Bakhtin suggested two forms of stratification of language: the social language and speech genre. A social language, according to Holquist (1981), is a discourse distinct to a specific group of society in a given social system at a specific time. On the other hand, the speech genre is a type of an utterance that corresponds to relates “to typical situations of speech communication, typical themes, and, consequently, also to particular contacts between the meanings of words and the actual concrete reality under certain typical circumstances” (Bakhtin, 1986, p.87).

Meaning Making in Classrooms

From a sociocultural perspective, learning is an ongoing internalization process in which activities exhibited in the social plane are reflected within the individual. Meaning-making, therefore, is a dialogic process that necessitates bringing together and working on ideas and is not merely a transfer of information (Mortimer & Scott, 2003). Hence, language and meaning-making are socially negotiated and dialogically based through the active interaction of utterances (Bakhtin, 1986; Mortimer & Scott, 2003). Consequently, the process of learning and development represents a continuous process of assessing and evaluating one’s understandings with ideas presented on the social plane (Mortimer & Scott, 2003). Individuals encounter new ideas and negotiate them with old ideas to associate them with new meanings through a communicative process rather than merely replacing old ideas with new ones (Scott & Mortimer, 2005). Language is thus central to acquire the school academic “social language” and to participate in the corresponding “speech genres” (Aguiar, Mortimer, & Scott, 2010).

To that end, teachers would use at least two different languages in the classrooms, the everyday and school science social languages, and would alternate between the speech genres from descriptions, explanations, and patterns of interaction to support students’ understandings (Buty & Mortimer, 2008). In science classrooms, teachers belong to a community that speaks the scientific language while students often belong to a community that does not. Teachers would then use the language for meaning-making while students use their language to construct a view of the subject (Lemke, 1990). The teacher and students engage in a social process where teaching and learning are taking place.

Opportunities should be provided for students to use the acquired scientific language and receive feedback on the extent to which they have appropriate competency in it (Tobin, 1998). Students develop their understandings in the classrooms where they make sense of the teacher's statements and relate them to their existing knowledge and experiences. Exploration of both the everyday and the scientific views is thus required to resolve the tensions students may face while encountering new ideas. Hence, the teacher plays a central role as a mediator of social and academic language in the classroom discourse (Mortimer & Scott, 2003).

Classroom Discourse

The sociocultural perspectives resituated the research into classroom discourse and how meanings are developed in the social context of the science classroom (Duit & Treagust, 1998). Over the years, researchers attempted to study science discourse in the classrooms and adopted different approaches to analyze discourse (Aguiar et al., 2010; Buty & Mortimer, 2008, Lemke, 1990; Littleton & Mercer, 2010, Mortimer, 1998; Mortimer & Scott, 2000; 2003; Scott, 1998; Scott & Ametller, 2007; Scott et al., 2006).

Discourse Patterns

Analysis of discourse patterns and teacher interactions has been used to characterize classroom discourse over the years. Lemke (1990), for example, identified a major pattern in science classrooms, particularly during whole-class interactions. He labeled the pattern as triadic dialogue or IRE where three elements are involved: an initiation (I) by the teacher, a response (R); by the student, and evaluation (E); by the teacher. Yet, in some studies, the response elicited feedback or follow-up rather than an evaluation (Salloum & BouJaoude, 2019b; Scott et al., 2006). When feedback was provided, a chain of interactions was observed and, in some situations, responses were followed by elaboration, a summary, or an explanation (Salloum & BouJaoude, 2019b). The IRE or IRF pattern of discourse allows the teacher to maintain control over topic development and student participation (Salloum & BouJaoude, 2019b). However, the triadic dialogue was criticized as it includes clashes between authoritativeness and dialogicity in addition to it confining students' independence (Buty & Mortimer, 2008; Lemke, 1990; Salloum & BouJaoude, 2019b).

Authoritative/Dialogic Functions

Given the role of the teacher in bridging the gap between everyday and scientific meanings, the teacher holds a position of authority in the classroom (Scott, 1998). Mortimer (1998) further argued that dialogic functions of text, that is its use to generate meanings, could offer categories to analyze the process of understanding taking place. This line of argument influenced analysis of the authoritative and dialogic functions of the classroom discourse. The teacher's authoritative discourse is evident when the teacher intends to convey or emphasize information. The dialogic discourse, on the other hand, is evident when the teacher encourages students to display, explore, and debate their ideas (Scott, 1998). Teacher's authoritative statements express the scientific perspective, however, for meaningful learning to materialize, a dialogic exploration of the everyday concepts is needed for resolution of the different views (Scott et al., 2006).

The significance of dialogicality for meaningful understandings in the classroom called for students' interactions in the classrooms. Accordingly, a move towards dialogic teaching was put forward. Alexander (2008) argued for dialogic teaching to engage learners in addition to stimulating and extending their thinking which would advance their learning and understanding. Dialogic teaching, according to Alexander, is purposeful, collective, reciprocal, supportive, and cumulative (Alexander, 2008). That is, teachers purposefully plan and guide classroom talk for specific educational goals while addressing learning tasks together. Furthermore, teachers and students would listen and share ideas and alternative viewpoints freely; these ideas are used to build meaningful lines of thinking. Dialogic teaching would help relate everyday and scientific perspectives on topics discussed in the science classrooms (Aguiar & Mortimer, 2013).

Scott, Mortimer, and Aguiar (2006) suggested that shifts between authoritative and dialogic discourse are an inevitable part of teaching where the purpose of teaching is the meaningful learning of scientific knowledge. The findings of Scott et al. indicate that an authoritative discourse is needed for the introduction of new ideas followed by a dialogic discourse to apply and explore the ideas. This is in accordance with previous findings of Scott (1998) and Mortimer (1998) where alternation in the function of discourse is suggested to be important to develop conceptual thinking on the intra-psychological plane. That is to achieve a balance between ideas' presentations and opportunities to explore ideas.

Multi-level Framework to Analyze Classroom Discourse

Mortimer and Scott (2003) emphasized the teacher's role in making the "scientific story" available in the science classroom in addition to supporting students in making sense of the "story". Mortimer and Scott identified five linked aspects that focus on the role of the teacher as the mediator of social and academic language, which they grouped in terms of focus, approach, and action. The identified linked aspects are teaching purposes, content, communicative approach, patterns of discourse, and teacher's interventions. Based on the sociocultural theory and empirical analyses of classroom talk, they proposed a multi-level framework to analyze “speech genre” in science classrooms (Mortimer & Scott, 2003). The framework was used to look into how teachers support students in constructing meanings in science classrooms utilizing different patterns of interactions and forms of discourse (Aguiar & Mortimer, 2013; Aguiar et al., 2010; Buty & Mortimer, 2008; Hennessy, Deaney, Ruthven, 2006; Mortimer & Scott, 2003; Salloum & BouJaoude, 2019a, 2019b; Scott & Ametller, 2007; Scott et al., 2006).

The findings of the studies reiterate the vital importance of the teacher as a mediator of the social plane. The discrepancies between everyday and scientific views were highlighted when students’ points of view are taken into consideration in the classroom discourse. The studies were mostly conducted in monolingual settings. Seemingly, only two studies by Salloum and BouJaoude (2019a, 2019b) have analyzed Lebanese classroom discourse in multilingual settings using this framework. Multilingual classrooms are qualitatively different from monolingual classrooms as the language of instruction may be different from the teacher’s and students’ home language. Given meaning-making as a dialogic process mediated through language, students and teachers must be proficient in the language of instruction for meaningful understanding to take place. In addition, an ability to reason and interact in the language of instruction is needed to overcome the gap between scientific and everyday knowledge. Therefore, it is essential to investigate the scientific classroom discourse second language learners engage in with their teachers in multilingual settings.

Second Language Learners

Second language learners (L2) in Lebanon and other countries are exposed to international languages, such as English, as the medium of instruction. However, this exposure does not reflect their understandings of the culture. Rollnick (1998) proposed that it is pivotal to initiate L2 learners into the "culture of science" before meaningful learning could take place. L2 learners could bring ways of thinking which are not supportive of the study of science into the classrooms. The words and their meanings have their roots in cultural backgrounds.

Rollnick (2000) remarked that learning science through a second language would initiate the learner to two social planes at once. One is where the student is learning the scientific language while the other is that of learning the second language. According to Rollnick (1998), second language learners fall into two broad categories: the first category includes "those who come to an English-speaking country having received part or all of their schooling in another language", while the second category includes "those who are citizens of a multilingual country where the language of official communication and the economy is English and who are officially taught at school through the medium of English" (Rollnick, 1998, p.123).

Rollnick (2000) pointed out difficulties that learners studying science in a second language might encounter. The negotiation of the science concepts occurs in a second international language that may belong to a different language group than that of their home spoken language with different grammars, phonologies, alphabets, and vocabulary (Salloum & BouJaoude, 2019a). Research into language practices in multilingual settings showed that code-switching is commonly used by both teachers and learners for a range of goals. Code-switching generally refers to short switches from the language of instruction to another language, usually home language, and then back again (Probyn, 2015). Research has shown that code-switching was used for various reasons. For example, switches to home language are used to translate an English word, to rephrase an explanation/concept, to elaborate a concept, and to give examples from learners' own experiences. These views on second language learners directed research towards studying the use of international language and/or the home language in the science classroom (Probyn, 2001, 2006, 2009, 2015; Rollnick & Rutherford, 1996; Rollnick, 1998, 2000; Salloum & BouJaoude, 2019a, 2019b).

Home Language as a Resource

Based on the sociocultural perspective, an approach to overcome L2 learners' challenges in learning science is to embed learning in authentic scientific practices utilizing students' everyday meaning-making and language, particularly home language (Warren et al., 1994). Therefore, it might be necessary to provide students with opportunities to use their home language in the meaning-making processes. This section hence presents empirical studies that were conducted to explore language practices in multilingual settings where home language helped students develop their science understandings better (Probyn, 2006; Rollnick & Rutherford, 1996; Salloum & BouJaoude, 2019a, 2019b).

Rollnick and Rutherford (1996) conducted a study in which they analyzed Swazi college students' use of home language (SiSwati) and English in a physics science classroom on air and air pressure. The study focused on the ways the home and international languages were used in the classroom. In addition, the study investigated whether the language of choice affected the remediation of alternative conceptions in addition to the acquisition of scientific conceptions. Rollnick and Rutherford audiotaped one or two groups at random on different days. The audiotapes were then transcribed. The transcripts were divided into coherent segments and then themes were identified accordingly. Their findings indicated several instances where students code-switched to SiSwati. The switches occurred with whole sentences, phrases and numbers, nouns, adjectives, and where the grammatical transitions were smooth. They identified various reasons for the different language uses within discussions. Switch to English was made, for example, when quotes were made from the materials or for the use of a word describing a scientific concept. Moreover, switches to SiSwati were used for the repetition of explanation of ideas explained in English, in preparation to record something in writing and to clarify concepts or eliminate alternative conceptions. In light of their findings, Rollnick and Rutherford asserted that the use of vernacular language is a powerful medium for exploring existing ideas.

Probyn (2006) explored the classroom language perceptions, practices, and problems of six grade 8 teachers who teach science through the medium of English as an additional language. The teachers were from four different schools of various sizes and very limited resources. Teachers' videotapes for three science lessons and audio-recorded interviews were transcribed for analysis. The transcripts were analyzed for the teacher and learners' relative use of Xhosa (home language) and English along with the reasons for code-switching. Additionally, teachers' questions and responses were examined for the cognitive challenge of the lesson content. Probyn also looked into the provided support by teachers for second language learning. Probyn found that teachers differed greatly in the amount of whole-class talk. Also, all teachers except for one presented their lessons in English and code-switched to Xhosa occasionally. Although this teacher emphasized learners' need for understanding the content, she felt it is the English teacher's responsibility to help the learners bridge the gap between the oral Xhosa presentation and the need to read and write be assessed in English. Two teachers in the interviews indicated that they normally would have included more Xhosa in their lessons, but they changed their way of teaching for the videoed ones. Furthermore, Probyn identified different support strategies used by the teachers to support students' understanding which included codeswitching, diagrams, illustrations, and relating new concepts to the learners' previous experiences and contexts. In summary, Probyn's findings confirm that when the language of teaching and learning is different from the home language it creates a barrier to learning. Additionally, teachers often resort to codeswitching to learners' home language to resolve tensions between science content and English.

Salloum and BouJaoude (2019b) investigated science classroom talk as an intersection between "local teacher talk and the global influence of high-stakes tests" (Salloum & BouJaoude, 2019b, p.3). The study was conducted with middle school students in classes of one teacher who taught physics and chemistry in a public school. The teacher was selected because her teaching practices focused on achieving equilibrium between teaching for conceptual understandings and teaching for the test. Observation of the teacher was over five months for a total of 60 periods. Twenty of the videoed sessions were transcribed and analyzed. The analysis of the classroom talk was conducted at three levels, session type, episodes within sessions, and meaningful teacher utterances within episodes. The teachers' utterances were coded and then analyzed according to knowledge-type categories adapted from BouJaoude and Jurdak (2010) in addition to added emergent categories. Findings indicate that conceptual development episodes largely included utterances that fall under factual and conceptual understandings. Shifts in these types of episodes were predominantly implicit and dialectical. However, in practice and test preparation sessions, knowledge types of utterances differed based on the nature of the material. Utterances were highly procedural-algorithmic in mathematical or algorithmic material. However, utterances were mostly factual and procedural when qualitative concepts were taught. Shifts between types were explicit in this type of episode. Furthermore, the teacher used initiation questions in triadic dialogue as well as chains of triadic dialogue. The teacher emphasized that these practices were used to promote conceptual learning while covering the content of the high-stakes tests. Salloum and BouJaoude proposed that chains of triadic dialogues in the classrooms are forms of internally persuasive discourses among teachers and students bounded with the authoritarian discourse of high stake-tests. They further claimed that the teachers' commitment to conceptual learning and teaching in addition to the challenge of covering content on time allowed her to act as a facilitator to ensure that students have meaningful understandings of science concepts. Building on this, Salloum and BouJaoude asserted that tensions between authoritative and dialogic discourse are essential for developing meaning in science. Furthermore, they suggest that the use of home language was one of the reasons the teacher was able to build a partnership with the students toward doing well on public, high stakes tests.

Salloum and BouJaoude (2019a) conducted a study in middle school Lebanese chemistry classrooms where they analyzed the language practices the teachers and students engage in to support understanding. In addition, they analyzed how teachers and students gave meaning to their language practices. The study was conducted in four science classrooms within public and private schools of different socioeconomic contexts. Grade 7 and 8 chemistry classrooms were observed and videotaped in addition to observing grade 7 and 8 biology sessions. Classroom observations, the transcribed videotaped sessions, semi-structured interviews, informal conversations with teachers, and student focus group interviews were analyzed. Salloum and BouJaoude adapted an analysis framework developed by Mortimer and Scott (2003) to accommodate both the international and the home language. The framework allowed for the characterization of utterances in terms of knowledge types and patterns of interactions. Results showed that there were different ways through which the home language and/or English were used in the classroom. In addition, they indicated that students were more comfortable expressing themselves in their home language even though they realized the importance of the international language (English) for access to higher education and employment. However, minimal attempts were observed in private school settings to bridge English/Arabic/Science where teachers continued to use English even though students were uncomfortable and exhibited alternative conceptions. The public school teachers, on the other hand, used colloquial Arabic in concept explanation and elaboration to different extents. Arabic was used in these schools for classroom management and emotional communication. Even though many Arabic utterances were previously used to review the concepts, Salloum and BouJaoude noted a trend in teachers' utterances where initiation (I) – response (R) – feedback (F) (IRF) chains where English was used to conclude an episode. Another finding was that students in the public rural school responded using their home language when utterances were conceptual rather than factual. Moreover, teachers were concerned about students' language proficiency level as it would affect these students' comprehension and expressing themselves in exams. However, limited focused preparations were directed to address the needs of low English proficiency students. Furthermore, teachers have conflicting feelings about using home language in the classroom, as there is no placed policy to address this.

Chapter Summary

In the sociocultural theory of learning and development, Vygotsky asserted that development and learning occur first in the social contexts between people and then within the individual (Vygotsky, 1987). Through the social context, the individual acquires the tools needed for individual thinking through semiotic means such as language, gestures, and images. Similarly, Bakhtin emphasized the social context and asserted that utterances comprising speech are dialogic and are the real unit of communication. In addition, each utterance is unique based on the set of conditions in which it is presented (Mortimer & Scott, 2003). Hence, learning is an ongoing process of meaning-making where the learner reorganizes and reconstructs knowledge against prior knowledge and experiences.

The language of science is specialized and includes technical scientific terms that are often used along with common words to engage in scientific discourse. Students will need to reconcile the different meanings of the words used across the different contexts: everyday and scientific contexts for meaningful learning. Therefore, language proficiency is essential to the development of scientific thought and acquiring scientific knowledge (Mammino, 2010). Due to the descriptions of chemistry through language and other semiotic modes, chemistry is suitable to highlight language-related problems with learning and teaching (Mammino, 2010). Moreover, chemistry classes are full of abstract concepts according to Orgill and Bodner (2004) which are not easy to understand unless they are related to something from our everyday concepts.

Nonetheless, language-related difficulties are more notable with second language learners (L2) as they learn sciences while developing their language proficiency (Mammino, 2010; Rollnick, 2000; Taber, 2015). In multilingual contexts, L2 learners may encounter difficulties in learning science as negotiation of the science concepts occurs in a second international language. The international language may belong to a different language group that has different grammars, phonologies, alphabets, and vocabulary than that of their home spoken language (Salloum & BouJaoude, 2019a). The interaction of several languages is evident in the Lebanese classrooms with at least four languages existing at once.

The use of a home language or an international language as the language of instruction is controversial in multilingual contexts. The academic language is often viewed as one with superiority and access to global knowledge while the home language in some schools is even taboo to use in classrooms. However, research findings indicate that the use of home language within the classroom discourse is an important resource to help students struggling with understanding scientific concepts. The home language offers the teacher and students a medium of communication where they confidently and clearly articulate their thoughts (Amin, 2009). In light of these findings, it seems that using home language in the classroom would support conceptual understandings rather than act as an obstacle.

This study looked into classroom practices within science classrooms in the Lebanese context. Particularly, the study examined how the language practices teachers use to support conceptual understanding within the Lebanese chemistry classrooms. Given the presence of several languages in the classroom, this research study looked into whether the language of instruction hinders or supports the understandings of scientific concepts. Moreover, as the Lebanese studies were limited to middle school, it addressed if the observed language practices carry through higher grade levels where more abstract concepts are introduced. In addition, it explored how the home language is utilized within the social context of the chemistry classroom to support understanding. Furthermore, there is an absence of research in the Arab region on using spoken Arabic within the classroom. Hence, the study added to the knowledge on the choice of using spoken Arabic within the classrooms while teaching science in a foreign language.

CHAPTER III

METHODOLOGY

The study investigated the language practices teachers used to support their students' conceptual understanding in secondary chemistry classrooms. This study also explored how the use of home language (spoken Arabic) facilitated students' understanding in secondary chemistry classrooms. This chapter presents this study's research design, participants, data collection tools, and data analysis procedures. Specifically, the research questions guiding the study were:

1. How do the existing language practices that teachers use support the conceptual learning of abstract chemistry concepts?
2. How is the home language used across different knowledge types and cognitive processes?

Research Design

The purpose of this research study is to obtain an in-depth understanding of the existing language practices and their influence on students' conceptual understanding in multilingual classrooms, hence, the study was conducted using a qualitative case study research design. Two naturalistic instrumental case studies were conducted in two Lebanese secondary chemistry classrooms within different contexts. According to Stake (2006), experiencing the activity of the case as it occurs in its natural context is required to understand it.

Participants

The population of this study was the secondary chemistry classrooms in Lebanon where abstract chemistry concepts were introduced. The sample included two grade 11 scientific section chemistry classrooms adopting the Lebanese curriculum. Grade 11 classrooms. These classrooms were selected because they allow more interactions for conceptual understanding compared to grade 12 where most interactions are focused on preparations for the official exams. The schools and consequently classrooms were selected based on accessibility and convenience. The classrooms were selected such as they had English as the medium of instruction of science and Lebanese colloquial Arabic as the home language.

Schools Context

The schools that participated in this study were private co-educational schools (K-12) that serve a middle socio-economical community in Beirut, Lebanon. The language policy at both schools is that science is taught in English. School A offers the Lebanese program with two tracks in which English or French are the languages of instruction of science. School B offers the Lebanese program with English as the language of science instruction. Each Grade 11 section involved in this study was the only grade 11 English section in the school and followed the scientific track curriculum in that grade level.

Both teachers who participated in this study were experienced teachers with over ten years of experience in teaching chemistry. The teachers have also been teaching the students who participated in this study since grade nine. Each classroom was observed for twelve sessions where the covered topics varied between balancing redox reactions and titration. A summary of the school settings and lessons observed is found in Table 1.

Table 1

Summary of School Settings and Lessons Observed

	School A	School B
Type of School	Private co-educational	Private co-educational
Medium of instruction	English	English
Teachers Years of Experience	10 years	20 years
Total Number of classes observed	6	6
Topics Covered	Balancing Redox Reactions – Titration	Titration
Total Students in the classroom	23	16
Student Participants in this study	19	12

Before conducting the study, the researcher met with the principal of School A and the coordinator of the academic affairs of School B to explain the nature of the study. After securing the approval of the principals, teachers, students, and parents, the researcher observed and recorded the six sessions. The researcher ensured that the study followed the requirements of the university's Institutional Research Board (IRB) and thus did not cause any harm to the participants. The researcher informed the participants that they were going to take part in a research study. The participants remained anonymous throughout the study. In both schools, some students either declined to participate in the study or failed to provide valid parental consent and were consequently excluded from the study. 19 students (83% of the class) from school A and 9 students (75% of the class) accepted to participate in the study. The camera was placed at the back of the class facing the board and the teacher to ensure that the students who declined to participate were not videotaped. Moreover, these students were seated in a manner such that the scope of the camera's lens would not capture any of their faces. Their classroom interactions were generally minimal, however, on the occasion of an utterance or input from these students, the transcribed text was flagged and redacted from the analysis.

Data Collection Tools

As the study involved naturalistic case studies, classrooms were observed and videotaped for a sequence of six chemistry periods where interactions in the classroom occurred naturally (Merriam, 2009). The videotaped sessions of the Grade 11 chemistry classes were transcribed verbatim for analysis. Classroom observations and verbatim transcriptions of videotaped chemistry classrooms were used to understand how the language practices supported the conceptual understandings of abstract chemical concepts. Observations give the researcher a direct encounter with the phenomenon of interest (Merriam, 2009). Hence, the sources of data for this study were classroom observations and videotapes of the selected Grade 11 chemistry classrooms in addition to informal conversations about the language of instruction concerning science and learning.

Data Analysis

An analytical framework developed by Mortimer and Scott (2003) which characterizes teachers' and students' utterances in the classroom discourse was used to analyze the data. The framework is based on five linked aspects that focus on the role of the teacher in supporting students in making sense of the available scientific story provided by the teacher in the classroom. These aspects are illustrated in Table 2. The framework was widely used to analyze classroom discourse and meaning-making processes in the classroom (Aguiar & Mortimer, 2013; Aguiar et al., 2010; Buty & Mortimer, 2008; Hennessy et al., 2006; Mortimer & Scott; 2003; Salloum & BouJaoude, 2019a, 2019b; Scott & Ametller, 2007; Scott et al., 2006). However, Salloum and BouJaoude (2019a) identified that the analytical framework develops by Mortimer & Scott (2003) is designed for monolingual settings. Therefore, the adapted version of the framework developed by Salloum and BouJaoude (2019a) was adopted in this study to account for the different languages used in the classroom. This is due to the similar contexts of the classrooms in Salloum and BouJaoude and this study, as both of them, were conducted in Lebanon.

Table 2

The Five Linked Aspects of Classroom and Teacher Talk Used in the Data Analysis Framework.

Focus:	Teaching Purposes	**Content**
Approach:	**Communicative Approach**	
Action:	**Patterns of Discourse**	Teacher Interventions

The purposes of this study involved an investigation of the teacher's language practices about students' understanding of the abstract chemical concepts. Hence, the focus was on three aspects of this framework to characterize the discourse for an understanding of the abstract chemical concepts. These were the content, communication approach, and patterns of discourse. These three aspects are discussed below. The content, communicative approach, and patterns of discourse were identified as aspects where language variations and practices will surface.

Content

To focus on the development of the conceptual understanding of the concepts being taught, utterances in interactions were analyzed based on knowledge types (Table 3) and cognitive processes (Table 4). The discourse in the transcribed videotapes was divided into units that represent complete ideas which were labeled as an “utterance”. Each utterance was coded using the taxonomy of DeVito and Grotzer (2005) which was based on the revised Bloom’s taxonomy (Anderson & Krathwohl, 2001; Krathwohl, 2002).

Knowledge Types

For identification of knowledge types, utterances were coded based on science knowledge types, these include: factual, conceptual, procedural (inquiry, algorithmic, and testing), and metacognitive (Table 3). The coding scheme is based on the taxonomy developed by DeVito and Grotzer’s (2005) taxonomy (Anderson & Krathwohl, 2001; Krathwohl, 2002). Salloum and BouJaoude (2019a) further developed the coding scheme to account for the multiple languages witnessed in the classroom. Codes developed by Salloum and BouJaoude (2019a) were used to discern the use of the home and the second language. After coding, the utterances were analyzed for prevailing patterns of knowledge types.

Table 3

Knowledge Type and Language Variation Definition and Codes

Knowledge Type	Code	Definitions
	F	
Factual	**F_i**: Integrated Arabic Utterances **F_a**: All Arabic Utterances **F_e**: All English Utterances	The basic elements that students must know to be acquainted with a discipline or solve a problem in it.
	C	
Conceptual	**C_i**: Integrated Arabic Utterances **C_a**: All Arabic Utterances **C_e**: All English Utterances	The interrelationships among the elements within a larger structure that enable them to function together.
	P-I	
Procedural: Inquiry	**P-I_i**: Integrated Arabic Utterances **P-I_a**: All Arabic Utterances **P-I_e**: All English Utterances	How to do something: concrete methods and processes of inquiry (e.g. observe, measure, compare, etc…) How to do something: projected and theoretical methods (what to do if…)
	P-A	
Procedural: Algorithmic	**P-A_i**: Integrated Arabic Utterances **P-A_a**: All Arabic Utterances **P-A_e**: All English Utterances	How to do something: use and apply formulas and procedures to find answers (e.g. plugging values, balancing chemical equations, etc…)
	P-T	
Procedural: Testing	**P-T_i**: Integrated Arabic Utterances **P-T_a**: All Arabic Utterances **P-T_e**: All English Utterances	How to do something: skills and understandings directly related and needed to answer test items correctly.
	M	
Metacognitive	**M_i**: Integrated Arabic Utterances **M_a**: All Arabic Utterances **M_e**: All English Utterances	Knowledge of cognition in general as well as awareness and knowledge of one's cognition.

Cognitive Processes

For identification of the cognitive processes, utterances were coded based on the categories for the cognitive processes which include: perceiving, remembering, understanding, applying, analyzing, evaluating, and creating (Table 4) (Anderson & Krathwohl, 2001; Krathwohl, 2002; DeVito & Grotzer, 2005). A similar approach to the coding of Salloum and BouJaoude (2019a) was followed to account for the multiple languages used in the classroom. The developed codes are found in Table 3. After coding, the utterances were analyzed for prevailing cognitive processes patterns.

Table 4

Cognitive Processes Definition

Cognitive Processes	**Code**	**Definition**
Perceive (a)	**P** **P_i:** Integrated Arabic Utterances **P_a:** All Arabic Utterances **P_e:** All English Utterances	Becoming aware of something directly through any of the senses, especially sight or hearing.
Remember	**R** **R_i:** Integrated Arabic Utterances **R_a:** All Arabic Utterances **R_e:** All English Utterances	Retrieving relevant knowledge from long-term memory.
Understand	**U** **U_i:** Integrated Arabic Utterances **U_a:** All Arabic Utterances **U_e:** All English Utterances	Determining the meaning of instructional messages, including oral, written, and graphic.
Apply	**AP** **AP_i:** Integrated Arabic Utterances **AP_a:** All Arabic Utterances **AP_e:** All English Utterances	Carrying out or using a procedure in a given situation.

Analyze	**AN** **AN_i:** Integrated Arabic Utterances **AN_a:** All Arabic Utterances **AN_e:** All English Utterances	Breaking material into its constituent parts and detecting how the parts relate to one another and an overall structure or purpose.
Evaluate	**E** **E_i:** Integrated Arabic Utterances **E_a:** All Arabic Utterances **E_e:** All English Utterances	Making judgments based on criteria and standards (checking and critiquing)
Create	**C** **C_i:** Integrated Arabic Utterances **C_a:** All Arabic Utterances **C_e:** All English Utterances	Putting elements together to form a novel, coherent whole or make an original product.

Discourse Patterns

Discourse in the videotaped sessions was divided into “episodes” where each episode starts with the first utterance about a specific scientific idea (Salloum & BouJaoude, 2019a). The episode ends with an utterance that signals a change to a new scientific idea. Each episode was coded based on the interaction types labeled by Salloum and BouJaoude (2019a) (Table 5). Some descriptions for the interaction types were further elaborated to encompass patterns observed in the classrooms. For the initiation interaction type, the teacher often used a statement rather than a question to initiate interactions. Thus, the description of initiation was amended to be inclusive of statements. As for the feedback interaction type, Salloum and BouJaoude (2019a) described it as a response that is rephrased or paraphrased, and/or responder is asked to clarify and explain their response. However, on many occasions, in particular, when the response is offered in Arabic, the teacher’s feedback tended to be as a translation of the response and then the feedback was often in the form of repeating the response and then clarifying or explaining the response. The description was adjusted to include that as well. Furthermore, the elaboration interaction type was not always by the initiator but also the responder, often if the teacher is elaborating. The teacher frequently would elaborate on the student's responses regardless of whether she initiated the question or not. The changes are seen as bold and underlined in descriptions of initiation, feedback, and elaboration in Table 4. After coding, the episodes were analyzed for prevalent patterns in the discourse and how they are influencing students' understanding.

Table 5

Codes Used to Analyze Utterances for Discourse Patterns

Interaction Type	**Code**	**Description**
Initiation	**I** I_i: Integrated Arabic Utterances I_a: All Arabic Utterances I_e: All English Utterances	Question **<u>or statement</u>** that initiates an interaction
Response	**R** R_i: Integrated Arabic Utterances R_a: All Arabic Utterances R_e: All English Utterances	Response to the initiation questions
Feedback	**F** F_i: Integrated Arabic Utterances F_a: All Arabic Utterances F_e: All English Utterances	The response is rephrased or paraphrased **<u>or repeated with clarification and explanation</u>** and/or responder is asked to clarify and explain their response
Evaluation	**E** E_i : Integrated Arabic Utterances E_a: All Arabic Utterances E_e: All English Utterances	The response is deemed correct or incorrect
Elaboration	**EL** EL_i: Integrated Arabic Utterances EL_a: All Arabic Utterances EL_e: All English Utterances	The initiator **<u>or responder</u>** explains the scientific idea and/or summarizes what it involves

	D	
Directive	D_i: Integrated Arabic Utterances D_a: All Arabic Utterances D_e: All English Utterances	Teacher gives instructions to students to follow

Communicative Approach

Another focus of the analytical framework is on the communicative approach and whether the approach influences the understanding of the chemistry concepts. The communicative approach focuses on the means through which teachers interact with students to attend to the ideas that come up in the lessons (Mortimer & Scott, 2003). Four fundamental classes of communicative approaches were identified by Mortimer and Scott (2003) (Table 6) that categorize teacher and students' talk along two dimensions. The first of which shows a continuum between dialogic and authoritative talk while the second is a continuum between interactive and non-interactive talk. The dialogic approach acknowledges multiple voices/points of view in exploring phenomena, whereas an authoritarian approach focuses on one point of view with no exploration of different ideas (Mortimer & Scott, 2003). A detailed definition of each of the four identified communicative approach classes is provided in Table 7. For the communicative approach, the unit of analysis was the whole class session, rather than individual utterances.

Table 6

Four Classes of Communicative Approach (Mortimer & Scott, 2003)

	Interactive	**Non-Interactive**
Dialogic	A. Interactive/Dialogic	B. Non-Interactive/Dialogic
Authoritative	C. Interactive/Authoritative	D. Non-Interactive/Authoritative

Table 7

Definition and Codes of Communicative Approach Classes

Communicative Approach	Definition
Dialogic/Interactive –DI	Students' points of view are listened to and taken account of in the classroom even when these are quite different from the school science perspectives
Dialogic/Non-Interactive - DNI	Teacher explicitly presents and draws attention in a non-interactive form different points of view set forth by students and/or others (dialogic)
Authoritative/Interactive – AI	Teacher leads students through a series of purposeful questions and answers to reach one specific point of view he/she has in mind
Authoritative/Non-Interaction - ANI	Teacher presents or lectures a specific point of view, which is likely to be the school science account

Quality Measures Criteria

Research studies are conducted to produce reliable and valid knowledge. The researcher must ensure the reliability and validity of his/her results. As qualitative research is heavily based on assumptions about reality (Merriam & Tisdell, 2016) yet both criteria and terminology "for discussing and assessing rigor in qualitative research are in flux" (Merriam & Tisdell, 2016, p. 237). Merriam and Tisdell (2016) identified internal validity or credibility, external validity or transferability, and reliability or consistency as the quality criteria to ensure the trustworthiness of the study. This section illustrates the several quality criteria adopted and measures considered to address the criteria.

Reliability

Reliability or consistency or dependability is concerned with the degree of replicability of a research study (Merriam & Tisdell, 2016). However, human behavior is always changing so the replication of a qualitative study will not yield the same results (Merriam & Tisdell, 2016). Merriam and Tisdell (2016) discuss that this fact does not invalidate the results but rather the findings are consistent with the presented data, the study can be considered dependable. Merriam and Tisdell (2016) suggest triangulation, peer examination, researcher's position, and audit trail to ensure dependability. The audit trail consists of a detailed account of details "how data were collected, how categories were derived, and how decisions were made throughout the inquiry" (Merriam & Tisdell, 2016, p.252).

The researcher adopted the four strategies suggested by Merriam and Tisdell (2016). According to Merriam and Tisdell (2016), triangulation types include the use of multiple methods, multiple sources of data, multiple investigators, and multiple theories. In this study, the researcher triangulated using multiple methods of data sources (Merriam & Tisdell, 2016). Moreover, the researcher attempted to explain her assumptions and theoretical positions regarding the topic in the literature review.

Peer examination was conducted through a form of an interrater reliability test. The researcher and another science education researcher analyzed half a transcript together. Then, they analyzed the other half independently followed by a meeting where the results of their analysis were reviewed, differences were clarified until a total agreement was reached. Both researchers then analyzed a full transcript independently. The percentage agreement across the researchers was satisfactory for the different levels of analysis was as follows: knowledge types (84.9%), cognitive processes (87.2%), and patterns of discourse (90.4%). For the communicative approach, the two researchers were in complete agreement with the analysis. The researcher then completed the data analysis.

In addition, the researcher conducted peer examination to ensure the consistency of the findings. According to Merriam and Tisdell (2016), the audit trail is “a detailed account of the methods, procedures, and decision points in carrying out the study”(p.252). The researcher used an audit trail which is reflected earlier in this chapter.

Internal Validity

Internal validity or credibility refers to the degree to which the findings of the study reflect reality (Merriam & Tisdell, 2016). Merriam and Tisdell (2016) suggest several measures to enhance the internal validity of the research study that include triangulation, adequate engagement in data collection, peer examination, and the researcher’s position.

According to Merriam and Tisdell (2016), triangulation is a powerful measure to increase the internal validity of the research and has several types. The researcher triangulated the data using multiple data sources and clarified her theoretical assumptions derived from the literature. Another strategy is adequate engagement in data collection, according to Meriam and Tisdell (2016), an adequate engagement in data collection is dependent on each study. It is achieved when the data and emergent findings indicate saturation that is no new information would surface as you collect more data. The researcher observed and collected data from six sessions in each school to ensure an adequate representation of the practices in the classrooms. Another measure is peer examination where colleagues scan the raw data and discuss the plausibility of the findings (Merriam & Tisdell, 2016). The researcher conducted the peer examination as discussed earlier.

External Validity

External validity or transferability refers to the extent of generalizability and applicability of the findings of the study (Merriam & Tisdell, 2016). However, Merriam and Tisdell (2016) indicated the difficulty of transferring the findings from one context to another as the researcher wishes to understand in depth a particular case rather than develop a generalization from a single case (Merriam & Tisdell, 2016). Merriam and Tisdell (2016) suggest that the researcher use rich thick descriptions and maximum variation of the study sites or participants. To meet this criterion, the researcher provided a thick description of the context and the school settings to provide interested readers the material to determine whether findings can be transferred to their research contexts.

CHAPTER IV

RESEARCH FINDINGS

This chapter presents the findings of the study which aimed at exploring the language classroom practices of teachers in secondary chemistry classrooms. This study has a two-fold purpose: (1) investigate the language practices teachers use to support their students' conceptual understanding in secondary chemistry classrooms and (2) explore how the use of home language (spoken Arabic) facilitates students' understanding in secondary chemistry classrooms. The data collected from the transcribed videos, observed sessions, and informal conversations with the teachers were used to answer the following research questions guiding the study:

(1) How do the existing language practices that teachers use to support the conceptual learning of abstract chemistry concepts?

(2) How is the home language used across different knowledge types and cognitive processes?

This chapter reports the findings under three sections. The first section includes the data analysis for Teacher A, classroom A. The second section includes the data analysis for Teacher B, classroom B. The third section presents a summary of the findings of classrooms A and B. To answer the research questions, each of these sections discusses the dialogicity of the classroom interactions, the patterns of the teacher's language practices, and the use of home language and variations across knowledge types and cognitive processes.

Analysis of Data from Classroom A

This section presents findings for the first case, classroom A; it is divided into three parts. The first two parts contribute to answering the first research question by describing the dialogicity of the classroom interactions and the patterns of the teacher's language practices. The third part contributes to answering the second research question by presenting the use of home language and variations across knowledge types and cognitive processes.

Dialogicity of Interactions in Teacher A's Chemistry Classroom

As indicated in chapter 3, the communicative approach explicates the means through which teachers interact with students to attend to the ideas that are presented in the classroom. The communicative approach of the teacher can be inferred from classroom interactions, how the teacher engages with learners to accomplish conceptual understanding in addition to the nature and number of utterances used in the classroom.

Classroom Interactions

Teacher A's sessions were mainly centered on the scientific point of view. On several occurrences, the teacher shut down alternative terms or concepts suggested by students and redirected the discussion back to the scientific point of view. The teacher sometimes engaged in some of the ideas explored by students, however, she guided the discussion back to the scientific points and the session's objective. Teacher A's sessions were mainly interactive in which she prompted students to actively engage in the classroom discourse. The whole class discussion was dominant in the sessions, even when few students participated.

The dominant patterns of discourse were variations of IRE (Initiation-Response-Evaluation) and IRF (Initiation-Response-Feedback) across the different sessions. Teacher A often posed questions to elicit the students' engagement in addition to maintaining their attention. However, the questions were often close-ended and purposeful to reach the targeted scientific point of view. Furthermore, Teacher A consistently gave immediate evaluations of students' contributions. The authoritative voice of the teacher was evident through direct evaluation, and in other instances, the teacher's evaluation was the repetition of the answer followed up by writing on the board or just moving to a new question/point (see underlined lines in the example below). Hence, the dominant communicative approach employed by Teacher A was authoritative interactive. The example below shows an episode where the authoritative interactive approach was the communicative approach.

Authoritative Interactive Interaction. In the following example, the students were applying the rules for assigning oxidation numbers to determine oxidized and reduced species. Several lines were removed from the discussion below to highlight aspects that reflect the authoritative interactive discourse. The interaction in this episode was initiated by the student. The teacher's questions posed in this interaction demonstrate that the teacher is searching for information to complete the scientific story she's building so that the students master assigning oxidation numbers. The evaluative voice of the teacher is reflected in lines 4, 11, 17, 25, and 28 (see underlined lines in the example below). Line 9 exemplifies how the teacher accepted some terms exclusively in English as the accepted scientific answer. Throughout this interaction, it is evident when the teacher shifts to informative authoritative rather than evaluative (lines 19 and 21).

(1) **S:** Miss **le el** *(why the)* oxygen **hon** *(here)* minus 2

(2) **T:** Because it's the rule it's a combined [pause]

(3) **S1:** Atom

(4) **T:** <u>Atom</u>

….

(5) **T:** 3 oxygen atoms, the sum, **berja3 b3eed** *(I repeat),* the oxidation number is or refers to a number of electrons lost gained or shared.

(6) **S2:** Ah Miss **byetghayar el** *(does it change? the)* oxidation number **iza haide el** *(if this is the)* element

(7) **T:** If the element

(8) **S2: 3emlet ma3 7ada tene hon el** Cl 3emlet **ma3** O^- **ken el** oxidation number *(It did with another one here the* Cl *did with* O^- *the oxidation number was)*

(9) **T: Shu ya3ne 3emlet** *(What does "it did" mean)* use scientific words

(10) **S2:** Reacted with O^-

(11) **T:** <u>Yes</u>

(12) **S2: 3atetna** *(It gave us)* o.n. [oxidation number abbreviated] +1 **ya3ne el** *(meaning the)* oxidation number

(13) **T:** Yes with it depends oxidation number equals in your mind what

(14) **S2: Inno** *(I mean that)*the number of electrons

(15) **T:** <u>The number of electrons,</u> so it can share

(16) **S2:** More than one

(17) **T:** <u>Thank you</u> Student2 [to indicate he provided the proper answer] more than one with three oxygen atoms

(18) **S2: Bas** *(But)* if it were in this polyatomic ion it shared only one

(19) **T**: <u>Yes with Oxygen.</u> Here ClO_3^-, again, since oxygen is also a combined atom in this polyatomic ion, which leaves us with: oxidation number minus two three times minus three minus six follow the red ok? You will see that the oxidation number of Cl equal to five, meaning that

there are five electrons shared here mmm with, mmm three oxygen atoms for Cl^-. The monoatomic ion is easy it's always equal to what? [pause for answer]

(20) **S3:** The charge

(21) **T:** The value of the charge. Now, when we compare the variation of the oxidation number of the same element, from reactants to products, you can see that Cl and ClO^- have one plus one. Then, if you compare, follow the arrow, with this respectively the o.n. [oxidation number abbreviated] of Cl and ClO_3^- is equal to plus five. You see that the value decreased or increased from one to five.

(22) **S4:** Decrease

(23) **S5:** Decrease

(24) **T: Ma hek** *(It's not that)* **ya** Student6, you should know the decrease increase a bit. Don't forget so it's an oxidation half-reaction meaning the electrons are

(25) **S4:** Gained

(26) **S5:** Gained

(27) **T:** Gained

Dialogic Interactive Interaction. Although the dominant approach was authoritative interactive, Teacher A also had a dialogic interactive approach in some of the sessions. She actively allowed space for different ideas to emerge, however, she directed the discussion to include the ideas that would feed into the concept of titration. In the following example, the series of interactions shows the dialogic interactive communicative approach. It shows that the students were actively engaged in this discussion. The exercise included the determination of the oxidant and reductant in the redox reaction. The teacher moved along with the term “spectator atom” introduced by the student (see underlined lines 12 and 28). She linked it to the underlying concept that the element was not involved in the reaction. Line 16 (underlined) also shows the evaluative voice of the teacher.

(1) **T:** Now compare what are the variation if found?

(2) **S1: El** *(the)* O

(3) **S2:** The Oxidation of

(4) **T:** In which elements the oxidation number varies

(5) **S3:** Hydrogen **la2** *(no?)*

(6) **T:** Yes, Hydrogen didn’t change

(7) **S2: El** *(the)* Oxygen varied decreased from minus 1 to minus 2

(8) **S1:** Miss **Su2al** *(a question)*

(9) **T:** Do you know what does plus 1 mean if it didn’t change? **Shu ya3ne** *(what does that mean?)*

(10) **S2:** Spectator atom

(11) **S3: Ya3ne** *(that means)* it’s not reactant

(12) **T:** <u>He said something like spectator atom.</u>

(13) **S2:** It didn’t react.

(14) **T: Ya3ne** *(that means)* it didn’t? [pause for answer]

(15) **S4: La** share **wala** lose **wala** gain *(Neither share nor lose nor gain)*

(16) **T:** <u>**La** share **wala** lose **wala** gain </u>*(Neither share nor lose nor gain)*

(17) **T:** So it didn’t **iza 3am beshteghel** redox reaction **3anna** two possibilities it didn’t **shu** *(if Im working in* redox reaction *we have* two possibilities it didn’t *what?)*

(18) **S4:** Lose gain nor share

(19) **T:** Lose nor gain **mafi sharing b**l redox **le**? *(There is no sharing in redox why?)* **le** *(why?)* why in the redox reaction we cannot say sharing of electrons think

(20) **S2: La2ano 3anna** [stopped by teacher] *(because we have)*

(21) **S5: 3ashen bas fi** oxidation *(because we only have* oxidation***)***

(22) **T: W** *(and)* oxidation means

(23) **S5:** Loss

(24) **S6:** Loss of electrons

(25) **T:** Loss of electrons for another element to

(26) **G:** Gain

(27) **T:** Gain it and undergo a reduction exactly [this was mentioned as the teacher was saying another element to]

(28) **T:** So we have a transfer of electrons and not sharing of electrons so plus 1 [pointing to reactant side] plus 1 [pointing to product side] **khtara3na shi jdeed hala2 ok** el IUPAC **byunbusto, shi ismo** spectator atom **bas hiyye el** concept **mazbout**? Ok *(we invented something new now IUPAC will be happy with us [sarcastically] something called spectator atom but the concept itself is right ok?)*

(29) **S-21:** Miss **le** *(why)* plus 1?

(30) **S-21:** Miss **le** *(why)* plus 1?

(31) **S 2: Kif** plus 1 **w** plus 1 **w ma 3emlet shi? *(****How is it* plus 1 and plus 1 *and it didn't do anything)*

(32) **T:** I will answer this, I will answer this, I will answer this. It's about the way the atom shares electrons in this molecule; it's an exception. I will explain it later but now focus on the concept.

(33) **T:** Yes [responding to student question]

(34) **S:** Same [pointing to Student21 to indicate that he has the same question]

(35) **T:** Same ques I will explain it later. Now, oxygen now practically what does minus 1 transform into minus 2 [indicate] ?

(36) **S3:** Oxidation number decreases

(37) **S6:** Decreases

(38) **S3:** Decreases

Number and Distribution of Utterances

As indicated in chapter 3, an utterance is defined as a unit that represents a complete idea within the discourse. Teacher A's sessions were dominated by whole-class teacher talk; however, the amount of classroom talk was distributed almost equally between the teacher and the students. To show the distribution of utterances between Teacher A and the students, and to avoid overwhelming the reader with the amount of data generated in the six observed sessions, the first two and last two sessions are summarized in Table 8. The first and last two sessions were selected to ensure that the classroom practices were captured across the sessions. The researcher noticed no significant changes in the teacher's practices across the observed days.

Table 8

Frequency Distribution and Percentages of Utterance Distribution of Teacher A and Students

Lesson #	Teacher A		Students	
	Frequency	%	Frequency	%
Lesson 1	414	56.8	315	43.2
Lesson 2	380	51.1	364	48.9
Lesson 5	325	52.4	295	47.6
Lesson 6	307	54.0	261	46.0

Although the distribution of the utterances in classroom talk of Teacher A and the students were relatively equal, the dominant language used differed. A summary of the overall language variations of Teacher A's use of English and Colloquial Arabic over the six observed lessons is shown in Table 9. Teacher A used English more than Colloquial Arabic in most of the sessions, where 69% to 79% of the utterances were in English. However, in lesson 6, English was only used for 50.8% of the utterances, and integrated and Colloquial Arabic was used as frequently as English.

Table 9

Frequency Distribution and Percentages of Language Variations for Utterances of Teacher A

Lesson #	English		Integrated		Arabic	
	Freq.	%	Freq.	%	Freq.	%
Lesson 1	286	69.1	93	22.5	35	8.5
Lesson 2	285	75.0	82	21.6	13	3.4
Lesson 5	259	79.7	42	12.9	24	7.4
Lesson 6	156	50.8	119	38.8	32	10.4

Even though Teacher A used English far more than Colloquial Arabic in the classroom, students' use of the languages differed. As shown in Table 10, the students' use of the languages was relatively equal between English and Colloquial Arabic in most sessions. The students' use of English was at most 58.10% (Lesson 1) where they were prompted several times to use English. During lesson 1, Teacher A explicitly asked the students to "use English" as shown in the examples in the following section. On the other hand, in lesson 6, several students were asking questions using integrated or Arabic utterances. In that session, the teacher did not prompt the students to use English and an almost equal distribution is observed across languages used.

Table 10

Frequency Distribution and Percentages of Languages for Utterances of Students in Sessions of School A

Lesson #	English		Integrated		Arabic	
	Freq.	%	Freq.	%	Freq.	%
Lesson 1	183	58.1	80	25.4	52	16.5
Lesson 2	163	42.6	155	44.8	46	12.6
Lesson 5	160	54.2	90	30.5	45	15.3
Lesson 6	91	34.9	96	36.8	74	28.4

Teacher A Patterns of Practices

During the sessions, different patterns emerged for the practices employed by Teacher A to support her students' conceptual understanding in the classroom. Teacher A presented lessons in English and shifted to home language (colloquial Arabic) occasionally. In whole-class presentations/explanations, Teacher A almost always used English but switched to Colloquial Arabic to respond to frustrated students who did not understand the concepts presented. She also used Colloquial Arabic to probe or prompt responses such as "**yalla**" (*ok then*), "**tetzakaro bl** example" (*do you remember in the* example), and/or address students' specific questions. Additionally, Teacher A used Colloquial Arabic to make jokes such as "**ahh msh huwe**" (*ohh not him*), to relieve some tension in the classroom, to grab students' attention, and to elicit students' involvement.

Teacher A interacted with her students and often posed questions to elicit engagement from the students. However, most questions were close-ended and required one word or few words as answers which is illustrated in the interactions shown below. Also, the questions were mostly statements where the teacher started with a sentence and then stopped at a word with a questioning tone or simply waited for a response from the students. Below are examples of the identified patterns of the language practices that Teacher A employed in her classroom excerpted from several sessions.

Use of English to State Objectives and Start Classroom Interactions. A trend that emerged across the different sessions was the use of English for starting the session and stating the objectives. The teacher almost exclusively used English to explain what the students were to learn/apply in the sessions. Almost all the sessions started with informal interactions with the students for classroom management purposes. The following examples are from various sessions where the stated objective is underlined, and some managerial interactions were removed.

Teacher A, Example 1. The following example is from the beginning of a session where the objective was to apply the rules of oxidation number variations to determine redox reactions.

(1) **T:** Now today we're gonna see how do we use the variations of oxidation number in order to determine if we have a reduction or an oxidation reaction

(2) **T:** Student21, the example 1 we took was what

(3) **S : El** *(the)* MnO_4^-

(4) **T:** MnO_4^-, the permanganate anion ok I'm gonna show it to you tomorrow, **bta3rfo haida** *(you know this),* but tomorrow we're going to do a reaction with MnO_4^- as a reactant and see the color variation if it is in excess or a limiting with other chemical species that have other colors.

(5) **T:** Now, Student21 let's apply the rule, give me the expression

Teacher A, Example 2. The following example is from the beginning of a session where the objective was to use the oxidation numbers to determine whether reactions are redox.

(1) **T:** Ok the objective is to finish number 11 and to mmmm undergo a reduction reaction we will do a qualitative study **elle hiyye** *(that is)* to check the color change of the reactant and of the product and determine who is the limiting or who is the excess reactant according to the color change **halla2** *(now)* I'm gonna do it it's similar to the reaction that you did or you had in your semi-test okay [question tone] so that means that

(2) **T:** So let me finish the number 11 we talked about a disproportionation reaction meaning we have **tetzakaro bl** *(remember in the)* example of Student6 he can give one electron to umm to whom we did

Teacher A, Example 3. The following example is from the beginning of a session where the teacher was set to solve exercises from the worksheet previously distributed in an earlier session.

(1) **T: Yalla** *(ok)* let's start with the page 1, what is the objective of the session?

(2) **S:** Redox titration **be2raha?** *(do I read it?)*

(3) **T:** Please, I read it, yes read it, **yalla** *(ok let's go)*

(4) **S:** Redox titration is a procedure where a solution of known concentration titrant is used [reading]

(5) **T:** So, known concentration, meaning that we already know the molar concentration of the solution The solution of known concentration is called a titrant

(6) **S to Ss: Akhadto** page 2? *(did you take page 2?)*

….

(7) **S:** to determine the unknown concentration of another solution analyte [student reading mispronounces analyte]

(8) **T**: Analyte, analyte. So, I'm gonna use the known concentration solution known as the? [gestures for students to answer]

(9) **S**: Titrant

Emphasize the Use of English as the Language of Science. Teacher A recognized the importance of using English as the language of science. She asked students explicitly to use English or sometimes repeated the utterances in English herself. This aligns with the teacher's view of the importance of English as the language of science. During conversations with the researcher, the teacher specified that the students often felt comfortable using colloquial Arabic in the interactions. However, to engage the students in English, Teacher A explicitly instructed the students to use English when communicating. The below examples were extracted from different sessions to show the explicit instructions to use English. The examples are underlined, and some managerial interactions were removed.

Teacher A, Example 1. In the following interaction, the teacher asked the students how many elements were present in the reaction and why they were five. One student responded with an integrated utterance in which he used English only to state the elements Mn and O. However, the student used Colloquial Arabic for transition words such as "**la2an** *(because)*", "**w** *(and)*" and the number "**arb3a**" *(four)*. The teacher explicitly instructed the student to use English to state the answer.

(1) **T:** How many elements do we have? Five (....) atoms do we have? [Through context question is why five atoms?]

(2) **S: la2an Mn w arb3a O** *(Because Mn and four O)*

(3) **T:** because we have, <u>Say it in English</u>

(4) **S:** one Mn **w arb3a** Oxygen *(one Mn and four O)* [repeated answer but rephrased in English]

(5) **T:** atoms and in English - do you know four in English - see it's easy once you get used to it - and four oxygen atoms

Teacher A, Example 2. In the following example, the students were applying the rules for assigning oxidation numbers. Specifically, the rule stated, "The addition of all the oxidation numbers of all the atoms in the polyatomic ion is equal to the value of the charge of the ion." One of the students needed further elaboration on how to apply the rule. The student initiated the question in Colloquial Arabic. The teacher used Colloquial Arabic to request that the student ask the question in English. However, despite being requested to use English, the student mostly resorted to integrated utterances where English was used for the scientific terms only. This instance is demonstrated in the below example.

(1) **S1: Ya3ne nehna hon mnekhod kil wehde lahala la2an kil wehde** *(That means we take each one alone because each one)* [The student's question was interrupted by the teacher]

(2) **T: <u>7kine</u>** <u>in English</u> **jarreb la2ano ana sa2alet m3alemtak** *(Talk to me in English try because I asked your teacher)* I asked your English teacher by the way and she told me that even in her periods you tend to speak in Arabic

….

(3) **T:** Now Ok so ask me clearly, what's here? Try it.

(4) **S1:** Miss **Ya3ne b haide el tari2a el** polyatomic *(Miss that means in this way the method of the* polyatomic*)*

….

(5) **S1: Hone el** *(Here the)* polyatomic ion **el** oxidation

(6) **T:** Polyatomic ion it's a

(7) **S1:** (…) Oxidation number (….) The numbers here

(8) **T:** The summation, the addition of all the oxidation number **kamena** is equal to the [pauses for answer]

(9) **T:** Value of the charge [the teacher answers her own prompt]

(10) **S1: Ya3ne** miss we take each one **3a ases ino** mono *(that means miss we take each one bases that it is mono)*

(11) **T:** No you take each atom that is forming this polyatomic ion

(12) **S1: Ya3ne ya** *(that means)* miss **el** *(the)* Cl2 the oxidation number of Cl2

(13) **T:** It's, it's the number

(14) **S: Mna3melo** addition **lal** *(we did the addition for)*

(15) **T:** It's the number of Cl you have one atom of Cl yes yes

(16) **S1: El** Cl **Mna3melo** addition **lal** (….) *(The Cl we do an addition for the)*

(17) **T:** What's the oxidation number (.…) yea what the number of electrons lost or gained yes and you add them because it's a total exchange of electrons

(18) **S2:** Miss **La2an ma mna3ref adde el** oxidation number of Cl *(Miss because we don't know how much the oxidation number of Cl)*

(19) **T:** Of Cl you need to determine the oxidation number of Cl that's why we use this way

Teacher A, Example 3. In the following example, the teacher did not ask the students to explicitly use English. However, she only accepted the scientific term in English. To solve one of the exercises, one of the students was tasked with reading the problem. The teacher asked the student to read the equation of the reaction, for her to write it on the board. While reading the equation, the student used “**3atetna**” *(gave)* instead of its English equivalent “gave” in the chemical reaction. The teacher did not accept “**3atetna**” *(gave)* as an answer and emphasized the use of the word in English: gives/produces instead.

(1) **T:** Give me the equation **ya** Student15

(2) **S1:** 3Cl

(3) **T: ah 3afwan** *(oh sorry)*

(4) **S2:** 3 C l O minus $3ClO^{-}$ ClO^{3-} + $2Cl^{-}$ [reading]

(5) **S1:** Cl Cl Cl

(6) **T:** 3 C L O minus yes

(7) **S1: 3atetna** Cl *(gave us Cl)*

(8) **T: La2 mafi 3atetna** *(No not gave)*

(9) **S1: Shu??** Arrow? *(What do I say arrow?)*[The student meant: What I can’t use **3atetna** *(gave),* I say arrow instead?]

(10) **T: Shu** please Student1 **shu mn2oul** arrow *(What?? Please student1 what do you mean we say arrow?)*

(11) **T: Ya** Allah **ya** miss **min** grade 9 **b3eed nafs el khbar** *(Oh God miss since grade 9 I repeat the same points)*

(12) **S3:** Gives

(13) **T:** Gives, merci

(14) **T:** gives produces whatever

Another student attempted to give an alternative word to give/produce and used the word “react.” The teacher asked the student to explain what reacts means. Again, one of the students used the Colloquial Arabic equivalent “**tfe3alo**” *(reacted)*. The teacher asked the student to explain “**tfe3alo**” *(reacted)* and then explained that it is an adjective for the reactant so it did not apply to the reaction. Here the teacher used the student's linguistic resource and understanding of the term **"tfe3al"** to help him understand the concept of reacted and reactants.

(15) **S4:** React

(16) **S to S: La2 msh** react *(No not react)*

(17) **T: Msh** react **la2** *(not react no)*

(18) **T: ya3ne shu ya3ne** react *(what does react mean?)*

(19) **S1: 7ataynehon sawa b** same side *(We put them together on the same side)*

(20) **S5: Tfe3alo** *(reacted)*

(21) **T: Shu ya3ne tfe3al** *(What does 'reacted' mean?)*

(22) **T:** they are no longer found **ya3ne** *(that mean)* it's an adjective for a reactant

(23) **S6: Ah bekafeya** react and give *(react and give is enough)*

(24) **T: Meshe**

(25) **T:** So **fi** give **bl da2** *(So there is give in this)*

(26) **S7:** Produce

Relating Science to Everyday Life. Teacher A related scientific concepts to everyday life using different strategies. Such strategies included analogies and exercises that were designed using examples of chemistry in everyday life.

Teacher A, Example 1. In the following example, after the students did not grasp the concept of oxidation number variation and the meaning of increase/decrease of oxidation number, the teacher resorted to using an example of money exchange. She called up a student to participate in this interaction. The teacher alternated between using the home language (Colloquial Arabic) and English when the student was stuck.

(1) **T:** Now, Student6 **inta lyoum na2sak sabe3talef** [referring to 7000 Lebanese pounds T pronounced as] **bukra midre min meen 3melet film sar na2sak** *(Now student6 you are missing 7000* [Lebanese Pounds] *today, tomorrow I don't know whom you played so you are missing)*

[The teacher started the interaction with an analogy in which she asked the student if he needed 7000 Lebanese pounds on the first day and on the next he only needed 2000 Lebanese pounds, what did he do to reach that?]

(2) **G: La** *(no)* Student1

(3) **T: Ah haida** Student1, **ken lezem** Student1 **yetla3** [joking with the students], ok **tab inta na2sak lyoum sabe3talef Lira, bukra sar na2sak alfen** [Lebanese Pounds] *(Oh that's Student1 I should've called on Student1 ok now you are missing today 7000* [Lebanese Pounds] *tomorrow you are missing 2000* [Lebanese pounds]*)* **ma 7ada yjeweb lee** *(No one gives him the answer)*

(4) **S1: Bade mino alef ana** *(I want from him 1,000* [Lebanese pounds]*)*

(5) **T:** Listen, listen

(6) **S2: La2a khamstalef** [5000 Lebanese Pounds] *(He found 5000* [Lebanese pounds] *)*

(7) **S3: Khamstalef we23et minne** *(*5000 [Lebanese Pounds] *fell from me)*

(8) **T: Inta na2sak sab3a bukra na2sak alfen lesh kif shu** *(You are missing 7 tomorrow you are missing 2000* [Lebanese pounds] *why how?)* **Kif dabbaret 7alak** *(How did you manage that?)* simple math **ya** Student6 ok?

(9) **T: Na2sak sabe3talef lira kif bukra shu 3melet la sar** tomorrow **na2sak alfen** *(you need 7000 Lebanese Pounds how? What did you do tomorrow so that you are missing 2000 Lebanese Pounds?)*

(10) **S4: Akhadet khamstalef** *(He took 5000* [Lebanese pounds]*)*

(11) **S5: Abadet khamstalef** *(He collected 5000* [Lebanese pounds]*)*

(12) **T:** Merci **akhadet** *(it took)* gained

(13) **T: adde alfen khamse adde?** *(How much 2000 5 how much?)*

(14) **S3: Shu** *(What?)*

….

(15) **T: so inta ken na2sak sabe3talef 7ada** *(So you needed 7000 someone)*

(16) **S5: Eh Miss huwe eede el shmel** *(Yes Miss he is my left hand)*

(17) **T: Eh ma3loum** *(yes of course)*

(18) **T: so Student15 2allak inta sar ma3ak alfen** (2000) **bukra na2sak alfen** (2000) **la2ano 7ada 3atak adde** *(So Student 15 told you, you now have 2000 tomorrow you are missing 2000 because someone gave you how much?)*

(19) **T: khamse ok** *(five ok)*

After interacting with the students to establish their understanding using Colloquial Arabic. The teacher transferred this understanding into English and integrated it with the scientific concepts.

(20) **T:** So this is why the value of the oxidation number **ken** *(it was)* plus 7 **sar** *(it became)* plus 2 **ma3neta** *(that means)* this chemical species

(21) **T: shu 3emlet** *(What did it do)* in order to ensure **bas 3anda** *(but it has)* oxidation?

(22) **G:** Gain

(23) **T:** So Gain 5 electrons

(24) **T:** if you want to compare the variation of this oxidation number

(25) **S4:** Decrease and undergoes reduction

(26) **S:** Oxidation number

(27) **T:** It was plus 7 then plus 2

(28) **S4: Saret** plus 2

(29) **T:**It's **shu** *(what)*

(30) **S-13:** oxidation number decreases so reduction

(31) **T:** Yes

Teacher A, Example 2. Another example the teacher used to relate science to the everyday life of the students was that of a chemist examining a contaminated river. The teacher attempted to give real-life examples of where and when titration was used outside the classroom. She introduced a lab activity in which a chemist was investigating a contaminated river. Minimal participation of the students was observed as the teacher was introducing the activity. Students' participation was either to read the given of the lab activity exercise, hence why minimal Colloquial Arabic was used.

(1) **T:** Now, how are we going to use in the industry the titration example maybe I am a chemist that works in a lab. They gave me a mmm a sample for example a river of the water of a river contaminated water of a river I need to know for example if the water contains some ion.

(2) **T:** So, in order to know this ion is found and how much mmm is its molar concentration value I will do the titration ok? Fine, continue

(3) **S:** The objective of this lab activity is to conduct a redox titration of a [reading]

(4) **T:** A Mohr[1] salt this is salt [showing container with salt] it's the name of the salt [reading]

(5) **T:** Look, I'm gonna show it to you. Can you give me a watch glass?

(6) **T:** I'm gonna pour mmm show it to you. This is the salt that contains Fe^{2+} ion. And you know into **aslan ino** *(that originally)* Fe^{2+} is green when you dissolved in a solution. This salt is a bit special.

(7) **T:** Continue, [the teacher asked the student to continue reading the exercise she started stating the statement she wants him to continue from] it contains more than cation anion yes

(8) **S:** With permanganate ion MnO_4^- in an acid medium [reading]

(9) **T:** So, meaning that I'm gonna use the salt potassium permanganate ion mmm potassium permanganate solution [explanation of the statement the student read]

(10) **S:** In acid medium [reading]

(11) **T:** In acidic medium, we did something similar two weeks ago

(12) **S: Berouho el** HO^- ? *(Does the HO- go away?)*

(13) **T:** We need an H+ in the reactants and I'm gonna undergo the reaction With a solution that contains Fe2+ ion found in this salt which called the Mohr salt ok?

(14) **S: Huwe el** salt **b2albo** Fe2+ ? *(The salt has Fe2+ in it?)*

(15) **T:** Yes

Use of Colloquial Arabic in Classroom Management. Teacher A mainly used colloquial Arabic for management and disciplinary purposes. The following examples show the use of colloquial Arabic by the teacher and students in. several interactions.

1 Common name for ammonium iron (II) sulfate

Teacher A, Example 1. The following interaction shows the use of Colloquial Arabic in the interactions as the students were sitting in the lab.

(1) **T: <u>Yalla sabaya betjeebo karase</u>** <u>please</u> *(Let us go girls could you get chairs please)*

(2) **T: Tfaddalo bser3a** *(Please quickly)*

….

(3) **T:<u> Yalla badkon tu2o3do la2ano</u>** *(let's go you need to sit because)* it's a long titration

(4) **S to S :** Bring a chair

(5) **S2: Feena**?? *(Could we?)*

(6) **S3: eh akid yalla** *(yes of course let's go)*

(7) **S2 to S3: Msh a7san hunik ?** *(isn't better over there?)*

(8) **T: Bas ekher shi baddak** because *(At the end you need to because)*

(9) **S to S: Ma feekon tu23do hon** *(you can't sit here)*

(10) **S: Bayyen?** *(Do I show?)* [referring to camera]

(11) **S: Ehhh betbayne** *(yes you do show)*

(12) **T:** Student-18 **ana ma b7eb tlemize yu23do 3ala el** workshop *(I don't like my students to sit on the workshop)*

(13) **S-18:** Miss **ma be2sha3** *(I don't see)*

(14) **T: Betjibe Bet2oulile ana b7elelak yeha** *(you get you tell me I solve it for you)*

(15) **T:** Don't sit, don't sit **Rouhe jeebe kerse w 23oude hon** *(Go get the chair and sit here)*

(16) **S:** Miss **mafi chair aslan** *(There isn't a chair in the first place)*

(17) **T: Badi 2ousal ab3d aktar** *(I wanna reach farther)*

(18) **T: Ok Meen ma la2a mahal w mesh 3aref 7alo shu bado ya3mol** *(Ok who couldn't find a place to sit and doesn't know what to do)*

(19) **T: Tb hala2 yalla betbadlo btu2afo w bte2e3do btu2afo w bte2e3do** *(Ok now you would switch between each other you stand and sit)* [to signal that the two students would alternate between sitting and standing]

(20) **T:** Student-6 **yalla khaleek wa2ef hon w bas tet3ab btu23od hon fine?** Ok

(ok you stay standing for now and then when you're tired you sit here ok?)

Teacher A, Example 2. In the following example, Teacher A asked one of the students to read the rules for assigning oxidation numbers. The teacher highlighted that she selected the student specifically to engage him in the session so he studies the material.

(1) **T:** Do you know what I'm doing today **3am 2ujubrak tedros la2an ana ba3rif bl bet ma btedros hek** *(I am forcing you to study because I know at home you don't study)* so how many times ana **hala2 3am ejebrak t3eed el rule. Inta wala b7ayetak 3eyedon ana hek ba3rif** *(Now I am forcing you to repeat the rule. I know you've never repeated them in your life)*

(2) **S: La2 Be2reyon bas** *(No I read them only)*

(3) **T: Bte2reyon bas tb 3eedon tlet arba3 khames marrat ta na3refon so 3al aleele ana ma3e hala2 3eyedon 3 marrat** *(You read, but repeat them three four times so we know them, at least with me now you repeated them three times).*

(4) **T:** Which **is ya3ne ino thawra b7ad nafsa** *(which is a revolution by itself)*

(5) **T:** Ok read it again listen to the rule **ya** Student6

Teacher A, Example 3. One of the students was drinking in the lab, the teacher asked him to stop drinking.

(1) **T:** Student-15 **elna ma teshrab** *(we said don't drink)* [As they are in the lab]

(2) **S:** Miss **deyman beshrab** *(I always drink)*

(3) **T: Laa bgher ma3 gher asetze ma3e ma bisir hal shi mghalbat** *(No that would be with another teacher not with me you're mistaken)*

Use of Colloquial Arabic after Attempts in English. Teacher A mainly explained and elaborated in English. However, she switched to explaining in Colloquial Arabic while codeswitching to English for scientific terms when her other attempts failed to help the students understand.

Teacher A, Example 1. The teacher was explaining the concept of a disproportionation reaction and how the same species is oxidized and reduced simultaneously. The teacher started her explanation using role-play where few students represented a chemical species in the example.

(1) **T:** Now but today how can a chemical species be an oxidizing agent and at the same time a reducing agent **shu ya3ne 3amaliyan** *(practically, what does it mean?)*

(2) **T: Ta3a shway** Student10 **w2af ta3e** Student14 **ta3e** Student19 *(Come here a bit Student10 stand Student 14 come over Student 19 come over)*

(3) **T:** Each one of you has one electron let's suppose this: take this electron takes this electron and take this electron [giving pencils] ok

you are ClO^- so sometimes ClO^- let's say 1 2 or 3 I don't care about the number it's the concept that I'm talking about ClO^- has to gain one electron let's suppose in order to be stable not ClO^- a chemical species needs to gain one electron in order to be stable or to react with another chemical species in order to be stable.

Teacher A further elaborated using English, however, to involve the students in the interaction she switched to the Colloquial Arabic and asked them why one chemical species would "force" (**tejbor**) the other to "take its electrons". In line 12, the teacher codeswitched to Colloquial Arabic to relate the concepts with electron affinity and electronegativity.

(4) **T:** Let's suppose Student10 has also the same issue **bas lesh** *(but why)* sometimes mmm Student14 **badda tejebro la** *(it needs to force)*Student10 **yekhod minna el** *(takes from the)* electron **ma3 ino huwe ma baddo** *(even though it does not want it)*

(5) **T: Shu mnsameya la** Student14 **b hal 7ale** *(What do we call Student14 in this case?)*

(6) **S1:** Strongest

(7) **T:** Strongest what

(8) **S2:** Oxidizing agent

(9) **T:** Reducing agent

(10) **T:** Why she is the strongest reducing agent

(11) **S-13: La2an** *(Because)* she allows the other to undergo reduction

(12) **T: Jabarto** to do this **W huwe shu bkoun** in this case *(It forced it* to do this *and* in this case *what would it be?)*

The teacher further interacted with the students in integrated utterances to explain the chemical concept of disproportionation reaction. However, one of the students did not seem to grasp the concept. The following excerpt illustrates the teacher's reliance on Colloquial Arabic to bridge the gap in the discourse. As shown below, the teacher only codeswitched to English for the scientific terms to help the student understand.

….

(13) **T:** It depends on the chemical affinity **ya3ne ma3 ayya** *(that means with which)* chemical species **hiyye** *(is it)* yes Student3

(14) **S-3:** Miss **nehna bas mara2 ma3na** strongest oxidizing agent **elteelna 7asab el** electron **ya3ne el** electron **iza ken haida el** strongest oxidizing agent w **iza ken hon** strongest reducing agent **bas hon alabtiyon 7asab el** formula **ya3ne**

*(*Miss *when we learned before about the* strongest oxidizing agent *you said it depends on the* electron *meaning if the* electron *was that of* the strongest oxidizing agent and *if it was* strongest reducing agent *but here you switched them depending on the* formula*?)*

(15) **T: Ma alabnehon** *(We didn't flip/switch them)*

(16) **S-3: Bala** *(yes)*

(17) **T: 3am tna2de 7alek ya** Student3 *(you are contradicting yourself)*

(18) **T: la2ano hinne tnayneton bya3mlo nafs el** the two ideas **ele 3am tehkiyon 3andon** the same answer *(Because both of them do the same thing the* two ideas *that are taking them* the same answer)

(19) **T: Shu bta3mel bl** electron gain them **ya3ne bet2asheton la ghayra el** oxidizing agent is a chemical species that *(What does it do with*

electron gain them *that means it takes it by force from the* oxidizing agent is a chemical species that)

(20) **S1:** Gain them

(21) **S-3: Ya3ne msh hinne bya3towa***(That means they did not give it)* **[**showing understanding]

(22) **T:Le bet2asheton la ghayra la2ano haideke mesta2tel ykebbo ma hiyye 2usset** affinity chemical affinity **le ana hal2ad awiyye ashatto yei w huwe mano metmasak fi lal** electron *(Why does it snatch it from the other one? Because the other one can't wait to throw it away. It is a matter of* chemical affinity *why is it that strong so it snatches it and why is it not holding on this* electron*?)* **shu 3am ya3mol** *(what is it doing?)* he's giving it away

(23) **S -3: Ah msh el** one that loses **huwe el** oxidizing agent **el** one **ele bekhalle el tene** to lose *(Oh not the* one that loses *it is* oxidizing agent *the* one *that makes the other one* lose)

(24) **T:** Fine **Ele byejbor el tene ya3mol** oxidation *(*Fine *the one that forces the other to do* oxidation)

(25) **S-3:** oxidation

(26) **T:** that's why it's called oxidizing agent

Teacher A, Example 2. In the following example, the teacher also resorted to Colloquial Arabic to help link the student's ideas and the scientific concept. In conducting a lab activity, Students asked about the medium of the reaction and how can they determine it. The teacher, using English, attempted to explain the difference between an initial medium and a medium changed by a product of a reaction.

(1) **S1:** Miss **ya3ne iza el** HO^-*(Miss that means if the* HO^-*)* **mawjoude bl** reactant **ino** reactant **hiyye** basic medium *(It is found in the* reactant *that the* reactant *is* basic medium)

(2) **T: 3amaliyan shu ya3ne what does this mean? If HO- is** *(Practically, what does this mean if* HO- is*?)*

(3) **S1:** Present in the reactant **ya3ne hiyye** (….)[asking for clarification] *(ok so that means it is….)*

(4) **T:** You need it which means it's part of the reactants you need it to be in the reactants in order for the reaction to take place

(5) **S1: Ya3ne** *(that means)* basic medium

(6) **T:** Yes. **Bas law kenet mawjoude bl** products *(But if it is present in* products) You don't care maybe it was in product form maybe after the reaction takes place the medium becomes basic it's not the question it becoming basic is different than if it at the initial state the medium should be basic or not in order for this reaction to take place.

(7) **S2: Sar fi 3ande** HO^- *(I know have* HO^- ***)***

(8) **S1: Ya3ne iza saret** basic **aw kenet** basic **hiye zeta** basic medium **iza kenet** product or reactant *(That means if it became* basic *or it was* basic *it is the same* basic medium *if it was* product or reactant)

(9) **T:** No **ya** Student-18 you are getting this a little bit wrong. I will explain in Arabic and in English, frankly **fi 3anna meshekle ya Student-18 la7 3eed. Ya Student-18, inte** *(There is a problem Student-18, I will repeat you)* you need, let's say I'm gonna take this example, that we are going to do **li huwwe** *(that is)*, give me one min, just so I search for the

reaction. MnO_4^- **ya** Student-18 should react with I^- in an acidic medium it's not balanced ok?

(10) **S1:** Ok

(11) **T:** We are going to balance it right away to form Mn^{2+} and Iodine ion. Student-18 look at the reactant how many reactants do you have?

(12) **S1:** Three

(13) **T:** Which means one of them should grab your attention **shu huwe** *(What is it?)*

(14) **S1: El** *(the)* H^+

The teacher continued using English dominantly in the discourse to explain the scientific concept. However, the teacher explicitly stated that she will use Colloquial Arabic in addition to English to address the question due to the students' obvious lack of understanding. This occurred after several attempts of explaining the same concept in English.

(15) **T: Ya3ne ya Student-18 bl Arabi el mshabra7 inte b haje la yenwajado tlete chemical species bl awal wa ela hal reaction ma bestir hala2 shu byetla3lek hon msh ha el su2al** *(That means* Student-18 *in plain Arabic you need the three chemical species to be present at the beginning of the)* **su2ale ana b hal tlete** *(My question is for these three)* reactants **el mawjoudin bl** *(if they are found in)* initial state one of them **iza ken mawjoud bya3te** *(if it present it gives)* property **lal** *(for)* solution material used

(16) **S1:** Acidic

(17) **T:** Fine Ya3ne **ya** Student-18 **inte** *(you)* you do not care **shu ra7 yetla3lek** *(What will we get)* **ana su2ale huwe haide el** reaction **la tsir**

hal behaje lal H^+ **wala la2** *(My question is for this reaction to occur do I need* H+ *or not)*

(18) **S1: Bala** *(yes)*

(19) **T: Bl tele shu betsammiya haide b aya** medium **3am bestir** initially **ya3ne el** initial mixture *(Consequently what do you call this in what* medium *is this taking place* initially *I mean the* initial mixture*)*

(20) **S1: Y3ne ma behemne el** final? *(So I don't care about the final)*

(21) **T: Hala2 la2** *(Now no)* it's not the question yes you don't care about the final **La2ano** *(because)* if you don't have

(22) **S3: Bas el** *(but the)* overall

(23) **T:** Of course, yes.

(24) **T: Iza hiyye mawjoude hone 7a tbayen ma3na bl** overall **3am tefhame? Ma 3am behtamm shu 3am yetal3le** once **hal tlete** reactants **3am yetfe3alo sawa 3abele a3rif ana hole haide el** reaction **la tsir** *(If it is present here it will show in the* overall *are you getting me? I don't care what I am getting* once *these three reactants are reacting together I would like to know for this* reaction *to take place)* how many reactants are involved and one of them is it H^+ in this case it will confer to the medium acidic property did you understand?

(25) **S1:** Miss **ana haide el** point **fhemta bas ana bas su2ale iza mawjoude bl** product **iza bet7added shu el** medium **aw la2** (Miss *I understood this* point *but my question is only whether it is present in the* product *would it determine what the* medium *is or not?)*

(26) **T: La2 haida gher su2al huwe el su2al sahih bas ana ma 3am ellek** *(No that is a different question the right question is but I am not telling*

you) the final solution is it acidic or basic I'm asking you initial state **ta ta3mle hal** *(so you do this)* reaction **shu el** *(what is)* chemical species **ele badda tkoun mawjoude b awal** *(that needs to be present at first)* in order for them to react **fhemte el** *(did you understand the)* difference**?** You're question is valid but it's not my question **badna nettefe2 awal shi 3al su2al** I'm gonna rephrase it in English **bas abel tfaddal** *(We need to agree on the question first* I'm gonna rephrase it in English *but before go ahead)*

(27) **S1: Nehna bl** *(We in the)* basic medium **ma el** *(not the)* OH^- **ma betkoun bl** *(is not in the)* initial state

(28) **T:** You add it again because it's the easiest way to teach the student to do it

(29) **S1: Ma fhemet** *(I don't understand)* [asked to clarify]

(30) **T:** It is the easiest way to let you balance in a basic medium

(31) **S1: Bas kif mna3ref ina** basic *(But how do we know that it is* basic)

(32) **T:** I'm gonna say to you it's basic in the given or if you apply it in the lab it will not take place unless you add HO^-

Home language across Knowledge Types and Cognitive Processes

To contribute in answering the second research question, the development of conceptual understandings of the scientific concepts was inferred from the analysis of knowledge type and cognitive processes utterances in classroom A. The sessions varied in focus between concept development and practice and test preparation. All the sessions included problem-solving to help the students master the skills needed to pass the exams.

Knowledge Types

The dominance of the factual and conceptual utterances was observed across the different sessions. Table 11 shows the percentage distribution of the knowledge-type utterances of Teacher A and the students in classroom A. Teacher A usually started with questions to activate prior knowledge and establish common grounds for classroom interactions. Factual utterances were dominant where they varied between 62.9% and 76.6%, whereas conceptual utterances varied between 12.5% and 19.9%. In all the sessions, students applied concepts through solving exercises. In those interactions, the utterances also included 'procedural' utterances which varied depending on the focus of the class. In the session where a lab activity was introduced (lesson 5), the percentage of inquiry utterances was 11.6% compared to algorithmic and testing utterances which were 5.0% and 0.7% respectively.

Table 11

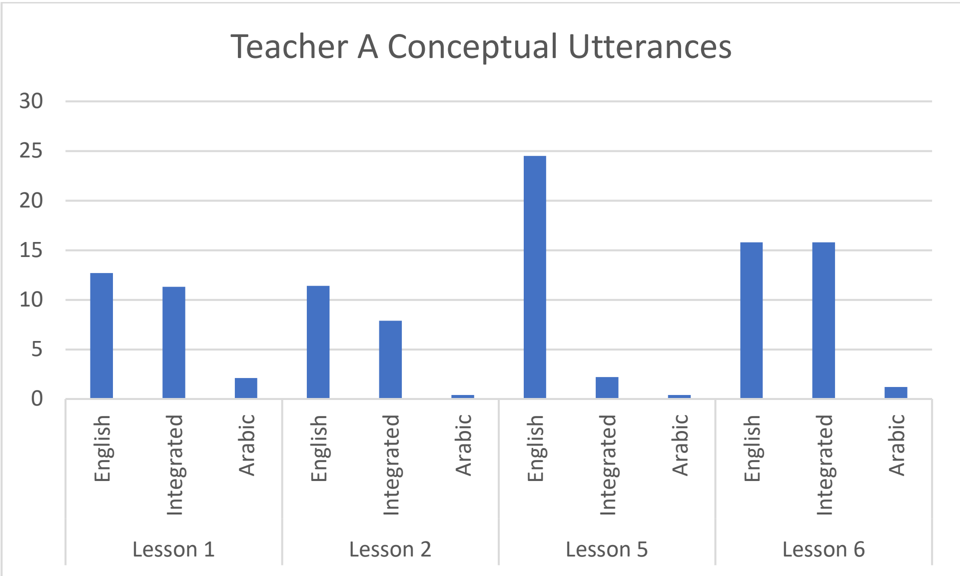
Percentage of Knowledge Types Utterances of Teacher A and Students in School A

Lesson #	Factual	Conceptual	Procedural		
			Inquiry	Algorithmic	Testing
Lesson 1	72.4%	16.4%	2.5%	8.5%	0.2%
Lesson 2	76.6%	12.5%	4.5%	6.2%	0.2%
Lesson 5	62.9 %	19.9 %	11.6 %	5.0 %	0.7 %
Lesson 6	67.6%	20.7%	3.3%	6.7%	1.7%

The language used varied across the teacher, students, and knowledge types. Table 12 shows the distribution of the utterances for Teacher A across different knowledge types and languages used. As indicated earlier in this chapter, Teacher A dominantly used English in the classroom discourse. This is consistent with the dominance of the 'factual' utterances in English where they varied between 38.9% and 50.4%. However, the 'factual' utterances were only 15.0% in integrated and Arabic utterances. The ‘conceptual’ utterances were also dominantly in English where they varied between 11.3% and 24.4%. The ‘procedural-inquiry’ utterances were also dominantly in English where they varied between 2.8% and 17.0% and 5.7% and 8.2% for ‘procedural-algorithmic’ utterances. None of the utterances were of the ‘metacognitive’ level. In sum, despite the dominance of English, the distribution of the language used in the ‘conceptual’ level utterances was relatively equal between English and integrated utterances in lessons 1, 2, and 6 as shown in Figure 1. This indicates an increase in the use of integrated utterances for the ‘conceptual’ utterances compared to the lower-level ‘factual’ utterances.

Figure 1

Percentage Distribution of Conceptual Utterances of Teacher A



Students in Teacher A’s classroom also used English predominantly in the classroom discourse as they were prompted repetitively to use English in their interactions. Table 13 shows the frequency distribution and the percentages of the knowledge-type utterances for students in classroom A. Similar to the teacher, the dominant utterances were of ‘factual’ level where they varied between 39.4% and 54.7% in English. In integrated utterances, ‘factual’ level varied between 22.9% and 40.4%. However, even though the ‘conceptual’ utterances were minimal, the utterances were dominantly integrated and varied between 3.0% and 9.6%. Additionally, the ‘procedural-algorithmic’ utterances were dominantly in English and varied between 0.5% and 8.5%. None of the utterances were of the ‘metacognitive’ understanding level.

Table 12

Frequency Distribution and Percentages of Knowledge Type Utterances of Teacher A

Lesson #	Language Variation	Factual		Conceptual		Procedural					
						Inquiry		Algorithmic		Testing	
		Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Lesson 1	Integrated	33	11.7	32	11.3	2	0.7	2	0.7	1	0.4
	Arabic	7	2.5	6	2.1	0	0	0	0	0	0
	English	137	48.4	36	12.7	8	2.8	19	6.7	0	0
Lesson 2	Integrated	32	11.4	22	7.9	5	1.8	3	1.1	0	0
	Arabic	2	0.7	1	0.4	1	0.4	0	0	0	0
	English	141	50.4	32	11.4	17	6.1	23	8.2	1	0.4
Lesson 5	Integrated	8	3.5	5	2.2	4	1.7	3	1.3	0	0
	Arabic	7	3.1	1	0.4	0	0	0	0	0	0
	English	89	38.9	56	24.5	39	17.0	14	6.1	3	1.3
Lesson 6	Integrated	37	15.0	39	15.8	7	2.8	14	5.7	1	0.4
	Arabic	15	6.1	3	1.2	0	0	0	0	0	0
	English	65	26.3	39	15.8	8	3.2	14	5.7	5	2.0

Table 13

Frequency Distribution and Percentages of Knowledge Type Utterances of Students in School A

Lesson #	Language Variation	Factual		Conceptual		Procedural					
						Inquiry		Algorithmic		Testing	
		Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Lesson 1	Integrated	54	22.9	7	3.0	1	0.4	3	1.3	0	0
	Arabic	16	6.8	1	0.4	0	0	0	0	0	0
	English	129	54.7	3	1.2	2	0.8	20	8.5	0	0
Lesson 2	Integrated	110	40.4	11	4.0	1	0.4	2	0.7	0	0
	Arabic	8	2.9	1	0.4	0	0	1	0.4	0	0
	English	130	47.8	2	0.7	1	0.4	5	1.8	0	0
Lesson 5	Integrated	44	19.2	22	9.6	5	2.2	3	1.3	0	0
	Arabic	20	8.7	2	0.9	1	0.4	0	0	0	0
	English	120	52.4	5	2.2	4	1.7	3	1.3	0	0
Lesson 6	Integrated	69	32.4	12	5.6	0	0	1	0.5	1	0.5
	Arabic	41	19.2	1	0.5	0	0	1	0.5	1	0.5
	English	84	39.4	1	0.5	0	0	1	0.5	0	0

Cognitive Processes

There was a dominance of the "understand" level utterances across the different sessions observed for this study. Table 14 shows the percentage of cognitive processes utterances in classroom A. 'Understand' level utterances were dominant across the lessons where they varied between 53.2% and 90.4 %. The second-highest level was the remember level between 8.5% and 35.6%. As the sessions included solving exercises, some utterances of the 'apply' levels also showed in the discourse. However, the 'analyze' level was at most 0.4% in the sessions. None of the utterances were of the 'evaluate' or 'create' levels.

Table 14

Percentage of Cognitive Processes Utterances in Classroom A

Lesson #	Perceive	Remember	Understand	Apply	Analyze
Lesson 1	0	35.6%	53.2%	10.5%	0.4%
Lesson 2	0.1%	8.5%	58.6%	5.0%	0.1%
Lesson 5	2.2%	16.6%	74.0%	7.0%	0.2%
Lesson 6	1.3%	1.1%	90.4%	6.7%	0.4%

The language used varied across the teacher, students, and cognitive processes. Table 15 shows the distribution of the utterances for Teacher A across different cognitive processes and languages used. As indicated earlier, Teacher A dominantly used English in the classroom discourse. This is consistent with the dominance of the 'understand' level utterances in English where they varied between 36.06% and 67.98%. The second dominant level differed across the lessons and in the language used. In lesson 1, the 'remember' level in English dominated, where the teacher was calling on students to recall rules for assigning oxidation numbers. In lesson 5, however, the 'apply' level and the 'remember' level were almost equal with 9.65% and 8.33% respectively. Despite the dominance of the use of English, Teacher A used equally integrated utterances in the last observed sessions for the ‘apply’ level utterances. None of the utterances were at the ‘evaluate’ or ‘create’ levels.

Students of classroom A also used English predominantly in the classroom discourse as they were prompted repetitively to use English in their interactions. Table 16 shows the frequency distribution and the percentages of the cognitive processes utterances of students in classroom A. Similar to the teacher, the students’ general trend was the dominance of utterances at the ‘understand’ level. However, the students’ dominant language varied across the levels and the different sessions. In lesson 1, the dominant language used was English. In addition, the ‘remember’ level was dominant (34.3%). The focus in this session was for students to recall the rules for assigning the oxidation numbers. As in lesson 1, the dominant language used in lesson 5 was English, but the “understand” level was dominant (36.1%). However, in lesson 2, the dominant utterances were integrated where students expressed themselves at the ‘understand’ level (43.4%). Moreover, in lesson 6, the dominant utterances were at the ‘understand’ level where English (39.0%) and integrated (37.1%) utterances were almost used equally. None of the utterances was of the ‘evaluate’ or ‘create levels.’

Table 15

Frequency Distribution and Percentages of Cognitive Processes Utterances of Teacher A

Lesson #	Language Variation	Perceive		Remember		Understand		Apply		Analyze	
		Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Lesson 1	Integrated	0	0	8	2.7	56	19.1	5	1.7	0	0
	Arabic	0	0	1	0.3	8	2.7	4	1.4	0	0
	English	0	0	75	25.6	112	38.2	22	7.5	2	0.7
Lesson 2	Integrated	0	0	2	0.7	56	20.1	3	1.1	1	0.4
	Arabic	0	0	0	0	4	1.4	0	0	0	0
	English	1	0.4	21	7.5	168	60.8	23	8.2	0	0
Lesson 5	Integrated	0	0	2	0.9	13	5.7	5	2.2	0	0
	Arabic	0	0	0	0	8	3.5	0	0	0	0
	English	3	1.3	19	8.3	155	68.0	22	9.6	1	0.4
Lesson 6	Integrated	1	0.4	1	0.4	81	32.8	15	6.1	0	0
	Arabic	0	0	0	0	18	7.3	0	0	0	0
	English	3	1.2	1	0.4	111	44.9	15	6.1	1	0.4

Table 16

Frequency Distribution and Percentages of Cognitive Processes Utterances of Students in School A

Lesson #	Language Variation	Perceive		Remember		Understand		Apply		Analyze	
		Freq.	**%**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**
Lesson 1	Integrated	0	0	22	9.2	43	18.0	2	0.8	0	0
	Arabic	0	0	2	0.2	8	3.3	7	2.9	0	0
	English	0	0	82	8234.3	57	23.8	16	6.7	0	0
Lesson 2	Integrated	0	0	6	2.2	118	43.4	0	0	0	0
	Arabic	0	0	0	0	10	3.7	0	0	0	0
	English	0	0	36	13.2	90	33.1	12	4.4	0	0
Lesson 5	Integrated	2	0.9	9	3.9	60	26.1	3	1.3	0	0
	Arabic	3	1.3	0	0	20	8.7	0	0	0	0
	English	2	0.9	46	20.0	83	36.1	2	0.9	0	0
Lesson 6	Integrated	2	0.9	0	0	79	37.1	1	0.5	1	0.5
	Arabic	0	0	0	0	44	20.7	0	0	0	0
	English	0	0	3	1.4	83	39.0	0	0	0	0

The following examples demonstrate how the home language was used to help students understand chemical concepts. They also show how the home language varied across knowledge types and cognitive processes.

Teacher A, Example 1. As demonstrated earlier in this chapter, the teacher was explaining the concept behind a disproportionation reaction and how the same species is oxidized and reduced simultaneously. The teacher started her explanation by using a demonstration involving few students each of whom represented a chemical species in her role-play example. She further elaborated using English; however, to involve the students in the interaction she switched to using the home language (Colloquial Arabic). Through the series of interactions (Table 10) where the teacher and the students used the home language and codeswitched for terms such as chemical species or oxidation, the students acquired conceptual understanding of an oxidizing agent and a reducing agent. As shown below, the students' utterances entailed conceptual knowledge type when they used home language versus factual level utterances when using English. However, as the interaction's purpose was to explain the concepts being taught, the utterance levels were at the 'understand' or 'remember' level.

Table 17

Interaction Excerpt between Teacher A and Students in Classroom A

Speaker	Utterance	Knowledge Types	Cognitive Processes
T	ClO- let's say 1 2 or 3 I don't care about the number it's the concept that I'm talking about ClO^- has to gain one electron let's suppose in order to be stable not ClO^- a chemical species needs to gain one electron in order to be stable or to react with another chemical species in order to be stable let's suppose Student10 has also the same issue **bas lesh** *(but why)*	conceptual	understand

	sometimes mm Student14 **badda tejebro la** *(it needs to force*)Student10 **yekhod minna el** *(takes from the)* electron **ma3 ino huwe ma baddo** *(even though it does not want it)*		
T	**shu mnsameya la** Student14 b **hal 7ale** *(What do we call Student14 in this case?)*	factual	remember
S1	Strongest	factual	remember
T	Strongest what	factual	remember
S2	Oxidizing agent	factual	remember
T	Reducing agent	factual	remember
T	why she is the strongest reducing agent	conceptual	understand
S-13	**La2an** *(Because)* she allows the other to undergo reduction	factual	understand
T	**Jabarto** to do this **W huwe shu bkoun** in this case*(It forced it* to do this *and* in this case *what would it be?)*	factual	understand
S3	Strongest oxidizing agent	factual	understand
T	Now but in when Student14 is with Student19 **ma btestarje ta3mela hek lee** *(It doesn't dare to do this for her why?*	conceptual	understand
S4	**Btodroba** *(she hits her)* **[**a joke as an answer]	NA	NA
T	**La2ano** *(because)* Student19 will force her to what	factual	understand
S-13	**Hiyye bta3teya el** electron *(She gives her the* electron*)*	factual	understand
T	Exactly	NA	NA
T	**Se3eta shu btel3ab el** role **hiyye hon** strongest what *(Ok then what role does it play here?)*	factual	understand
S-13	**Hiye mara btkoun** *(She will be one time)* strongest reductant	factual	understand
T	She's the strongest what	factual	understand
S-13	**Hon** *(Here)* oxidant	factual	remember
T	What did she do with the electron is she excess	factual	remember
S1	Oxidant	factual	remember

S2	Oxidizing agent	factual	remember
T	Why	conceptual	understand
T	Because she accepted the electron because **7adreta** is a very strong reducing **ya3ne 3anda** *(It has)* electron **w bl 2uwe** *(by force)* it's a strong electron affinity	conceptual	understand
T	So Student14 **marra shu 3emlet ma3** Student10 Student14 *(so student14 once did what with* student10 student14*)*	conceptual	understand
S-10	**3atyetne** *(It gave us)* electrons	factual	understand
T	**kenet** *(it was)* chemical species that's Giving away its electrons known as the .. [waiting for response] the chemical species that gives away its electrons in a redox reaction **shu shu mn2oul 3anna** *(What what do we call this?)*	factual	remember
S 3	Reducing agent	factual	remember
T	Reducing agent	factual	remember
T	**w nafsa** *(and the same)* Student14 **ma3** *(with)* another chemical species **kenet mest3ede ino shu ta3mol** *(it was ready to do what?)*	factual	understand
S4	**Tekheda** *(to take it)*	factual	understand
T	**tekheda** *(to take it)* so plays the role of an oxidizing agent it's the same concept here [pointing to board]	conceptual	understand
S-19	But she's not the strongest **huwe el** *(he is the)* strongest	factual	understand
T	Yes yes	NA	NA
T	It depends on the chemical affinity **ya3ne ma3 aya** *(that means with which)* chemical species **hiyye** *(is it)* yes Student3	conceptual	understand
S-3	Miss **nehna bas mara2 ma3na** strongest oxidizing agent **elteelna 7asab el** electron **ya3ne el** electron **iza ken haida el** strongest oxidizing agent w **iza ken hon** strongest reducing agent **bas hon alabtiyon 7asab el** formula **ya3ne** *(*Miss *when we learned*	conceptual	understand

	before about the strongest oxidizing agent *you said it depends on the* electron *meaning if the* electron *was that of* the strongest oxidizing agent and *if it was* strongest reducing agent *but here you switched them depending on the* formula*?)*		
T	**Ma alabnehon** *(We didn't flip them)*	factual	understand
S-3	**Bala** *(yes)*	factual	understand
T	**3am tna2de 7alek ya** Student3 *(you are contradicting yourself)*	NA	NA
T	**la2ano hinne tnayneton bya3mlo nafs el** the two ideas **ele 3am tehkiyon 3andon** the same answer *(Because both of them do the same thing the* two ideas *that are taking them* the same answer)	conceptual	understand
T	**shu bta3mel bl** electron gain them **ya3ne bet2asheton la ghayra el** oxidizing agent is a chemical species that *(What does it do with* electron gain them *that means it takes it from the* oxidizing agent is a chemical species that)	conceptual	understand
S1	Gain them	factual	understand
S-3	**Ya3ne msh hinne bya3towa** *(That means they did not give it)* **[**showing understanding]	factual	understand
T	**Le bet2asheton la ghayra la2ano haideke mesta2tel ykebbo ma hiyye 2usset** affinity chemical affinity **le ana hal2ad awiyye ashatto yei w huwe mano metmasak fi lal** electron *(Why does it snatch it from the other one? Because the other one can't wait to throw it away. It is a matter of* chemical affinity *why is it that strong so it snatches it and why is it not holding on this* electron*?)*	conceptual	understand
T	**shu 3am ya3mol** *(what is it doing?)*	conceptual	remember
T	he's giving it away	factual	remember
S -3	**Ah msh el** one that loses **huwe el** oxidizing agent **el** one **ele bekhalle el**	conceptual	understand

	tene to lose *(Oh not the* one that loses *it is* oxidizing agent *the* one *that makes the other one* lose)		
T	Fine **Ele byejbor el tene ya3mol** oxidation *(*Fine *the one that forces the other to do* oxidation)	conceptual	understand
S-3	oxidation	factual	understand
T	that's why it's called oxidizing agent	factual	remember

Teacher A, Example 2. This example was used earlier to illustrate the use of analogies to bridge the scientific/everyday discourse. Students were not grasping the concept of oxidation number variation and what the increase/decrease of oxidation number indicates. The teacher resorted to using an example of money exchange. The teacher alternated between using the home language (Colloquial Arabic) when the students were and the international language (English) in other interactions. Students' discourse was mainly in Colloquial Arabic (home language). Students' knowledge type utterances varied between conceptual and factual. The cognitive processes utterances were of the higher level " apply" type.

Table 18

Interaction excerpt between Teacher A and Students in Classroom A

Speaker	**Utterance**	**Knowledge Types**	**Cognitive Processes**
T	Now Student6 Student6 **inta lyoum na2sak 7000 bukra midre min meen 3melet film sar na2sak** *(you are missing today 7000* [Lebanese Pounds] *tomorrow you)*	conceptual	apply
Ss	**La** *(no)* Student1	NA	NA
T	**Ah haida** Student1 **ken lezem** Student1 **yetla3** ok **tab inta na2sak lyoum 7000 Lira bukra sar na2sak 2000** [Lebanese Pounds] *(Oh that's Student1 I should've called on Student1 ok now you are missing today 7000*	factual	apply

	Lebanese Pounds tomorrow you are missing 2000)		
T	**ma 7ada yjeweb lee** *(No one gives him the answer)*	conceptual	NA
S	**Bade mino 1000** [Lebanese Pounds] **ana** *(I want from him 1000)*	factual	apply
T	listen listen	NA	NA
S2	**La2a 5000** [Lebanese Pounds] *(He found 5000)*	factual	apply
S3	**5000 we23et minne** *(5000 fell from me)*	factual	apply
T	**Inta na2sak 7 bukra na2sak 2000 lesh kif shu** *(You are missing 7 tomorrow you are missing 2000 why how?)*	conceptual	understand
T	**kif dabbaret 7alak** *(How did you manage alone?)* simple math **ya** Student6 ok?	NA	NA
T	**Na2sak 7000 lira kif bukra shu 3melet la sar** tomorrow **na2sak 2000** *(you need 7000 lira how? Tomorrow what did you do?*	conceptual	apply
S4	**Akhadet 5000** *(I took 5000)*	factual	apply
S5	**Abadet 5000** *(I took 5000)*	factual	apply
T	Merci **akhadet** *(it took)* gained	factual	apply
T	**adde 2000 5 adde?** *(How much 2000 5 how much?)*	conceptual	apply
S	**Shu** *(What?)*	conceptual	understand
	….		
T	**so inta ken na2sak 7000(Arab) 7ada** *(So you needed 7000 someone)*	conceptual	apply
S–T	**Eh Miss huwe eede el shmel** *(Yes Miss he is my left hand)*	NA	NA
T	**Eh ma3loum** *(yes of course)*	NA	NA
T	**so Student15 2allak inta sar ma3ak 2000 (alfeen) bukra na2sak 2000 (alfeen) la2ano 7ada 3atak adde** *(So Student 15 told you you now have 2000 tomorrow you are missing 2000 because someone gave you how much)*	conceptual	apply
T	**khamse ok** *(five ok)*	conceptual	apply
T	so this is why the value of the oxidation number **ken** *(it was)* plus 7 **sar** *(it became)* plus 2 **ma3neta** *(that means)* this chemical species		

T	**shu 3emlet** *(What did it do)* in order to ensure **bas 3anda** *(but it has)* oxidation	inquiry	understand
Ss	Gain	factual	understand
T	So Gain 5 electrons	factual	understand
T	if you want to compare the variation of this oxidation number	inquiry	understand
S-13	Decrease and undergoes reduction	conceptual	understand
S	Oxidation number	factual	understand
T	It was plus 7 then plus 2	inquiry	understand
S -13	**Saret** plus 2	inquiry	understand
T	It's **shu** *(what)*	factual	understand
S-13	oxidation number decreases so reduction	conceptual	understand
T	Yes	NA	understand

Summary of findings for Classroom A

The dialogicity of the classroom interactions, number and utterance distribution, in addition to patterns of practices were determined for Teacher A to contribute to answering the first research question. The dominant communicative approach employed by Teacher A was the authoritative interactive approach. To involve the students in the 'science story', Teacher A engaged the students often in IRE/IRF chains of interactions. In some lessons, there was evidence of the dialogic interactive approach where students' ideas were explored, and their participation was more meaningful. The amount of talk in Classroom A was distributed relatively equally between Teacher A and the students. Teacher A used English dominantly in her sessions, but the students used English and Colloquial Arabic relatively equally. When Teacher A prompted her students to use English, the students' use of English increased. Also, the students tended to use English for short one-word answers.

Several patterns emerged for Teacher A during the observed sessions. Teacher A used English to state objectives and start classroom interactions. She also emphasized the use of English as the language of science. She repeatedly asked her students in classroom A to use English in the classroom discourse. Teacher A used English dominantly in her sessions even in explanations and elaborations. She would only use Colloquial Arabic in her explanations after several attempts to explain/elaborate the concepts in English. She used Colloquial Arabic and codeswitched to English to introduce key terms. However, Colloquial Arabic was mainly used for classroom management purposes. Furthermore, Teacher A attempted to relate science to everyday life (monetary example).

The variation of the home language across knowledge types and cognitive processes was determined for classroom A to contribute to answering the second research question. Teacher A's sessions varied between concept development and practice and test preparation; where all sessions included problem-solving. As indicated earlier, the use of language differed between Teacher A and the students within the classroom. In the interactions where Teacher A used Colloquial Arabic, the students were more engaged, and the discussion seemed to be more meaningful. Also, Classroom A students' utterances were of higher levels when they used Colloquial Arabic. Often, the short one-word answers were of the lower knowledge type and cognitive processes levels. The 'factual' level of knowledge type utterances was dominant across the different sessions. The 'understand' level of cognitive processes utterances was dominant across the observed sessions.

Analysis of Data from Classroom B

This section presents findings for the second case, Teacher B, and is divided into three parts. The first two parts contribute to answering the first research question by describing the dialogicity of the classroom interactions and the patterns of the teacher's language practices. The third part contributes to answering the second research question by presenting the use of home language and variations across knowledge types and cognitive processes.

Dialogicity of Interactions in Teacher B's Chemistry Classroom

As indicated in chapter 3, the communicative approach explicates the means through which teachers interact with students to attend to the ideas that are presented in the classroom. The communicative approach of the teacher can be inferred from classroom interactions, how the teacher engaged with learners to accomplish conceptual understanding. in addition to the nature and number of utterances used in the classroom.

Classroom Interactions

Teacher B's observed sessions were centered on learning about titration and learning the skills for solving exercises. The teacher assigned practice exercises and worksheets as homework. Then during the sessions, Teacher B asked one of the students to demonstrate the solution on the whiteboard. Then, the teacher circulated among the students to check whether they have done their homework. Afterward, she begins to correct the solution on the board while engaging the students in a discussion to ensure that they understood all the concepts. She also asked students to point out difficult items and these were highlighted in the class discussion. The teacher allowed sometimes the exploration of other ideas, but she brought the discussion back to the session's objective and the scientific points to be addressed. Teacher B's sessions were mainly interactive; she prompted students to actively engage in the classroom discourse.

Whole class discussions were dominant in the sessions where few students participated in the discussions.

The dominant patterns of discourse were variations of IRE (Initiation-response-evaluation) and IRF (Initiation-response-feedback) chains across the different sessions. Teacher B often asked questions to stimulate the students' engagement in addition to maintaining their attention. She led the students using close-ended, purposeful questions to reach the targeted scientific concepts. Moreover, Teacher B's authoritative voice was clear through her immediate evaluations of student responses. The evaluation was often a repetition of the answer followed by a new question. In other cases, the teacher repeated the question to indicate that the correct answer was not provided. Sometimes the evaluation was coupled with words of encouragement such as "excellent" or "bravo" or "plus one on the classwork". The dominant communicative approach that Teacher B employed was authoritative interactive, as demonstrated in the example below.

Authoritative Interactive Interaction. In the following excerpt, the teacher wanted to establish the exercise's objective to determine the mass of a given product. She started this classroom interaction by asking the students to recall the objective of the titration in the exercise. In the previous session, the teacher introduced an interactive exercise where an everyday application of titration was used. She guided the students through a series of leading close-ended questions to reach the targeted objective. The teacher's questions (lines 1, 4, 6, 8) show that she was looking for one acceptable answer. As shown in lines 4 and 8, the teacher was evaluating students' responses by acknowledging the answer as probable but then asking the question again to indicate that she's looking for a different answer.

(1) **T:** Ok Student-2 what is the objective of my titration? How do I titrate? I want to check yesterday the vinegar you saw it **ino (***that)* it was labeled 5%. Let's say we have same label here what can I check? **Elna (***we said)* what yesterday we checked what? [Teacher draws figure on the board]

(2) **S_1:** Percentage

(3) **S_2:** Volume

(4) **T:** Percentage or once I showed you yesterday the vitamin C

(5) **S_3:** Concentration

(6) **T:** I can check what?

(7) **S_3:** Concentration

(8) **T:** We can say concentration. With vitamin C I checked what

(9) **S:** Mass

(10) **S_2:** Mass **tul3o nos kilo** *(we got half a kilo)*

In line 6, the teacher repeated the question as the students did not provide the answer she wanted. Once few students provided the answer she was looking for (lines 9, 10), the teacher started a new line of questioning for the next steps for solving the exercise (line 11).

(11) **T: Hala2** *(Now)* later on **in sha' Allah** *(if God wills)* we can check the solubility and other substances but this year we are restricted by percentage concentration **w el** *(and the)* mass. What do I do to check for the percentage or concentration or the mass?

(12) **S_2:** I take a sample.

(13) **S_3:** Titration

The teacher started selecting the answer to complete the scientific story she was building (line 14) so that the students learn the steps to solve the exercise (lines 19, 21).

(14) <u>**T:** I have to take a sample</u>

(15) **S_4: Ba3deen** *(then)*

(16) **S_5:** Dilute

(17) **T:** Once I take a sample [students chatter in the background] usually we have two ways [teacher waiting for response]

(18) **S_5: El** (*the)* dilute

(19) **T:** We have two ways first way we make dilution especially if I have some concentrated or commercial solution **w tafa2na** *(we agreed)* commercial **ya3ne** *(that indicates)* concentrated solution so if I have especially commercial solution I make dilution so I have to take some sample **lakan** *(then)* I have to take sample

(20) **S: Lesh bya3mel dilution iza hinne baddo ya3mela study** *(Why do they do dilution if they want to study it?)*

(21) **T: Lakan** *(then)* study substance sample then??? **Khalas** *(that's it so)* I can titrate directly.

(22) **S_2: Eh w ba3den** (….) **(***yes and then)*

(23) **T:** here I have dilution then?

(24) **S_2:** After dilution

(25) **T :** Here I have dilution then

(26) **S_2:** Then I take C **mn haide** *(from this)*

(27) **T:** Withdraw

(28) **S_2:** Withdraw to a beaker

(29) **T:** <u>To a beaker excellent **ya** Student-2</u>

(30) **S-3: Ba3den haide** *(then we use this)* **el** *(the)* graduated cylinder

(31) **T: La2** *(no)*

(32) **S-3: La2 shu** *(no what?)*

(33) **S3:** Burette burette

(34) **S4:** Burette

(35) **T:** <u>Burette</u>

(36) **S-3: Ehh el** *(yes the)* burette

(37) **T:** <u>Then I titrate by burette</u>

(38) **S-3: Ehh** *(yes)*

Dialogic Interactive Interaction. Teacher B also used a dialogic interactive approach in one of the sessions. The following shows an excerpt from the interaction which exemplifies the dialogic interactive communicative approach of Teacher B. She actively sought the students' points of view by introducing an inquiry exercise. She asked the students to consider their class as the Ministry of Health where they were tasked to determine the accuracy of labels on some products. She introduced this exercise to relate titration to daily life and to learn about its application. She explicitly asked the students to share what they heard about the role of the Ministry with questions such as "**Kamen meen 3ando aya shi bl nesbe**" *(Ok what else? Who has anything else regarding)* (line 10) and **"shu btesma3o kamen" (***What do you also hear?).* The students were actively engaged in this discussion. Both the teacher and students mostly used Colloquial Arabic (home language) to express themselves. The teacher codeswitched to English for the scientific terms.

(1) **T: Yalla hala2** *(ok now)* examples from our life very important who know the ministry of health? The job or role of the ministry

….

(2) **T:<u>Khalina nesma3 kil wahad shu seme3 3an hay shu dawra shu mumkin na3mol</u>** *(Let us now listen to each one what did you hear about this? what is its role ? What could we do?)*

….

(3) **T: El** *(the)* ministry of health **lezim ykoun akide el** main major **aw** main subject **la elo huwe el** chemistry chemist **la2an** without chemist **hala2 7a tshufu b aya** process **bl zabot** I can't work on my or continue my work *(The ministry of health has to have for sure the main major or main subject for this is chemistry chemist because without a chemist now you will see in which process exactly I can't work on my or continue my work)*

(4) **S – 4: Iza 7ada bado ya3te dawa lal 3alam, lezim awal shi y7added** concentration **kil shi. W haide e**l ministry of health **hiyye bta3mel** titration **la haida el dawa la ta3rif iza huwe** accepted aw rejected. *(If someone wants to give a medicine to the people they should first determine the concentration and everything and this* ministry of health *does the titration for this medicine to determine whether it is* accepted or rejected*)*

(5) **T: Ya3ne** *(That means)* I have some given concentration on a medicine or anything, then the role of ministry?

(6) **S-4:El** *(the)* titration [teacher draws on the board]

(7) **T:** Titration

(8) **S -4:** Accepted or rejected [says to Teacher B? teacher draws on the board]

(9) **T:** Accepted or rejected, excellent.

(10) T: <u>Kamen meen 3ando aya shi bl nesbe lal</u> <u>ministry of health?</u> *(Ok what else? Who has anything else regarding the ministry of health?)*

(11) **S1: Iza el matar w el saydaliyet 3am bebi3o ashya** *(If the airport and pharmacies are selling things)*

(12) **T: El matar msh bas** medicine food *(The airport not only medicine food)*

(13) **S1: Eh bshouf iza 3am yra3o el ma3ayeer** *(Yes we see that they are conforming with specifications)*

The teacher used students' answers provided in Colloquial Arabic to continue the scientific story she was building. In some instances, she allowed space for different ideas to emerge (lines 4, 11, 13). However, she directed the discussion to include the ideas that would lead to an understanding of the concept of titration (lines 5,14). For example, once a student provided the answer she was looking for (line 13), Teacher B started narrowing further the discussion to bring together the titration procedure. She

(14) **T: Bera3o el ma3ayeer. Shu ya3ne bera3o el ma3ayeer? <u>Lahazto? Ana behemne haidel el 2osas ele into 3am tesma3owa bl akhbar b 7ayetna how can I translate in chemistry bera3o el ma3ayeer shu azdon</u>** *(They conform with specifications what does it mean to conform to the specifications? Did you notice? What I care about in these stories you're hearing about in the news in our daily lives is how can I translate that to chemistry. They conform to specifications what does it mean?)*

(15) **S1: Ya3ne byederso el ashya** *(That means they study the things)*

(16) **T: Lama 3am y2oulo ra3o el me3yar shu azdon**? Accepted *(When they say they are conforming with the specifications what do they mean accepted?)*

Teacher B repeated her question on "**shu ya3ne bera3o el me3yar"** *(what does it mean to conform with specifications?)* (lines 14, 16, 19, 21 to lead the students to relate the conversation and the terms to that of the procedure of the titration.

(17) **S:** Concentration?

(18) **S:** Miss **ya3ne** *(Miss that means)*

(19) **T: Ya3ne shu azdna hal** *(so what do we mean in this)* in the process **ya3ne** *(meaning)* do you agree with Student-4 **bera3o el me3yar shu azdon fiya** *(conform with specifications what do they mean by it?)*

(20) **S: Ya3ne iza** accepted

(21) **T: Bera3o el me3yar ya3ne hal** accepted value **aw ma bera3o el me3yar ya3ne** *(They conform to specifications means accepted value or they do not conform to specifications means)*

(22) **S -4:** Rejected

(23) **T:** rejected not accepted value. **Tab** *(Ok so)* do you have any idea not rejected not accepted?

….

(24) T: Bya3towon inzar wa *(They give them a warning and) w* **besakro shu bya3mel ya3ne** *(and they close it what does that mean?)* **Asesan shu bya3mlo hinne shu btesma3o kamen hek ashya walla la edro yousalo la hal part 3amalo shi** *(Originally what do they do? What do you also hear things such as so they could have reached this part they did something)*

(25) **S-4:** Titration

(26) **T: Ma be2ellek** titration *(They do not say* titration*)* **<u>b2oul shi m3ayyan</u>** *(they say something specific)*

In line 26, Teacher B's approach started diverting to authoritative as she was explicitly asking the students. In line 28, the authoritative evaluative voice of the teacher is evident where she repeated the answer followed up with "excellent" to indicate that the student got the right answer.

(27) S3: Ahh **3ayyinee** *(Sample)*

(28) **T :Akhado 3ayyine** excellent *(They took a sample)* **akhado 3ayyine shu ya3ne 3ayyiune ya3ne** sample *(They took a sample what does that mean sample meaning* sample*)*

(29) S3: Ya3ne part zgheer part **minna** *(That means a small part from it)*

Number and Distribution of Utterances

The amount of classroom talk was distributed almost equally between Teacher B and the students. However, the length of the utterances of Teacher B was often recognizably longer than that of the students. Students often offered one or two-word answers, however, Teacher B elaborated her utterances. To show the distribution of utterances' between Teacher B and the students, and to avoid overwhelming the reader with the amount of data generated in the six observed sessions, the first two and last two sessions are summarized in Table 19. The first and last two sessions were selected to ensure that the classroom practices were captured across the sessions. The researcher noticed no significant changes in the teacher's practices across the observed days.

Table 19

Frequency Distribution and Percentages of Utterance Distribution of Teacher B and Students

Lesson #	Teacher B		Students	
	Frequency	%	Frequency	%
Lesson 1	260	46.4%	300	53.6%
Lesson 2	225	51.3%	214	48.7%
Lesson 5	253	49.9%	254	50.1%
Lesson 6	297	45.6%	354	54.4%

The distribution of the utterances in classroom talk of Teacher B and the students were relatively equal. The integrated utterances were dominant where Colloquial Arabic was used throughout the lesson, however, chemical terms were inserted in English. Teacher B used both Colloquial Arabic and English in all of the sessions, where 46.9% to 66.4% of the utterances were integrated. However, English utterances varied between 21.9% and 44.2% across the sessions. A summary of the overall language variations of Teacher B's use of English and Colloquial Arabic over the six observed lessons is shown in Table 20.

Table 20

Frequency Distribution and Percentages of Language Variations for Utterances of Teacher B

Lesson #	English		Integrated		Arabic	
	Freq.	%	Freq.	%	Freq.	%
Lesson 1	115	44.2%	122	46.9%	23	8.8%
Lesson 2	85	37.8%	126	56.0%	14	6.2%
Lesson 5	56	22.1%	168	66.4%	29	11.5%
Lesson 6	65	21.9%	196	66.0%	36	12.1%

Both Teacher B and the students used Colloquial Arabic in the classroom. As shown in Table 21, the students' use of integrated utterances was dominant, it varied between 51.0% and 67.3%. Interestingly, the students' use of only English was at most 32.2% and it was mostly one or two words utterances.

Table 21

Frequency Distribution and Percentages of Languages for Utterances of Students in Sessions of School B

Lesson #	English		Integrated		Arabic	
	Freq.	%	Freq.	%	Freq.	%
Lesson 1	69	23.0%	161	53.7%	70	23.3%
Lesson 2	69	32.2%	97	45.3%	48	22.4%
Lesson 5	32	12.6%	171	67.3%	51	20.1%
Lesson 6	81	22.9%	180	50.8%	93	26.3%

Teacher B Language Practices

During the sessions, different patterns emerged for the practices employed by Teacher B to support her students' conceptual understanding in the classroom. Teacher B presented lessons in English and codeswitched to home language (colloquial Arabic) occasionally. During whole-class presentations/explanations, Teacher B almost always codeswitched between Colloquial Arabic and English while also using the whiteboard to draw diagrams for support. Teacher B used English to introduce the concepts, read exercises, and highlight key terms. However, she integrated Colloquial Arabic utterances as transitions such as "**yalla"** *(ok then),* "**lakan"** *(then)*, "**hala2 hon"** *(now here),* "**fa"** *(then).*

Teacher B used Colloquial Arabic (home language) more frequently in concept elaboration and explanation. Also, Teacher B tended to switch to Colloquial Arabic to help students follow the reasoning of the exercise (e.g. "**lahazto hala2"**? *(Did you notice now?)* "**Metel ma elna"** *(Like we mentioned before)*), to probe or prompt responses, and/or addressing student's specific question. Additionally, Teacher B used

Colloquial Arabic to make jokes, to relieve some tension in the classroom, to grab students' attention, and to elicit students' involvement.

Teacher B often engaged students with questions to elicit their responses. However, most questions were close-ended and required one or few words as answers, which is illustrated in the interactions shown below. Also, the questions were mostly statements in which the teacher starts with a sentence and then stops at a word with a questioning tone or simply waits for a response from the students. Students' answers alternated between short English utterances and more elaborate Colloquial Arabic or mixed utterances. Students were very engaged when the teacher's questions were in Colloquial Arabic and the discussion was lively. Below are examples of the identified patterns of the language practices that Teacher B employed in her classroom.

Use of English to State Objectives and Start Classroom Interaction. A trend that emerged across Teacher B's different sessions was the use of English to start the session and to state the objectives.. However, the teacher integrated Colloquial Arabic for transition words such as "**ino"** *(that),* **"hala2"** *(now),* **"yalla"** *(ok then),* and **"elna"** *(we said).* Almost all the sessions started with informal interactions with the students for classroom management purposes. The following examples are form different sessions where the stated objective is underlined, and some managerial interactions were removed.

Teacher B, Example 1. The following example was at the beginning of the session. The teacher asked the students to share the roles of two chemicals in everyday life. These chemicals (potassium permanganate and oxalic acid) were used as reactants in titration exercises.

(1) **T:** Student1, <u>please answer the questions about role of potassium permanganate in everyday life and oxalic acid in everyday life .</u>

(2) **S-1: Na3am?** *(Yes?)* Ok [student stands in front of the class to present]

(3) **T:** <u>What is the role first of potassium permanganate in everyday life ?</u>

(4) **S-1:** Removes magnesium and iron from the water and rust caused in water equipment and pipes. Treatment of fish disease. Medical purposes including an antiseptic and fungicide treatment of various skin infections such as eczema,dermatitis, acne and other fungal infections in hands and legs. Ttreatment of wounds with pus, oozing, and blisters.

(5) **S: Shu hay?** *(What is that?)*

(6) **S-1: El 3amal ele byetla3 mn el jere7** *(The pus that comes out of the wound)*

(7) **T:** <u>What is the role of oxalic acid **hala2** *(now)* you have some idea about oxalic acid? What do I mean by oxalic acid what is it?</u>

(8) **S-1:** Oxalic acid is a poisonous crystalline acid with a sour taste, present in rhubarb leaves, wood sorrel, and other plants.

(9) **T:** What is mmm the disadvantage of oxalic acid?

(10) **S-1:** Kidney stones, low blood pressure, mouth and throat pain, vomiting, weak pulse.

(11) **T:** Thank you. <u>Let's **hala2** *(now)* correct briefly the graded homework did you find any problem while solving (…)</u> [several students start answering]

Teacher B, Example 2. The following example is at the beginning of a session. The teacher started the classroom interactions by revising the main objective for titration.

(1) **T:** Student-2 **yalla** *(ok now)* let's summarize what we did yesterday about the titration. **Elna** *(We said)* what is the main of objective for titration?

(2) **S2: Miss la la nla2e iza fi shi zeyed b alb el shi aw la2** *(Miss to find if there is something added in the thing or not)*

….

(3) **S2:** Miss miss **tanshuf** *(so we see)*

(4) **T: Eh (***yes***)** titration

(5) **S2: iza fi shi huwe 3anjad bl …. Wala la2** *(if there is really something in (….) or not)*

(6) **T:** To check

(7) **S2:** To check if the substance is the same.

(8) **T:** As what

(9) **S2:** As the as the

(10) **T:** As the label says

Teacher B, Example 3. The following example is from the beginning of a session. The teacher started the session by stating the objective for the exercise they previously worked on in the session before.

(1) **T:** Ok Student-2 what is the objective of my titration? how do my titrate? I want to check, yesterday the vinegar you saw it **ino (***that)* it was labeled 5%. Let's say, we have same label here, what can I check? E**lna (***we said)* what yesterday we checked what? [Teacher draws figure on board]

(2) **S1:** Percentage

(3) **S2:** Volume

(4) **T:** Percentage or once I showed you yesterday the vitamin C

(5) **S-10:** Concentration

(6) **T:** I can check what?

(7) **S-10:** Concentration

(8) **T:** We can say concentration. With vitamin C I checked what?

(9) **S:** Mass

Use of Integrated Language in Elaborations and Explanations. During elaborations and explanations, Teacher B often used Colloquial Arabic while inserting chemical terms in English as there is no equivalent for the terms in Colloquial Arabic. The teacher indicated to the researcher that she often switches to Colloquial Arabic since it is the language students use in their daily lives. She commented that in this way she would make sure that the students understood the chemical concepts.

Teacher B, Example 1. After introducing an inquiry exercise during which the students act as the Ministry of Health, the teacher was further engaging the students in relating the terms they hear on the news with the process of titration. She asked the students about terms they hear in the news such as "**iza btesma3o bl akhbar**" (*if you hear in the news?*), "**be2oulolkon 7atteen** label **fo2** label" *(they say that a label was placed over the other)*. She elaborated, explained, and related the terms to those of titration while using integrated utterances of Colloquial Arabic (home language) and English (international language).

(1) **T:** **Bas** *(but)* by titration I find [she writes 5% on board]. T**ab3an iza btesma3o 7atta bl akhbar keno y2elo yeb2o mghayreen el** label *(of course even on the news if you listened to it, they used to say they have changed the label)*

(2) **S5: Eh hek marra 2alo** *(Yes they said that once)*

(3) **S2 :Mghayreen el terikh** *(They changed the dates)*

(4) **T: La mawdou3 e**l expiry date **haida gher mawdou3** *(No the expiry date is a different matter)* **bas ktir be2oulolkon 7atteen** label **fo2** label **nafs el fikra aw masalan metel el** vitamin C **ka medicine kamen hon** what is the mass? *(But many times they say that a label was placed over the other, that's the same idea or for example like the vitamin C as a medicine also here, what is the mass?)* [Teacher shows them a bottle of vitamin C]

(5) **S6:** 500 gram milligram

(6) **S7: Miss ha mbayne mbayne** *(Miss this is very visible)* [to indicate that the label manipulated by the teacher was clearly visible]

(7) **T: Ma mbayne ma 3am 7awel 2ad ma fiyye zabeta aktar mn hek ma btezbat** *(Yea it is visible I tried as much as I can to conceal it but it didn't work)* **bas tan2oul kamen** I doubt **kamen** how **lakan** vitamin C **lan2oul** I doubt **inno** my vitamin C **huwe** 500 *(But let us say I also doubt how? Let us say I doubt that my vitamin C is really 500)*

(8) **S:** Miss **su2al** *(Miss, a question)*

(9) **T: Fa** actually **adde ya S tuli3 ma3na?** *(So, S actually how much did we have?)*

(10) **S:** 100

(11) **T: 100 lakan hinne 7ateen label 500 bas hiyye fi3liyan 100 mg** *(100 then they have placed a label of 500 but it is actually 100 mg)*

(12) **S2:** Miss **ma 7a tetla3 nos kilo ya3ne** *(Miss it will not be half a kilo)*

(13) **T: Hala2 ka** medicine **shu bisir masalan b ma ino ana 3am bekhod la n2oul** Panadol **one** tablet of Panadol **7atta 3laya** 500 mg **fa ana**

b2ammen ino rase 3am yuja3ne shu mna3mel mnekhod one tablet **byemshe el hal.**

Lama hinne ykouno 3anjad 7atteen 100 **bas el** label **ghalat shu bsir walla akhadet hal** Panadol **ma 7aset re2et le la2ano 7atteen** mass **2a2al mn el matloub bikoun ma ka2ano akhadet wala 7abbet** Panadol **wala ra2 rase w el 3akes kuliyan law keno hinne** 500 **w 7attayna tan2oul** 800 *(Now as a medicine what is the case? For example, let us say I am taking Panadol, one tablet of Panadol which has 500 mg as the label. So, I feel safe since I have a headache, we take one tablet and will feel better. When they put on the label 100 but the label is inaccurate what happens? So, I took a Panadol tablet but I did not feel better because the labeled mass is less than the dosage I am supposed to take. It is as if I did not take any Panadol tablet nor did I feel better or if the situation is reversed completely if it is actually 500 but we had the label as 800)*

(14) **S: Ouff**

(15) **T: Shu bsir?** *(What happens?)* **Bsir el** medicine toxic **la2ano** *(because)* I take from overdose **fa hon lakan** *(then here)* the importance of ministry of health to check always the percentage the concentration.

(16) **S:** Miss **bas fi nes byekhdo 7abteen ya3ne ma byeswa?** *(Miss but some people take two tablets is it unsafe?)*

(17) **T:** What can I check?

(18) **S:** Miss **tab 3ande su2al** *(Miss I have a question)*

(19) **T:** I can check the percentage I can check **lahazto hala2 el** *(did you notice now the)* mass I can check the concentration anything on the box I can check it ok?

Teacher B, Example 2. During this session, the teacher provided an exercise in which students were asked to determine the accuracy of the label of a commercial vinegar bottle. She introduced the formula for calculating percentage error. The following interaction was initiated by a student. He was looking for further clarification on why the teacher chose the experimental value of the commercial solution before it is diluted to calculate the percentage error. The teacher explained using the whiteboard pointing out the different beakers and using Colloquial Arabic and inserted chemical terms in English (lines 2,4, 6).

(1) **S-1:** Miss **le 7atayta honik el** concentrated **hiyye el** experiment [experimental value] **w bl** formula **7atayte te3et el** experiment [experimental value] **msh mn7utta bl 3ade abel el** dilution? *(Miss why did you put the* concentrated *over there isn't it the* experiment *and in the formula you put the* experiment *don't we usually put it before* dilution*?)*

(2) **T:** <u>**Ahh la2 azde hon tab3an** diluted **ya3ne** experimental **azde fiya lama ousal lal** commercial **ya3ne hay**</u> *(Oh no I mean here of course* diluted *meaning* experimental *I mean in it when I reach* commercial *meaning this)*

(3) **S-1:** Before dilution

(4) **T:** <u>**Ya3ne hay** [showing on figure on board] **inte** *(it means this you)* already **hone iza bdk** *(here if you want)* experimental **w hay iza baddek** el *(and this if you want the)* C zero **ele hiyye el** *(that is the)* label [pointing to figure on board] **fa** you compare the C zero experimental</u>

ma azde hon ana azde *(I don't mean here [pointing to a beaker] I mean here [pointing to another beaker]* by experiment **wsulte la hon** *(you reached here)* [pointing to figure on board] **ana azde** *(I mean)* by experiment **haide el** *(that is the)* chart **wsulte la hon** *(you reached here)* you compare the C zero experimental to that on the label you compare **hay aw hay aw yimkin badal mn ba3ed el** C zero **ele hiye el** *(that is the)* vinegar **kaffayna mn ba3da shefna el** percentage **kamen** *(also)* percentage experimental you compare it to that of the label **aw yimkin mn el** *(or maybe from the)* C 2ousal **lal** m **metel el** *(for m similar to)* vitamin C **kamen** *(also)* we compare it on the label. **Fa** *(So)* always **lakan** *(then)* we have to compare C zero experimental **sawa2 3melet** *(whether it did)* dilution **aw ma 3melet** *(or it didn't do)* dilution and C zero on label.

(5) **S-9:** Miss **bas azghar aw akbar** *(but smaller or larger)*

(6) **T:** Compare less than or greater **bas 7atta elna ma sharot kil mara ya3teene** *(but we even said it's not a condition to give me)* percentage error **bas** *(but)* to be more accurate **lezim ya3teene** *(should give me)* percentage error. **Iza bas 2al** compare to you **wAllah** less **hala2 addesh el** less **lan2oul** five **tan2oul tuli3** four point eight four point nine accepted **msh hal** range **ele kbir.**

Relating Science to Everyday Life. Teacher B related scientific concepts to everyday life using different strategies such as analogies, exercises that used ideas from industry, and finding out the uses of some chemicals in everyday life. The language she used while relating the concepts was mainly Colloquial Arabic, but chemical terms were introduced/inserted in English. The following examples are from various sessions where relating the science concept to everyday life is underlined, and some managerial or indirectly related interactions were removed.

Teacher B, Example 1. The following excerpt is from an interaction where the teacher was giving students the different ways to determine the mass of a product in a given exercise. However, one of the students was relating the change in mass added with a change in the number of moles upon dilution. To address the student's misconception, Teacher B explained the concept of the 'same' number of moles using the example of making tea or adding a spoon of salt/sugar to a cup.

….

(1) **S_1: La2** miss bas dilution **lahal ken 3anna** dilution **w bas byetghayar** number of moles **wala la2**? *(No miss but dilution alone we have dilution only does the number of moles change or not?)*

(2) **T: Inta 2elle metef2een 3laya** *(you tell me we've agreed on this before)*

(3) **S_1: Inte bet2oule la2** *(you say no)*

(4) **S_2: Bala** *(yes)* same n

(5) **T: Le? shu tafa2na?** *(why? What did we agree on?)*

(6) **S_1: Msh nehna zedna** distilled water **aw shi hek** ? *(Didn't we add* distilled water *or something like that?)*

(7) **T:** Once you have here **tan2oul** *(let us say)* 1 spoon of sugar once you take different number of mole **tan2oul masalan** *(let us say for example)* half spoon of sugar on this part you add water **hon** *(here)* different n once you take different n **hala2** *(now)* you work on this part [referring to figure on the board] once you add water to this cup to this beaker to this flask **hal** *(did the)* number of mole changed?

The teacher found that the student did not grasp the concept when introducing it in English with transition words in Colloquial Arabic. So, she proceeded not only to bring an example from the student's daily life but also to use Colloquial Arabic dominantly in her explanation (Line 12, 14, 18).

(8) **S_1: Bala la2ano el** mass **te3 el** sugar **tghayyar** *(yes because the mass of the sugar changed)*

(9) **T: Shu khass** el mass **3am behke nafs el** beaker **khalas** *(How is the mass related? I am talking in the same beaker)* we forget the previous part **hala2** *(now)* I'm working in this part.

(10) **S_1 : Ah la2 iza haidek nafs el** n *(Oh no it is the same n)*

(11) **S_2: Gher** *(different)* concentration

(12) **T: Nafs el shi eltelkon wa2ta lama ykoun 3anna** baby **badna nsharbo** soft drink **ma3 ino ma lezem aw badna nsharbo ymkn** tea **ktir** concentrated once I pour some volume of tea in the mug I add water **hal hal** quantity change? *(I told you the same thing before, when we have a baby and we want to give him a soft drink even though we shouldn't or we want to give him* tea *that is very* concentrated once I pour some volume of tea in the mug I add water *did the* quantity change?*)*

(13) **S_1: La2** *(No)*

(14) **T: B hal** *(In this)* mug **hal** *(did)* quantity changed? **Shu ghayyaret fiya wala shi ba3da nafs el** *(What did I change it or is it still the same)* amount **inta 3am tzeed 3ala hay haida el** *(you are adding to the)* number of moles **3m ykoun** *(this is)* before **haida** *(this)* before once you add el after still the same ok? **Baynama hon** *(while here)* once you

take **msh kil el** *(not all the)* one sugar spoon **7a tkoun killa hon** ***(****will be all here*) *(In this mug did the quantity change? What do you think? Did I change anything or is it still the same amount? You are adding to this number of moles and that is before that before once you add the after is still the same ok? But here once you take part of the one spoon not all of it you will be here)*

(15) **S$_1$: Ya3ne** mass of water **ma be2aser 3a** mass **el** sugar *(That means mass of water doesn't affect the mass of the sugar)*

(16) **T: Ma mnehke 3al** mass **mnehke 3al** volume *(We don't talk about the mass we talk about the volume)*

(17) **S$_1$: Eh** volume **azde** *(yes I mean volume)*

(18) **T:** Volume **ma be2aser ma 3am ellak inta mdawab one ma3el2et mele7 b nos kebeye zedtela may ma3el2et el mele7 7a tsir rebe3 ma3el2et mele7 aw 7a tdalla ma3el2et mele7 7a tdalla ma 7a yghayer shi bas shu yalle 7a ysir** diluted **el** effect **la haida ino 7a tsir** less diluted **3atoul khedo el** example **el** tea **masalan** once you have tea bag in a cup of tea once you put **tuli3 ktiiir** concentrated you add water **hal el** one bag **sar** half bag **la2 ba3do** *(no it is still)* one bag one bag **bas shu yalle 3melna** *(but what did we do)* once I added water just **el** *(the)* concentration change that's why I have the change in its taste **3atoul** *(always)* remember this example *(Volume does not matter, I am telling you that you have one teaspoon of salt dissolved in half a cup, I added water. Will this one teaspoon of salt become a quarter of teaspoon of salt? Or will it stay the same? Nothing will change it but what changed? You will have a diluted effect because this will be less*

diluted. Always remember the tea example, once you have tea bag in a cup of tea once you put and it is very concentrated you add water did the one bag change to half a bag? No, it is still one bag one bag but what did we do? once I added water just the concentration change that's why I have the change in its taste always remember this example.)

(19) **T:** Any questions concerning this part? **Khalas tayyeb** *(ok then)*

Teacher B, Example 2. In this episode, the teacher was relating the concept of titration to the role of the Ministry of Health. She encouraged the students to share what they know or have heard about the role of the Ministry of Health (lines 2, 6). Teacher B built on the students' responses and introduced the English word "equivalent" as a translation of sorts to the terms used by the students.

(1) **T: Yalla hala2** *(ok now)* examples from our life very important who know the ministry of health? The job or role of the ministry

….

(2) **T: Khasatan ele 3am ytebe3 akhbar ken ekher fatra ktir byesma3 wizaret el sohha w khaasatan mar2et ktir fatra ktir shtaghalo** *(Especially those who were following the news lately, you hear a lot about the Ministry of Health and specifically there was a while where they worked on)*

(3) **S: Ehh ma3 te3oul el** corona **el wazir khasso** *(yes with those who are dealing with corona, the minister is involved)*

(4) **S-4: Miss akhado tadebir khassa** *(Miss they took special measures)*

(5) **S-10: Wael Abou Faour wa2ta kamen** *(Wael Abou Faour was also involved)*

The teacher was trying to engage the students with what they know or have heard about the Ministry of Health (line 6). When the students shared a point that relates to the titration process (e.g. lines 7,11,16), the teacher highlighted that point using scientific terms (e.g. lines 8, 12, 17, 19).

(6) **T: Khalina nesma3 kil wahad shu seme3 3an hay shu dawra shu mumkin na3mol** *(Let us now listen to each one what did you hear about this? what is its role ? What could we do?)***. Abel ma nekhod into 7a tkouno hala2 b haida el saf 7a samme hala2** grade 11 ministry of health **ya3ne hala2 7a na3mel** exercise **kil wahad minkon byetkhayal 7alo ka2ano** ministry of health *(Before we take that you will now be, I will name this class* grade 11 ministry of health that means now we will do an exercise *where each one of you will put imagine himself as if he is the* ministry of health) **El** *(the)* ministry of health **lezim ykoun akide el** main major **aw** main subject **la elo huwe el** chemistry chemist **la2an** without chemist **hala2 7a tshufu b aya** process **bl zabot** I can't work on my or continue my work *(The ministry of health has to have for sure the main major or main subject for this is chemistry chemist because without a chemist now you will see in which process exactly I can't work on my or continue my work).*

(7) **S–4: Iza 7ada bado ya3te dawa lal 3alam lezim awal shi y7added** concentration **kil shi w haide e**l ministry of healthy **hiyye bta3mel** titration **la haida el dawa la ta3rif iza huwe** accepted aw rejected *(If someone wants to give a medicine to the people they should first determine the concentration and everything and this* ministry of health

does the titration for this medicine to determine whether it is accepted or rejected*)*

(8) **T: Ya3ne** *(That means)* I have some given concentration on a medicine or anything then the role of ministry.

(9) **S-4: El** *(the)* titration [teacher draws on board]

(10) **T:** Titration

(11) **S-4:** Accepted or rejected [says to Teacher Bs teacher draws on board]

(12) **T:** Accepted or rejected excellent

(13) **T: Kamen meen 3ando aya shi bl nesbe lal** ministry of health *(Ok what else? Who has anything else regarding the ministry of health?)*

(14) **S1: Iza el matar w el saydaliyet 3am bebi3o ashya** *(If the airport and pharmacies are selling things)*

(15) **T: El matar msh bas** medicine food *(The airport not only medicine food)*

(16) **S1: Eh bshouf iza 3am yra3o el ma3ayeer** *(Yes we see that they are conforming with specifications)*

Moreover, Teacher B explicitly indicated that she wanted the students to relate the chemistry concepts with their everyday life experiences (line 17).

(17) **T: <u>Bera3o el ma3ayeer shu ya3ne bera3o el ma3ayeer lahazto ana behemne haidel el 2osas ele into 3am tesma3owa bl akhbar b 7ayetna how can I translate in chemistry bera3o el ma3ayeer shu azdon</u>** *(They conform with specifications what does it mean to conform to the specifications? Did you notice? What I care about in these stories you're hearing about in the news in our daily lives is how can I*

translate that to chemistry. They conform to specifications what does it mean?)

(18) **S1: Ya3ne byederso el ashya** *(That means they study the things)*

(19) **T: Lama 3am y2oulo ra3o el me3yar shu azdon** ? Accepted [comment to student on board] *(When they say they are conforming with the specifications what do they mean accepted?)*

(20) **S:** Concentration?

(21) **S:** Miss **ya3ne** *(Miss that means)*

(22) **T: Ya3ne shu azdna hal** in the process **ya3ne** do you agree with Student-4 **bera3o el me3yar shu azdon fiya**

(23) **S: Ya3ne iza** accepted

(24) **T: Bera3o el me3yar ya3ne hal** accepted value **aw ma bera3o el me3yar ya3ne** *(They conform to specifications means accepted value or they do not conform to specifications means)*

(25) **S-4:** Rejected

(26) **T:** rejected not accept ed value

(27) **T: tab** do you have any idea not rejected not accepted?

….

(28) **T: Asesan shu bya3mlo hinne shu btesma3o kamen hek ashya walla la edro yousalo la hal part 3amalo shi** *(Originally what do they do? What do you hear also things so they could have reached this part they did something)*

(29) **S-4:** Titration

(30) **T:** <u>**Ma be2ellek** titration</u> *(They do not say* titration*)* <u>**b2oul shi m3ayyan**</u> *(they say something specific)*

(31) **S3:** Ahh **3ayyinee** *(Sample)*

(32) **T: <u>Akhado 3ayyine</u>** <u>excellent</u> *(They took a sample)***akhado 3ayyine shu ya3ne 3ayyiune ya3ne** sample *(They took a sample what does that mean sample meaning* sample*).*

(33) **S3: Ya3ne part zgheer** part **minna** *(That means a small part from it).*

Teacher B, Example 3. In the following example, the teacher asked the students to share the roles of two chemicals in everyday life. These chemicals (potassium permanganate and oxalic acid) were used as reactants in titration exercises. The students researched the uses of the chemicals and presented them to the class (Line 4, 8, 10)

(1) **T:** Student1, please answer the questions about role of potassium permanganate in everyday life, and oxalic acid in everyday life.

(2) **S-1: Na3am?** *(Yes?)* Ok [student stands in front of the class to present]

(3) **T:** What is the role first of potassium permanganate in everyday life?

(4) **S-1:** Removes magnesium and iron from the water and rust caused in water equipment and pipes. Treatment of fish disease. Medical purposes including an antiseptic and fungicide treatment of various skin infections such as eczema,dermatitis, acne and other fungal infections in hands and legs. Ttreatment of wounds with pus, oozing, and blisters.

(5) **S: Shu hay?** *(What is that?)*

(6) **S-1: El 3amal ele byetla3 mn el jere7** *(The pus that comes out of the wound)*

(7) **T:** What is the role of oxalic acid **hala2** *(now)* you have some idea about oxalic acid? What do I mean by oxalic acid what is it?

(8) **S-1:** Oxalic acid is a poisonous crystalline acid with a sour taste, present in rhubarb leaves, wood sorrel and other plants.

(9) **T:** What is mmm the disadvantage of oxalic acid?

(10) **S-1:** Kidney stones low blood pressure mouth and throat pain vomiting weak pulse.

(11) **T:** Thank you.

Emphasis on Exercise Solving Skills and Exposure to Grade 12 Exercise styles. As mentioned earlier, the observed sessions were focused on solving exercises. With the school closures in the first semester of the school year, the teacher rearranged the flow and content of the sessions. She noted that solving the exercises is essential for success in grade 12. Thus, she introduced exercises typical for the Grade 12 official Examination in grade 11 so the students would get used to the style. Throughout the sessions, Teacher B gave tips to solve the exercises such as translating the given into a figure. She also provided the students with a ‘flow chart’ of a typical sequence for questions within an exercise. The following examples show the discussions surrounding these tips and clues.

Teacher B, Example 1. The following utterances are from a series of interactions. Teacher B’s utterances were extracted to demonstrate her emphasis on translating the given of any exercise into a labeled figure. The following excerpt was at the beginning of solving an exercise. The teacher asked one student to share what is the first clue to solving an exercise.

(1) **T:** What was the first clue or the only clue **iza baddek** (*if you want)* by solving **ya** Student11 any chemistry exercise ?

(2) **T:** Ok what is the first clue? The only clue **iza bdk** *(if you want)*

(3) **S1:** Given

(4) **T: La2** *(no)*

(5) **S3:** The drawing?

(6) **T:** By drawing. Let's draw the given in the exercise.

In another session, one of the students asked the teacher for clarification on his solved homework. The teacher upon examining his answer instructed the student to always translate the given into a figure as that would clarify the questions. The teacher's instructions were delivered using integrated utterances where she mainly used Colloquial Arabic and codeswitched to English to introduce terms such as figure and concentration (line 1).

(1) **T: Awal shi, 3atoul 7utt el** figure advice **sade2ne advice la2ano bestir bta3rif inta el** concentration **haida b hal** part **w hal** part **ya3ne inta hon bas t2oul** solution S volume (*First thing, always put the* figure advice, *believe me* advice *because you will know what* concentration *it is referred to in the exercise in this part or that part so here when you say)*

(2) **S-10: Ya3ne tene marra bersom el** figure? (*So, next time I draw the* figure?)

(3) **T: Eh eh** *(yes yes)*

Teacher B, Example 2. In the following example, the teacher had previously introduced a titration exercise as homework. The previous exercises that the students encountered had the titrant in the burette and titrate in the beaker. However, this exercise had the titrate in the burette, so several students assumed it was a mistake in the given. This type of exercise sometimes is introduced in the official exams of grade 12. The teacher explicitly mentioned that it is rare that this type of exercise is introduced (lines 4, 12, 18) to reassure the students. Teacher B also mentioned that she introduced the exercise, so they would not face the same difficulties in grade 12 (line

18). In this interaction, Teacher B mainly used Colloquial Arabic to highlight the difference between this type of exercise and what the students are used to. She codeswitched to English to indicate terms such as “we titrate”

(1) **T:** B**as** *(but)* before we have some comment about exercise number nine.

(2) **S1:** Bl guide?

(3) **S2:** Miss **ken fi ghalat bl** guide (*There was a mistake in the* guide*)*

(4) **T:** **Bl** *(in)* guide **msh ghalat** *(not a mistake)* it will be rare case exception one percent **b kil el** *(in all the)* exercises

(5) **S: Eh eh** *(yes yes)*

(6) **S-3: Shu hiyye** *(What is it?)*

(7) **T:** Finish writing? [starts erasing the board]

(8) **S1: La2** miss **lahza** *(No miss one second)*

(9) **S2:** Miss **hala2** 7a **ndalna bl exerciset** *(Miss we will stay in the exercises now?)*

(10) **T:** Comment on the number nine in the number nine I have some solution of mass concentration 5 point 0.25 grams per liter I have

(11) **S3:** Miss **hala2 baddek t7elle kelo**? *(Miss do you want to solve it all?)*

….

(12) **T:** H**ala2 ween el mishekle ele 3andkon yeha into? Ino fi ghalat. Huwe mafi** mistake, **bas huwe shu 3am y2elna? Bas nehna shu m3awdeen?** Ninety nine percent **elna** we titrate. A**wal ma nshouf** titrate **ya3ne** found in? *(Now where is the problem that you’re having? You’re saying that there is a* mistake *but actually there is no mistake but what is he telling us? But what are we used to?* Ninety nine percent *we said* we titrate *once we see* titrate *that means* found in? *)*

(13) **S1:** Beaker

(14) **T:** Beaker **w elna** *(and we said)* by, with, against??

(15) **S2:** Burette

(16) **T:** Burette. H**one** *(here)* exception **hal** *(this)* exception **3am y2elna,** *(it is telling us)* we want to titrate FeSO4. So, **into shu khatar 3abelkon deghre? Ino lezem el** FeSO4 **ykoun?** *(What did you directly think about? That the FeSO4 should be in)*

(17) **S3: Bl** *(in)* beaker

(18) **T: Hiyye tkoun bl** beaker. F**a 7atta b** grade 12, **hala2 mn fatra kena 3am n7elelon** exercise **7allayna yimkin shi khamsta3shar (15)** exercise **mn hal khamsta3esh mara2 wahad mtl haida** exception ok? *(That it is in the* beaker *so even in* grade 12 *now a while ago we were solving an* exercise *we solved about fifteen* exercises *from those fifteen we just had one as an exception ok?)*

W bl session elna adde bl sessions mara2 wahad hala2 exception. Fa, shu 3am y2elna? Lama ykoun exception ma mne3tal hamm mnemshe mtl ma huwe bado. Fa ana mafroud ykoun in the beaker **shu 3am y2elle huwe el** $FeSO_4$ is placed **aw** is added from the burette. *(In the session, how many sessions have already passed we just now got an exception. So, what is 'he' telling us? When we have an exception, we won't worry we follow the steps provided. So I am supposed to have it* in the beaker. W*hat is he saying? That* $FeSO_4$ is placed *or* is added from the burette*).*

Khalas bemshe metel ma huwe 2alle ya3ne ok I want to titrate **w 7atta ween kamen fi shaghle ino** titrate **mafroud hiyye el** unknown concentration **hon bl 3akes 3atene el** concentration **fa** two exceptions **b nafs el** exercise. *(So that's it, I follow the steps he provided that means* ok I want to titrate *and he placed it where? There is also another thing* titrate *supposedly it is the* unknown concentration *here I have the opposite he provided me with the* concentration *so* two exceptions *in the same* exercise)

…..

(19) **S-4:** Miss **ma huwe 2alle awal shi ino el** FeSO4 is used to titrate **el shu ismo** *(*Miss *he said at the beginning that the* FeSO4 is used to titrate *the other thing)*

(20) **T: Eh ma 3am ellek nehna mafroud nfakker fiya ino** beaker **w hal 2usas bas bi ma ino huwe 2alle** added from burette **7a 2oul lakan khalas haide 3amele yeha** exception *(yes I am telling you we are supposed to think that it is* beaker *and those stuff but since he said* added from burette *I will say then that's it he did this as an* exception).

(21) **S-4: Ya3ne ana ma3e** concertation **w ma3e el** volume *(So that means I have* concentration *and I have the* volume*)*

(22) **T: La2 huwe shu 2allek?** *(No what is he telling u?)* Calculate the concentration. So, two exceptions **ya** Student-4. A**wal** exception **ino** the titrated **muftarad tkoun bl** beaker **w 3amale yeha bl** burette w **mafroud ino huwe** titrated **ykoun 3ando** unknown w **huwe 3atene yei** known. *(First* exception *that* the titrated *supposedly it should be in the* beaker *and he placed it for me in the* burette *and it should have been that the* titrated *should have* unknown *and he gave it to me as* known*).*

(23) **S-4: Ah ya3ne** 0.02 **hiyye la** FeSO4 *(Oh so that means* 0.02 *is for the* FeSO4*)*

(24) **T:** <u>**El** concentration **metel ma huwe 2ayelle ma 7a yetghayar shi bl** concertation **bas ana mafhoume el** concept **ino ana kif bade eshteghela bas btefro2 bl** experiment **bas ma 7a yefro2 shi bl value la2an 7a ykoun el** calculation the same</u>

(The concentration *as it is mentioned, nothing will change in the* concentration *but to me the* concept *so how will I work on this? It will only change in the* experiment *but nothing will change in the value because the* calculation is the same*)*

….

(25) **T:** <u>**Nafs el shi nafs el shi bas shu byefro2 ma3ek into inte m3awde t7utte hone** beaker **w hone** burette **w m3awde hon el** equivalent **w hone el haida fa bas ha btefro2 khalas tamem**?</u> *(It is the same thing same thing but what is different for you? You are used to place beaker here and there burette. You are also used that it is equivalent and here it is the thing so this is the only difference ok?)*

Use of Colloquial Arabic in Classroom Management. Teacher B used Colloquial Arabic for classroom management and disciplinary purposes. The below examples were extracted from episodes to show Teacher B's use of Colloquial Arabic.

Teacher B, Example 1. The following excerpt followed an interaction in which the teacher was asking one of the students to answer her question to direct his attention to the class discussion. But the student was not paying attention, so the following interaction demonstrates the conversation between the teacher and students in Colloquial Arabic.

(1) **T:** Student-6 what was my question?

(2) **S-6:** Miss **ma ken 3am yehke baddo aneenet el may** *(*Miss *he was speaking he wants a bottle of water)*

(3) **T:** **<u>Meen abda ana wala huwe?</u>** *(Who is the priority him or I?)*

(4) **S-6:** Miss **ma feene rakkez esma3 marteen** *(*Miss *I won't focus to listen twice)*

(5) **T:** **<u>W inta ma3 meen betrakez</u>** *(and you focus with whom?)*

(6) **S-10:** Miss **bas ken 3am yotlob may** *(*Miss *he was just asking for water)*

(7) **S-3: Huwe 3ando daynetnen w mokh Wahad** *(he has two ears and one brain)*

(8) **S-6: Ma 3am ellek ma fiyye rakkez** *(I am telling you, I can't focus)*

(9) **T:** **<u>Hone awlawiyet</u>** *(Here we have priorities)*

(10) **S-10:** Miss **bas ken 3am yetlob aneenet may** *(*Miss *he was just asking for water)*

(11) **S-3:** Miss **ma bye2dar yrakkez hek** *(*Miss *he cannot focus like this)*

(12) **T:** Answer my question ya Student-6, how can I go from C diluted to C organic? [referring to the initial commercial solution] What is the link between them?

Home language across Knowledge Types and Cognitive Processes

To contribute to answering the second research question, the development of conceptual understandings of the scientific concepts was inferred from the analysis of knowledge type and cognitive processes utterances in classroom B. As indicated earlier, the sessions focused on practice and test preparations in addition to concept development occasionally.

Knowledge Types

The dominance of the factual utterances was observed across the different sessions. Table 22 shows the percentage distribution of the knowledge-type utterances of Teacher B and the students in classroom B. Teacher B's session included asking one student to solve an exercise on the board. Meanwhile, Teacher B would circulate in class to check if students complete their homework. At the same time, she addressed students' questions. 'Factual' utterances were dominant where they varied between 43.7% and 71.8%. All the observed sessions included the application of the titration concepts through solving exercises. Hence, procedural-algorithmic utterances were second in dominance and they varied between 12.8 % and 36.8%. Teacher B also emphasized the correct format for answers in 'procedural-testing' utterances. These utterances varied between 4.5% and 13.6%. However, in lesson 5, the teacher introduced an inquiry-based exercise, hence, the second dominant level was the 'inquiry' level at 21.1%.

Table 22

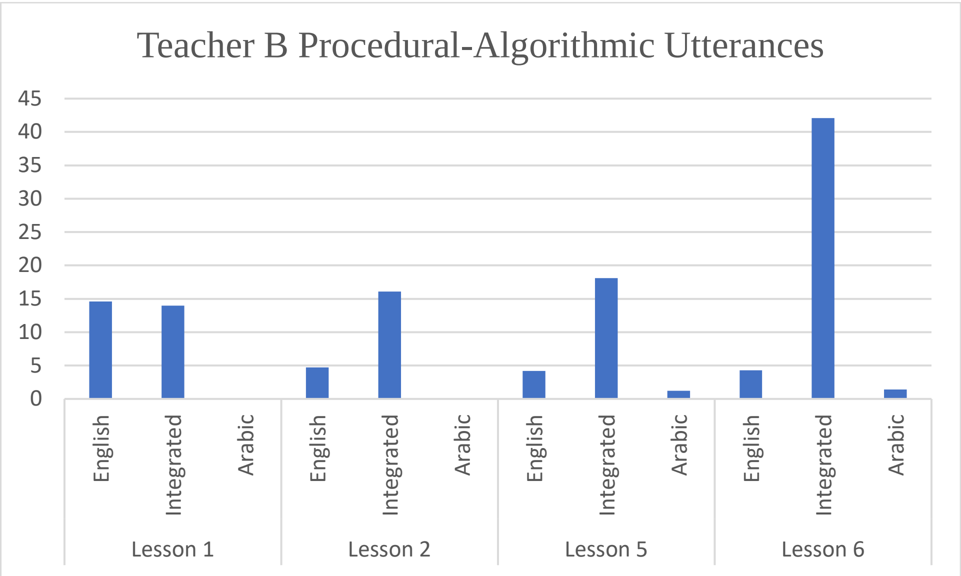
Percentage of Knowledge Types Utterances of Teacher B and Students in School B

Lesson #	Factual	Conceptual	Procedural		
			Inquiry	Algorithmic	Testing
Lesson 1	59.3%	4.3%	4.3%	18.4%	13.6%
Lesson 2	71.8%	7.8%	3.1%	12.8%	4.5%
Lesson 5	43.7%	7.4%	21.1%	20.7%	7.1%
Lesson 6	48.6%	6.3%	0.5%	36.8%	7.8%

The language used varied across the teacher, students, and knowledge types. Table 23 shows the distribution of the utterances for Teacher B across different knowledge types and languages used. As indicated earlier in this chapter, Teacher B dominantly used integrated utterances (both Colloquial Arabic and English) in the classroom discourse. The dominant utterances were the 'factual' level utterances. The language used however differed. The use of English for 'factual' level utterances varied between 8.6% and 30.2% integrated 'factual' utterances varied between 16.3% and 22.9%. The second dominant level was 'procedural-algorithmic' where integrated utterances were dominant and varied between 14.1% and 42.1%. However, in lesson 5, as the teacher introduced an inquiry exercise, the 'procedural-inquiry' level was dominant with 27.1% integrated utterances. The teacher highlighted some tips for the tests across the sessions, hence, 'procedural-testing' was dominantly integrated where they varied between 6.3% and 10.8%. None of the utterances were of the metacognitive understanding level. In sum, the dominant language used by teacher B was integrated utterances. Even though there was increased use of English with 'factual' utterances, the increase in using integrated utterances for 'procedural-algorithmic' utterances is evident as illustrated in Figure 2 where the teacher used the home language more.

Figure 2

Percentage Distribution of Procedural-Algorithmic Utterances of Teacher B



Students of classroom B also used integrated utterances predominantly in the classroom discourse. Table 24 shows the frequency distribution and the percentages of the knowledge-type utterances for students in classroom B. Similar to the teacher, the dominant utterances were of ‘factual’ level where they varied between 29.3% and 41.1% in integrated utterances. The second dominant knowledge types utterances were of the ‘procedural-algorithmic’ level. These varied between 7.8% and 20.7% in integrated utterances. However, in lesson 5, the ‘procedural-inquiry’ level was dominant at 10.2% integrated utterances. Moreover, as the teacher shared tips for ‘procedural-testing’ level utterances varied between 1.8% and 7.2% using integrated utterances. None of the utterances were of the metacognitive understanding level.

Table 23

Frequency Distribution and Percentages of Knowledge Type Utterances of Teacher B

Lesson #	Language Variation	Factual		Conceptual		Procedural					
						Inquiry		Algorithmic		Testing	
		Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Lesson 1	Integrated	28	17.1	8	4.9	7	4.3	23	14.0	17	10.4
	Arabic	0	0	0	0	0	0	0	0	0	0
	English	38	23.2	4	2.4	3	1.8	24	14.6	12	7.3
Lesson 2	Integrated	44	22.9	18	9.4	8	4.2	31	16.1	12	6.3
	Arabic	4	2.1	1	0.5	0	0	0	0	0	0
	English	58	30.2	3	1.6	3	1.6	9	4.7	1	0.5
Lesson 5	Integrated	27	16.3	9	5.4	45	27.1	30	18.1	18	10.8
	Arabic	2	1.2	1	0.6	1	0.6	2	1.2	0	0
	English	16	9.6	3	1.8	5	3.0	7	4.2	0	0
Lesson 6	Integrated	42	20.1	10	4.8	2	1.0	88	42.1	19	9.1
	Arabic	4	1.9	2	1.0	0	0	3	1.4	2	1.0
	English	18	8.6	7	3.3	0	0	9	4.3	3	1.4

Table 24

Frequency Distribution and Percentages of Knowledge Type Utterances of Students in School B

Lesson #	Language Variation	Factual		Conceptual		Procedural					
						Inquiry		Algorithmic		Testing	
		Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Lesson 1	Integrated	52	31.3	3	1.8	5	3.0	13	7.8	12	7.2
	Arabic	19	11.4	1	0.6	1	0.6	0	0	2	1.2
	English	58	34.9	0	0	0	0	0	0	0	
Lesson 2	Integrated	67	41.1	3	1.8	0	0	6	3.7	3	1.8
	Arabic	21	12.9	2	1.2	0	0	0	0	0	0
	English	63	38.7	1	0.6	0	0	0	0	0	0
Lesson 5	Integrated	64	40.8	10	6.4	16	10.2	24	15.3	3	1.9
	Arabic	7	4.5	1	0.6	0	0	2	1.3	2	1.3
	English	25	15.9	0	0	1	0.6	0	1.3	0	0
Lesson 6	Integrated	55	29.3	4	2.1	0	0	39	20.7	6	3.2
	Arabic	13	6.9	2	1.1	0	0	4	2.1	1	0.5
	English	61	32.4	0	0	0	0	3	1.6	0	0

Cognitive Processes

The teacher and students engaged in interactions in which Colloquial Arabic was used to reach conceptual understandings. However, the utterances used were mostly of the ‘understand’ levels. When solving exercises or elaborating further, utterances also involved the ‘apply’ level and ‘remember’ level. Similarly, some students’ utterances were difficult to discern between ‘remember’ and ‘understand’ as sometimes the utterance could imply both. The researcher decided the most likely level based on the context of the interaction.

There was a dominance of the ‘understand’ level utterances across the different sessions observed for this study. Table 18 shows the percentage of cognitive processes utterances in classroom B. ‘Understand’ level utterances were dominant across the lessons where they varied between 52.5% and 84.8%. The second-highest level varied across the sessions. As the sessions were mainly focused on solving exercises, the ‘apply’ level utterances were present across the sessions and varied between 10.0% and 18.3%. Yet, in lesson 5 the second dominant level was the ‘remember’ level at 28.9%. However, the ‘analyze’ level was at most 2.0% in the sessions. None of the utterances were of the evaluate or create levels.

Table 25

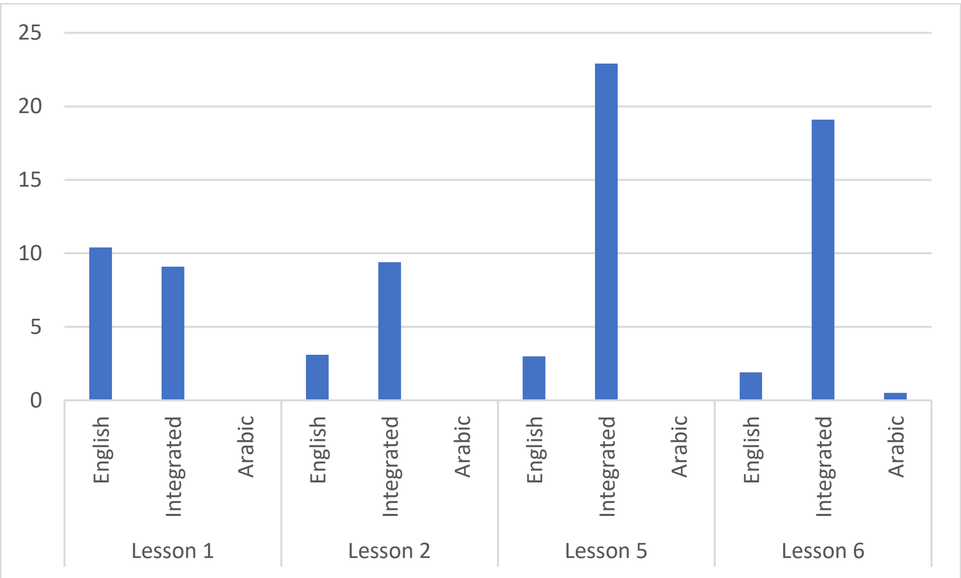
Percentage of Cognitive Processes Utterances in Classroom B

Lesson #	**Perceive**	**Remember**	**Understand**	**Apply**	**Analyze**
Lesson 1	0	5.2	84.8	10.0	0
Lesson 2	0	1.6	72.3	5.8	0
Lesson 5	0	28.9	52.5	18.3	0.3
Lesson 6	0	3.3	79.0	15.7	2.0

The language used varied across the teacher, students, and cognitive processes. Table 26 shows the distribution of the utterances for Teacher B across different cognitive processes and languages used. As indicated earlier, Teacher B dominantly used integrated utterances in the classroom discourse. The 'understand' level utterances were dominant. Integrated 'understand' utterances varied between 41.5% and 52.6%. However, in lessons 1 and 2, English was used almost equally as well where it varied between 35.4% and 37.2% which then decreased to at most 14.8%. The second dominant level observed across the sessions was the 'apply' level. Integrated 'apply level utterances varied between 9.1% and 22.9%. English 'apply' level utterances varied between 1.9% and 10.4%. None of the utterances were of the 'perceive' or 'evaluate' or 'create' levels. In sum, the dominant language used was integrated utterances. Consistently, as the cognitive processes levels increased, so did the use of integrated utterances as illustrated in figure 3 where the percentage distribution of the 'apply' level is shown.

Figure 3

Percentage Distribution of Teacher B Apply level Utterances



Students of classroom B also used integrated utterances in the classroom discourse. Table 27 shows the frequency distribution and the percentages of the cognitive processes utterances of students in classroom B. Similar to the teacher, the general trend was the dominance of utterances at the ‘understand’ level. However, the language used differed where the use of English varied between 1.9% and 34.5%. Integrated utterances, yet, varied between 41.5 % and 52.6%. The second dominant level, across the lessons, was the ‘apply’ level as the sessions were focused on solving exercises. This varied between 3.0% and 22.9%. None of the utterances were at the ‘perceive’ or ‘evaluate’ or ‘create’ levels.

Table 26

Frequency Distribution and Percentages of Cognitive Processes Utterances of Teacher B

Lesson #	Language Variation	Remember		Understand		Apply		Analyze	
		Freq.	%	Freq.	%	Freq.	%	Freq.	%
Lesson 1	Integrated	0	0	68	41.5	15	9.1	0	0
	Arabic	0	0	0	0	0	0	0	0
	English	3	1.8	61	37.2	17	10.4	0	0
Lesson 2	Integrated	0	0	95	49.5	18	9.4	0	0
	Arabic	0	0	5	2.6	0	0	0	0
	English	0	0	68	35.4	6	3.1	0	0
Lesson 5	Integrated	15	9.0	74	44.6	38	22.9	1	0.6
	Arabic	2	1.2	4	2.4	0	0	0	0
	English	10	6.0	16	9.6	5	3.0	0	0
Lesson 6	Integrated	2	1.0	110	52.6	40	19.1	8	3.8
	Arabic	0	0	10	4.8	1	0.5	0	0
	English	2	1.0	31	14.8	4	1.9	0	0

Table 27

Frequency Distribution and Percentages of Cognitive Processes Utterances of Students in School B

Lesson #	Language Variation	Remember		Understand		Apply	
		Freq.	%	Freq.	%	Freq.	%
Lesson 1	Integrated	5	3.0	79	47.6	1	0.6
	Arabic	2	1.2	21	12.7	0	0
	English	7	4.2	51	30.7	0	0
Lesson 2	Integrated	0	0	76	46.1	2	1.2
	Arabic	0	0	23	13.9	0	0
	English	7	4.2	57	34.5	0	0
Lesson 5	Integrated	35	22.3	67	42.7	15	9.6
	Arabic	7	4.5	5	3.2	0	0

	English	24	15.3	3	1.9	1	0.6
Lesson 6	Integrated	1	0.5	89	47.3	14	7.4
	Arabic	0		20	10.6	0	0
	English	8	4.3	53	28.2	3	1.6

The following examples demonstrate how the home language was used to help students understand chemical concepts. They also show how the home language varied across knowledge types and cognitive processes.

Teacher B, Example 1. The following example was used earlier in this chapter to illustrate the dialogic interactive approach of the teacher. Teacher B introduced this exercise to relate titration to daily life and to learn about its application. During this exercise, the teacher asked the students to consider their class as the Ministry of Health. They were tasked with determining the accuracy of labels on some products. The students were actively engaged in the discourse as they discussed the roles of the ministry. Through the series of interactions (Table 21), both the teacher and students mostly used Colloquial Arabic (home language) to express themselves. The students learned the terms associated with titration using the example from their daily lives. As shown below, the utterances varied between ‘inquiry’, ‘conceptual’, and ‘factual’ levels using integrated utterances. However, as the interaction’s purpose was to explain the concepts being taught, the utterance levels were mostly at the ‘understand’ or ‘remember’ level.

Table 28

Interaction Excerpt between Teacher B and Students in Classroom B

Speaker	Utterance	Knowledge Types	Cognitive Processes
T	**Yalla hala2** *(ok now)* examples from our life very important who know the ministry of health? The job or role of the ministry	Factual	apply
S	**Meen ya3ne** *(Who is that?)*	Factual	understand
S-3	**Dabet el [**incomplete they wanted to talk **dabet and mutaba2et muwasafet]** *(Conform to)*	NA	NA
S-10	**Mutaba2et el** *(conform to)*	NA	NA
S	**La2 wizaret el sohha** *(No the ministry of health)*	Factual	remember
T	**Khasatan ele 3am ytebe3 akhbar ken ekher fatra ktir byesma3 wizaret el sohha w khaasatan mar2et ktir fatra ktir shtaghalo** *(Especially those who were following the news lately, you hear a lot about the ministry of health and specifically there was a while where they worked on)*	NA	NA
S	**Ehh ma3 te3oul el** corona **el wazir khasso** *(yes with those who are dealing with corona, the minister is involved)*	conceptual	understand
S -4	**Miss akhado tadebir khassa** *(Miss they took special measures)*	Factual	understand
S -10	**Wael abo faour wa2ta kamen** *(Wael abou faour was also involved)*	Factual	understand
T	**Khalina nesma3 kil wahad shu seme3 3an hay shu dawra shu mumkin na3mol** *(Let us now listen to each one what did you hear about this? what is its role ? What could we do?)*	conceptual	understand
T	**Abel ma nekhod into 7a tkouno hala2 b haida el saf 7a samme hala2** grade 11 ministry of health **ya3ne hala2 7a na3mel** exercise **kil wahad minkon byetkhayal 7alo ka2ano**	inquiry	understand

	ministry of health *(Before we take that you will now be, I will name this class* grade 11 ministry of health that means now we will do an exercise *where each one of you will put imagine himself as if he is the* ministry of health)		
	El *(the)* ministry of health **lezim ykoun akide el** main major **aw** main subject **la elo huwe el** chemistry chemist **la2an** without chemist **hala2 7a tshufu b aya** process **bl zabot** I can't work on my or continue my work *(The ministry of health has to have for sure the main major or main subject for this is chemistry chemist because without a chemist now you will see in which process exactly I can't work on my or continue my work)*		understand
S – 4	**Iza 7ada bado ya3te dawa lal 3alam lezim awal shi y7added** concentration **kil shi w haide e**l ministry of healthy **hiyye bta3mel** titration **la haida el dawa la ta3rif iza huwe** accepted aw rejected *(If someone wants to give a medicine to the people they should first determine the concentration and everything and this* ministry of health *does the titration for this medicine to determine whether it is* accepted or rejected*)*	inquiry	understand
T	**Ya3ne** *(That means)* I have some given concentration on a medicine or anything then the role of ministry	inquiry	understand
S -4	**El** *(the)* titration [teacher draws on the board]	Factual	understand
T	Titration	Factual	remember
S -4	Accepted or rejected [says to Teacher B? teacher draws on the board]	Factual	remember
T	Accepted or rejected excellent	Factual	understand
T	**Kamen meen 3ando aya shi bl nesbe lal** ministry of health *(Ok what else? Who has anything else regarding the ministry of health?)*	inquiry	understand
S1	**Iza el matar w el saydaliyet 3am bebi3o ashya** *(If the airport and pharmacies are selling things)*	Factual	remember

T	**El matar msh bas** medicine food *(The airport not only medicine food)*	Factual	understand
S1	**Eh bshouf iza 3am yra3o el ma3ayeer** *(Yes we see that they are conforming with specifications)*	Factual	remember
T	**Bera3o el ma3ayeer shu ya3ne bera3o el ma3ayeer lahazto ana behemne haidel el 2osas ele into 3am tesma3owa bl akhbar b 7ayetna how can I translate in chemistry bera3o el ma3ayeer shu azdon** *(They conform with specifications what does it mean to conform to the specifications? Did you notice? What I care about in these stories you're hearing about in the news in our daily lives is how can I translate that to chemistry. They conform to specifications what does it mean?)*	inquiry	understand
S1	**Ya3ne byederso el ashya** *(That means they study the things)*	inquiry	understand
T	**Lama 3am y2oulo ra3o el me3yar shu azdon** Accepted [comment to student writing on board]*(When they say they are conforming with the specifications what do they mean accepted?)*	inquiry	understand
S	Concentration?	Factual	remember
S	Miss **ya3ne** *(Miss that means)*	NA	NA
T	**Ya3ne shu azdna hal** *(so what do we mean in this)* in the process **ya3ne** *(meaning)* do you agree with Student-4 **bera3o el me3yar shu azdon fiya** *(conform with specifications what do they mean by it?)*	inquiry	understand
S	**Ya3ne iza** accepted	Factual	understand
T	**Bera3o el me3yar ya3ne hal** accepted value **aw ma bera3o el me3yar ya3ne** *(They conform to specifications means accepted value or they do not conform to specifications means)*	inquiry	understand
S -4	Rejected	inquiry	remember
T	Rejected not accepted value	inquiry	remember
T	**Tab** do you have any idea not rejected not accepted	inquiry	understand
S	**Shame3 el a7mar** *(Red wax)*	Factual	remember
S2	**Besakrowa m***(They closed it)*	Factual	remember

S3	**Bya3towon inzar** *(They give them a warning)*	Factual	remember
S4	**Shame3 el a7mar** *(Red wax)*	Factual	remember
T	**Bya3towon inzar wa** *(They give them a warning and)*	Factual	remember
S	**Shame3 el a7mar** *(Red wax)*	Factual	remember
T	**Wa besakro shu bya3mel ya3ne** *(they close it what does that mean?)*	Factual	remember
S -4	Miss **la2 7asab** *(no it depends)*	NA	NA
T	**Asesan shu bya3mlo hinne shu btesma3o kamen hek ashya walla la edro yousalo la hal part 3amalo shi** *(Originally what do they do? What do you hear also things so they could have reached this part they did something)*	inquiry	understand
S – 4	Titration	Factual	remember
T	**Ma be2ellek** titration *(They do not say* titration*)* **b2oul shi m3ayyan***(they say something specific)*	Factual	remember
S3	Ahh **3ayyinee** *(Sample)*	Factual	remember
T	**Akhado 3ayyine** excellent *(They took a sample)*	inquiry	remember
	akhado 3ayyine shu ya3ne 3ayyiune ya3ne sample *(They took a sample what does that mean sample meaning* sample*)*		remember
S3	**Ya3ne part zgheer** part **minna** *(That means a small part from it)*	Factual	remember

Teacher B, Example 2. The following example shows the interaction between one of the students and Teacher B. Even though the objective of the exercise was to determine the mass purity of a substance through titration, the student asked the teacher about dilution. To address the student's misconception, Teacher B used Colloquial Arabic and English to give examples from the student's daily life. The first example the teacher provided (example of the tablespoon of sugar) was mostly using English while Colloquial Arabic was used for transition words. Yet, when the student's misunderstanding persisted, Teacher B used mainly Colloquial Arabic while code-switching to English for terms such as 'diluted'. As shown below, the utterances varied between ‘inquiry’, ‘conceptual’, and ‘factual’ levels using integrated utterances. However, as the interaction’s purpose was to explain the concepts being taught, the utterance levels were mostly at the ‘understand’ or ‘remember’ level.

Table 29

Interaction excerpt between Teacher B and Students in Classroom B

Speaker	**Utterance**	**Knowledge Types**	**Cognitive Processes**
S1	Miss **2uset ino 3ando tnen** concentration **ma ktir 3am tfout b rase**	initiation	conceptual
	…..		
T	Ok **3am y2ellak** *(he is telling you)* calculate the mass of carbon. I can calculate **hala2** *(now)* I have two ways or I can calculate the mass of iron I deduce or the percentage **lakan** *(then)* mass of carbon alloy minus Fe so I have 10.26 so the mass of carbon [fixed a writing on the board]	Algorithmic	Apply
S1	Miss **3ande su2al** *(I have a question)*	NA	NA
T	Excellent excellent **ya** student-12 [commenting on his solution on the board] plus **3al** classwork	NA	NA
S1	**Iza nehna 3melna** *(if we did)* dilution	inquiry	understand
T	**Iza 3melna hon** *(if we did here)* [referring to figure on board]	inquiry	understand
S1	**La2 3am 2oul iza 3melna** *(No I am just saying if we did so)*	NA	NA
T	Usually **lama ykoun** *(when we have)* mass product we don’t make dilution **fa izan** *(so)* supposing	conceptual	understand
S1	**Byetghayar el** number of mole *(the number of mole change)*	conceptual	understand
T	**Bi aya** *(in what)* part suppose **ma3 eno** *(although)* usually we don’t mix the dilution with the mass product	conceptual	understand
S1	**La2** miss dilution **lahal** dilution **lahal** *(No miss dilution alone dilution alone)*	conceptual	understand

T	**Tan2oul hon 3melna** dilution *(Let us say here we did dilution)*[added a beaker to the drawing on the board]	inquiry	understand
T	**Eh** *(yes)* which part we take?	Factual	understand
S_1	**La2** *(no)* miss	NA	NA
T	Which part we take?	Factual	understand
S_1	**La2** miss bas dilution **lahal ken 3anna** dilution **w bas byetghayar** number of moles **wala la2**? *(No miss but dilution alone we have dilution only does the number of moles change or not?)*	conceptual	understand
T	**Inta 2elle metef2een 3laya** *(you tell me we've agreed on this before)*	Factual	remember
S_1	**Inte bet2oule la2** *(you say no)*	Factual	remember
S_2	**Bala** *(yes)* same n	Factual	remember
T	**Le? shu tafa2na?** *(why? What did we agree on?)*	conceptual	remember
S_1	**Msh nehna zedna** distilled water **aw shi hek** ? *(Don't we mean* distilled water *or something like that?)*	conceptual	understand
T	Once you have here **tan2oul** *(let us say)* 1 spoon of sugar once you take different number of mole **tan2oul masalan** *(let us say for example)* half spoon of sugar on this part you add water **hon** *(here)* different n once you take different n **hala2** *(now)* you work on this part [referring to figure on the board] once you add water to this cup to this beaker to this flask **hal** *(did the)* number of mole changed?	inquiry	understand
S_1	**Bala la2ano el** mass **te3 el** sugar **tghayyar** *(yes because the mass of the sugar changed)*	Factual	understand
T	**Shu khass** el mass **3am behke nafs el** beaker **khalas** *(How is the mass related? I am talking in the same beaker)*	Factual	understand
	We forget the previous part **hala2** *(now)* I'm working in this part	testing	understand
S1	**Ah la2 iza haidek nafs el** n *(Oh no it is the same n)*	Factual	understand
S2	**Gher** *(different)* concentration	Factual	remember

T	**Nafs el shi eltelkon wa2ta lama ykoun 3anna** baby **badna nsharbo** soft drink **ma3 ino ma lezem aw badna nsharbo ymkn** tea **ktir** concentrated once I pour some volume of tea in the mug I add water **hal hal** quantity change? *(I told you the same thing before when we have a baby and we want to give him a soft drink even though we shouldn't or we want to give him* tea *that is very* concentrated once I pour some volume of tea in the mug I add water *did the* quantity change?*)*	inquiry	understand
S1	**La2** *(No)*	Factual	remember
T	**B hal** *(In this)* mug **hal** *(did)* quantity changed? **Shu ghayyaret fiya wala shi ba3da nafs el** *(What did I change it or is it still the same)* amount **inta 3am tzeed 3ala hay haida el** *(you are adding to the)* number of moles **3m ykoun** *(this is)* before **haida** *(this)* before once you add el after still the same ok? **Baynama hon** *(while here)* once you take **msh kil el** *(not all the)* one sugar spoon **7a tkoun killa hon** ***(****will be all here)* *(In this mug did the quantity change? What do you think? Did I change anything or is it still the same amount? You are adding to this number of moles and that is before that before once you add the after is still the same ok? But here once you take part of the one spoon not all of it you will be here)*	conceptual	understand
S1	**Ya3ne** mass of water **ma be2aser 3a** mass **el** sugar *(That means mass of water doesn't affect the mass of the sugar)*	conceptual	understand
T	**Ma mnehke 3al** mass **mnehke 3al** volume *(We don't talk about the mass we talk about the volume)*	conceptual	understand
S1	**Eh** volume **azde** *(yes I mean volume)*	Factual	understand
T	Volume **ma be2aser** *(it does not matter)*	inquiry	understand

T	**ma 3am ellak inta mdawab one ma3el2et mele7 b nos kebeye zedtela may ma3el2et el mele7 7a tsir rebe3 ma3el2et mele7 aw 7a tdalla ma3el2et mele7 7a tdalla ma 7a yghayer shi bas shu yalle 7a ysir** diluted **el** effect **la haida ino 7a tsir** less diluted **3atoul khedo el** example **el** tea **masalan** once you have tea bag in a cup of tea once you put **tuli3 ktiiir** concentrated you add water **hal el** one bag **sar** half bag **la2 ba3do** *(no it is still)* one bag one bag **bas shu yalle 3melna** *(but what did we do)* once I added water just **el** *(the)* concentration change that's why I have the change in its taste **3atoul** *(always)* remember this example *(Volume does not matter, I am telling you that you have one teaspoon of salt dissolved in half a cup, I added water. Will this one teaspoon of salt become a quarter of teaspoon of salt? Or will it stay the same? Nothing will change it but what changed? You will have a diluted effect because this will be less diluted. Always remember the tea example, once you have tea bag in a cup of tea once you put and it is very concentrated you add water did the one bag change to half a bag? No it is still one bag one bag but what did we do? once I added water just the concentration change that's why I have the change in its taste always remember this example.)*		understand
T	Any questions concerning this part? **Khalas tayyeb** *(ok then)*	NA	NA

Summary of Findings for Teacher B

The dialogicity of the classroom interactions, number and utterance distribution, in addition to patterns of practices were determined for Teacher A to contribute to answering the first research question. The dominant communicative approach employed by Teacher B was the authoritative interactive approach. To involve the students in the 'science story', Teacher B engaged the students often in IRE/IRF chains of interactions. In some lessons, there was evidence of the dialogic interactive approach where students' ideas were explored, and their participation was more meaningful. The amount of talk in Classroom B was distributed relatively equally between Teacher B and the students. Colloquial Arabic was used dominantly by Teacher B and her students within classroom B.

Different patterns of practice emerged for Teacher B within her classroom. She stated objectives and started classroom interactions in English. Yet, she explained and elaborated using integrated (English and Colloquial Arabic) utterances. And, Teacher B used Colloquial Arabic for classroom management. Moreover, Teacher B used related science to Everyday life using Colloquial Arabic (Role of Ministry of Health example). Furthermore, she highlighted skills needed for problem-solving, in particular, Grade 12 exercises.

The variation of the home language across knowledge types and cognitive processes was determined for classroom B to contribute to answering the second research question. Teacher B's sessions focused mainly on test preparation and practice. As indicated earlier, both Teacher B and her students used integrated (English and Colloquial Arabic) utterances within the classroom. The 'factual' level of knowledge type utterances was dominant. Teacher B used integrated utterances and English relatively equally across the ‘factual’ level of knowledge type utterances. However, towards the end of the observations, she started to use integrated utterances more. Moreover, the 'understand' level of cognitive processes utterances was dominant throughout both classrooms.

Chapter Summary

This chapter provided an overview of the findings for both case studies, the two Lebanese multilingual classrooms, to explore the language classroom practices of teachers in secondary chemistry classrooms. Data was generated from classroom observations, verbatim transcriptions, and informal conversations with the teachers. The classroom discourse was analyzed to determine the dialogicity of the classroom interactions, the patterns of the teacher’s language practices, and the use of home language and variations across knowledge types and cognitive processes. A summary of the findings is presented in this section where a combined overview of the two cases is presented to answer the research questions.

First Research Question: How do the existing language practices that teachers use support the conceptual learning of abstract chemistry concepts?

Teacher’s Existing Language Practices

The first purpose of this study was to investigate the existing language practices teachers use to support students’ conceptual understanding in secondary chemistry classrooms. For this purpose, the researcher examined the communicative approach, patterns of discourse, frequency of utterances, and patterns of teacher practices. The dialogicity of the classroom in addition to the number and distribution of utterances indicated the ways the teachers supported conceptual learning. The dominant communicative approach of both Teacher A and Teacher B was authoritative interactive. The episodes of the authoritative interactive approach were mainly used to involve the students while telling them the ‘science story’. Even though the students were involved in IRE/IRF chains of interactions, their involvement was often close-ended or one-worded. Despite the dominance of the authoritative interactive approach, some lessons showed evidence of the dialogic interactive approach. Through those series of interactions, students’ ideas were explored, and their participation was more meaningful. However, once students’ misunderstandings were addressed, the teacher shifted back to the authoritative interactive approach to guide the classroom discussions.

The frequency and distribution of utterances for the teachers and students were determined. The frequency distribution shows how much the class was dominated by teacher talk and the relative use of English and Colloquial Arabic in the classroom. In both classrooms A and B, the amount of talk was distributed relatively equally between the teacher and the students. As Teacher A’s dominant communicative approach was authoritative interactive, this was reflected in the domination of whole classroom talk in her sessions. Even though Teacher A’s sessions were interactive, the language practices within the classroom differed between Teacher A and her students. Teacher A used English dominantly in her sessions, however, her students used English and Colloquial Arabic relatively equally. Their use of English would increase when prompted by the teacher or when they used one-word answers. Similar to Teacher A, Teacher B’s authoritative interactive approach was also reflected in the distribution where the number of utterances was relatively equal between the teacher and the students. Yet, Teacher B’s utterances were consistently longer. On the other hand, similar language practices were observed within classroom B. Both Teacher B and the students dominantly used the home language in her sessions. Therefore, Teacher A and Teacher B used the home language to support students' meaning-making in their classrooms.

The patterns of practices were determined across the observed sessions for Teacher A and Teacher B to examine how these practices supported students' understanding. Both teacher A and Teacher B used English to state objectives and to start classroom interactions. In addition, they used home language for classroom management purposes. Moreover, both teachers attempted to relate science to everyday life using analogies (Teacher A, monetary example) or real-life examples (Teacher B, the role of the Ministry of Health). Additional different patterns were observed for each teacher. As mentioned earlier, Teacher A used English dominantly in her sessions. However, a trend emerged where she would use the home language only after several attempts to explain the concept in English. Teacher B, on the other hand, consistently used the home language in her explanations and elaborations. Teacher B also emphasized exercise solving skills to help the students in Grade 12. Throughout the sessions, she often noted whether this exercise style is common in Grade 12 or not. Teacher A, on the other hand, mentioned in one or two sessions, that an idea or exercise would be explored in Grade 12, however, it did not warrant recognizing it as a trend.

To sum up, even though both teachers' dominant approach was the authoritative interactive approach, utterances were distributed relatively equally between the students and the teacher in both classrooms. The language employed in the classrooms differed between the teachers where Teacher A dominantly used English, and Teacher B used integrated utterances. However, students in Classrooms A and B used integrated utterances dominantly. Teachers' practices differed in the classrooms, in particular, the use of the home language. Teacher A resorted to the use of Colloquial Arabic when other strategies to explain failed. In these interactions, where Colloquial Arabic was used, students were recognizably more engaged and used higher levels of knowledge types and cognitive processes. Despite that, Teacher A continued the use of English dominantly. On the contrary, Teacher B used home language dominantly in the classroom to explain and support students' understandings. The teachers' existing practices reflected the observed patterns of using the home language in the classroom. For example, Teacher A explicitly instructed students to use English and emphasized it as the language of science whereas Teacher B used home language extensively to explain and elaborate concepts.

Second Research Question: How is the home language used across different knowledge types and cognitive processes?

Variation of the Use of Home Language

The content of the observed sessions was analyzed according to the knowledge types and cognitive processes used. The knowledge types and cognitive processes were examined to determine the development of conceptual understandings of the scientific concepts. The frequency of each utterance was determined across the knowledge types and cognitive processes. Additionally, the variation of the utterances across the home language was counted. As indicated earlier, sessions of classrooms A and B differed in focus. Classroom A's sessions varied between concept development and practice and test preparation. All the sessions included problem-solving to help the students master the skills needed to pass the exams. On the other hand, Classroom B's sessions focused on practice and test preparations in addition to concept development occasionally. The variation in focus was influenced by the previous school closures which affected the opening of one school over another. As classroom A did not get affected, their planned curriculum advanced as planned. However, classroom B closed for a couple of months, and students were only following classes online. Teacher B adjusted the planned curriculum to assist the students to practice exercises and prepare them for the official exams of Grade 12.

As noted earlier throughout the sessions, Teachers A and B used Colloquial Arabic in their sessions for various purposes. Both teachers indicated that they use the home language in the classroom because they want their students to understand what they are teaching. Having said that, Teacher A only used Colloquial Arabic after several attempts of using English to teach the concept. The students were recognizably more engaged and used higher levels of knowledge types and cognitive processes when using Colloquial Arabic. However, Teacher A persisted to use English first, but when that failed, she would use Colloquial Arabic to teach the concept and then translate these into English. On the other hand, Teacher B mostly used both Colloquial Arabic and English in the sessions. She would use Colloquial Arabic and then switch to English for the scientific terms (e.g. 'burette, titrate, reactant). She used Colloquial Arabic, almost exclusively, when introducing examples from students' everyday lives and encouraged the students to use Colloquial Arabic as well. She then proceeded to translate the key terms into English.

Concerning knowledge types, different patterns of language used across the levels in both classrooms A and B were observed. In both classrooms A and B, the dominance of the 'factual' level utterances was observed across the different sessions. As indicated earlier, Teacher A used English dominantly across the various knowledge type levels. For classroom A, 'conceptual' level utterances were second in terms of dominance. The teacher's conceptual and higher-level knowledge type utterances often involved more Colloquial Arabic. She inserted Colloquial Arabic in her talk to help students follow the reasoning and to understand and build connections among the concepts. On the other hand, Teacher B used integrated utterances (both the home language and English) and English relatively equally across the ‘factual’ knowledge types. ‘Procedural-algorithmic’ utterances were second dominant in classroom B. Towards the end of the observations, Teacher B started using integrated utterances more, relative to the use of English. Students, in both classrooms, used integrated utterances dominantly across the various levels. English was used for short ‘factual’ answers or key scientific terms. Students of classroom A, however, used English more when prompted.

Regarding cognitive processes, in classrooms A and B, the ‘understand’ level utterances were dominant across the observed sessions. The language used differed between the teachers and the students. Similar to what was observed regarding the knowledge types, Teacher A used English dominantly across the various cognitive processes observed. For classroom A, ‘remember’ level utterances were second in dominance as the students were asked to recall rules in the sessions. Teacher A also employed Colloquial Arabic in higher-level cognitive processes utterances to help students follow the reasoning and to understand and build connections among the concepts. On the other hand, Teacher B used integrated utterances (both the home language and English) and English relatively equally. For classroom B, as all the sessions were focused on solving exercises, ‘apply’ level utterances were second dominant. Towards, the end of the observation, Teacher B increased her use of integrated utterances with higher-level cognitive processes utterances as well. In both classrooms, integrated utterances were often the default practice of the students to engage in the discourse. However, students used English dominantly for short ‘factual’ answers or key scientific terms while they used Colloquial Arabic when engaged in higher-level discussions.

To sum up, the home language was used differently across the knowledge types and cognitive processes. Concerning knowledge types, ‘factual’ level utterances were often stated in English by the teachers and the students. Similarly, in relation to cognitive processes, ‘remember’ level utterances were often in English. However, with ‘conceptual’ and ‘procedural’ level utterances and with ‘understand’ and ‘apply’ level utterances, home language was employed more to help students follow the reasoning and build connections of the different ideas. Teacher B frequently used the home language more extensively in her utterances while switching to English for key terms. Teacher A would follow a similar approach when teaching in English failed to support students’ understanding of the concepts. Students in both classrooms were more engaged and contributed more meaningfully to the discussion when the home language was used.

CHAPTER V

DISCUSSION, CONCLUSION, AND IMPLICATIONS

This study employed a qualitative research design and methods to collect and analyze data for understanding the existing language practices that support abstract concept development in chemistry classrooms. This study has a two-fold purpose: (1) investigate the language practices teachers use to support their students' conceptual understanding in secondary chemistry classrooms and (2) explore how the use of home language (spoken Arabic) facilitates students' understanding in secondary chemistry classrooms. This chapter includes a discussion of the research findings organized by the research questions, limitations of the study, implications of the study, and finally recommendations for further research.

Discussion of the Research Findings

This study attempted to contribute to the knowledge of whether using the home language in the classroom supports conceptual understandings, particularly in multilingual contexts. Specifically, the study investigated the classroom practices in two chemistry classrooms in Lebanon where the language practices used were examined to investigate if they support conceptual understanding. The study also explored the ways the home language was used to support understanding within the social context of the chemistry classroom. In this section, the findings of this study are discussed in the context of the relevant literature organized by the research questions.

Even though this study adopted similar methods used in the study of Salloum and BouJaoude (2019a), the observed grade levels differed. Salloum and BouJaoude's (2019a) study involved observing grade eight classes while this study investigated the language practices in grade 11 chemistry classrooms. Furthermore, the content across both studies differed since the concepts covered in the observed chemistry sessions contained more abstract concepts.

First Research Question: Teachers' Existing Language Practices

The findings of this study indicate a variation in the observed teachers' language practices to support conceptual learning in chemistry classrooms. As indicated earlier, to understand the practices used, the researcher examined the communicative approach, patterns of discourse, frequency of utterances, and patterns of teacher practices. The communicative approaches used by Teacher A and Teacher B influenced the forms of engagement in the classroom where both teachers' dominant approach was authoritative interactive. This is in line with the findings of Salloum and BouJaoude (2019a) where all the observed sessions in the Lebanese middle school classrooms were authoritative interactive and content-driven. The dominance of the authoritative interactive approach could be interpreted as a method that teachers used to keep the students engaged in the classroom while maintaining their authority in the classroom. Both teachers were comfortable in their position of authority in their classrooms (e.g. "I am a priority in the class", " **meen abda ana aw huwe**"). Additionally, consistent with previous research, the teachers engaged their students in a series of IRF/IRE chains of interactions (e.g. Lemke, 1990; Salloum & BouJaoude, 2019b; Scott et al., 2006).

Nonetheless, in both classrooms, some interactions showed evidence of dialogic interactive approaches. The dialogic interactive episodes mainly emerged for two purposes: introducing everyday concepts/exercises for the students and addressing students' misunderstandings. During the interactions where students' misunderstandings were addressed, students' views were explored until they showed an understanding of the introduced concepts. Similarly, when introducing an activity from the students' everyday lives, the teachers' approach would start as dialogic interactive. Then, the teacher would shift back to the authoritative interactive approach to guide the classroom discussions. These findings align with previous findings of Aguiar and Mortimer (2013), Aguiar et al. (2010), Mortimer (1998), Scott (1998), Scott et al. (2006), and where teaching for meaningful learning of scientific knowledge required shifts between authoritative and dialogic discourse.

Despite the dominance of the authoritative interactive approach, utterances were distributed relatively equally between the students and the teacher in both classrooms. The language practices, however, differed between the teachers and students in each classroom. Teacher A dominantly used English while Teacher B dominantly used integrated utterances (both English and Colloquial Arabic). On the other hand, students in both classrooms dominantly used integrated utterances. Both teachers noted that students expressed themselves more easily in their home language. The students' use of integrated utterances in the classrooms is aligned with the findings of Probyn (2006), Rutherford and Rollnick (1993), and Salloum and BouJaoude (2019a) where students were noted to use both the home language and international language in their utterances.

Moreover, both teachers attempted to relate science to everyday life using analogies (Teacher A, monetary example) or real-life examples (Teacher B, the role of the Ministry of Health). During these examples, the students were highly engaged and participated actively in the discussions. This finding corresponds to previous research where relating science concepts to everyday examples would be more meaningful for the students (e.g. Mortimer & Scott, 2003). Additionally, previous research findings indicate that teachers use the home language for affective purposes and classroom management (e.g. Probyn, 2009, 2015). This study supports these findings because both teachers used the home language for classroom management purposes and to ease tensions in the classrooms.

Teacher A presented her lessons in English and codeswitched to Colloquial Arabic occasionally. These results also reflect those of Probyn (2006, 2009) and Salloum and BouJaoude (2019a) where findings indicate that most teachers in the study presented in English and then codeswitched occasionally to the home language. As indicated earlier, Teacher A emphasized the use of English as the language of science. This was reflected in her explicit instruction to students to use English. Also, Teacher A's use of English to state objectives and to start classroom interactions. Even though Teacher B used integrated utterances more in the classroom, she also used English to state objectives and to start classroom interactions. These findings could be interpreted as an attempt to ensure the students master the language of science to help them succeed in chemistry and do well in official public examinations. Additionally, almost in all observed sessions, Teacher A asked one of the students to read a rule or the given of an exercise. This could also be interpreted as one of the ways the teacher was attempting to scaffold students' mastering of the language of science. These findings reflect the notion that the international language provides access to science. Moreover, Teacher A persistently used English and resorted to using the home language when students were frustrated. This practice is consistent with findings of Rollnick and Rutherford (1996), Probyn (2006, 2009), and Salloum and BouJaoude (2019a) where teachers codeswitched to home language to explain concepts when students seemed frustrated.

Alternatively, Teacher B used the home language consistently in her explanations similar to the public school teacher in Salloum and BouJaoude's (2019a) study findings, despite School B's policy to use English in the classrooms. This policy was highlighted in posters posted on the bulletin board of guidelines for class conduct where item #1 is to use English. Moreover, even though Teacher B recognized the importance of the international language as the language needed for tests, her dominant language practice was the use of the home language. Her explanations and elaborations were using integrated utterances. Additionally, Teacher B placed a great deal of emphasis on the exercise-solving skills for Grade 12 official examinations. This seems to be in accord with previous studies where teaching to the test for high stakes exams was considered a moral duty for the teacher (e.g. Salloum & BouJaoude, 2019b).

In summary, the findings of this study are in line with previous research findings where the language practices varied across the case studies. Notably, the teachers were aware that the students' language proficiency level would affect their understandings and expressing themselves in the exams. Nonetheless, teacher's approaches to bridge the students' linguistic gaps varied. Teacher A's approach was to encourage the students to use English extensively and offering the students the chance to practice English within her classroom. However, Teacher B highlighted key terms in the exercises so that students were aware of them and able to navigate the exercises successfully. Furthermore, teachers stated that they 'had' to use the home language; otherwise, the students would not understand the concepts being taught. This indicates that even though teachers were using the home language as a resource, they were not certain of the validity of such use especially given the language-in-education policies in Lebanon and the specific schools.

Second Research Question: Variation in Use of Home Language

This study attempted to contribute to understanding the role of the home language in understanding abstract science concepts, particularly in chemistry. As indicated earlier, to understand how the home language was used for conceptual understanding, the researcher examined the uses across the knowledge types and cognitive processes. As indicated earlier, the focus of the sessions of classrooms A and B differed. Classroom A's sessions varied between concept development and practice and test preparation. All the sessions included exercise solving to help the students master the skills needed to pass exams. On the other hand, Classroom B's sessions focused on practice and test preparation in addition to concept development.

Accordingly, the levels of knowledge types and cognitive processes differed across the classrooms. Concerning knowledge types, the 'factual' level utterances were dominant across the different sessions in both classrooms A and B. For classroom A, the second dominant level utterance was at the 'conceptual level. On the other hand, 'procedural-algorithmic' utterances were the second dominant in classroom B. The language practices differed across the teachers and the classes. Even though Teacher A used English dominantly, she integrated Colloquial Arabic in the utterances to assist students to connect and understand the concepts. The utterances that involved more Colloquial Arabic were often conceptual and of higher-level knowledge type levels. On the other hand, Teacher B used integrated utterances (both the home language and English) across the various levels. Students in both Classrooms used integrated utterances in the levels except for short 'factual' utterances that were stated in English.

Concerning cognitive processes, the dominance of the 'understand' level utterance was observed across the sessions, in both classrooms. For classroom A, 'remember' level utterances were second in dominance as the students were asked to recall rules in the sessions. For classroom B, 'apply' level utterances were second in dominance as the sessions focused on solving the exercises. Similar to what was observed regarding the knowledge types, Teacher A used English dominantly across the various cognitive processes observed. However, she employed Colloquial Arabic in higher-level cognitive process utterances to support students in building connections among the concepts. On the other hand, Teacher B used integrated utterances and English relatively equally. Nevertheless, similar to Teacher A, she used more integrated utterances in higher-level cognitive process utterances. In both classrooms, integrated utterances were often the default practice of the students to engage in the discourse.

The findings of this study align with those by Salloum and BouJaoude (2019a) where the knowledge types that prevailed in the classroom differed depending on the session's focus. Generally, the 'factual' level utterances were dominant across both classrooms A and B. However, sessions that were focused on test preparation and exercise-solving skills had more of a 'procedural algorithmic focus. In accordance with that, Teacher B's sessions had a higher frequency of 'procedural algorithmic' utterances as all sessions focused on exercise solving. During those sessions, Teacher B used the home language extensively, especially when making connections across concepts or procedures where she would codeswitch when introducing key scientific terms. This practice is similar to the findings of Probyn (2006, 2009) where teachers engaged their students using their home language while code-switching to English for key terms.

Conversely, sessions that focused on concept development included more 'conceptual' level utterances. Teacher A used English dominantly across the various knowledge type levels, however, she used Colloquial Arabic to help students follow the reasoning and build connections among the concepts. These findings are aligned with those of Probyn (2006, 2009) where teachers codeswitched to the home language for transitioning and aiding students to build connections among the concepts. Moreover, the increased student engagement when the teacher used Colloquial Arabic is aligned with the findings of Salloum and BouJaoude (2019a) whose findings indicated that using the home language moved the discussion to a more meaningful conceptual one.

Teachers A and B used ‘factual’ utterances to activate prior knowledge and establish a common background among the students; a finding in agreement with that of Salloum and BouJaoude (2019b). Both the teachers and students would use English for the short ‘factual’ utterance. The use of English could be attributed to the shortness of the utterances thus making it easier to use it or to the lack of knowledge of Arabic equivalent of some of the terms. For example, titration or redox reactions are terms to which students are introduced only in English. Even if they wanted to use the home language to say those words, they simply lacked the equivalent words in Arabic.

Similar to the findings of Salloum and BouJaoude (2019a), the findings of this study showed the dominance of using lower levels cognitive processes. The ‘Understand’ level was dominant across classrooms. However, as Classroom B focused more on exercise solving, the ‘apply’ level was also evident. Teacher B used integrated utterances and English relatively equally across the levels of cognitive processes. However, Teacher A used English dominantly, but employed Colloquial Arabic when using higher-level cognitive processes, mainly to help students understand and build connections among the concepts. These findings align with previous research (e.g. Probyn, 2009; Salloum & BouJaoude, 2019a). Probyn (2009) identified one broad category for codeswitching where the teachers would codeswitch to the home language for cognitive reasons in response to students’ limited language proficiency. This practice was used by Teacher A who codeswitched to Colloquial Arabic when necessary for the students. The use of the home language as a last resort parallels the practice of one of the teachers in the study of Salloum and BouJaoude (2019a).

In summary, the findings of this study are in line with previous research findings (e.g. Probyn, 2006, 2009; Rollnick & Rutherford, 1996; Salloum & BouJaoude, 2019a, 2019b) where using the home language promoted more meaningful learning of the science concepts. Students were more comfortable expressing themselves in Colloquial Arabic. Teachers also recognized the need to use the home language within their classrooms to promote understandings. However, it is pertinent to note that all these studies used similar methodologies to investigate the language practices in the observed classrooms. Considering the use of different methods such as conversational analysis (e.g. Janusz, & Perakyla, 2021; Khaniki & Noorirad, 2019) could give input to different findings where discrepancies and consistencies could be examined.

Limitations

One of the limitations lies in the design of the study where a qualitative approach to two case studies was adopted. The study focused on two case studies where the classrooms observed had English as the language of science instruction and Lebanese Colloquial Arabic as the home language. Hence, the study provided an opportunity to understand the characteristics of science talk in these limited contexts, a situation that would not be readily generalizable across all schools. However, the researcher described thoroughly the methods of data collection and analysis to ensure the transferability of the study findings. In this way, other researchers could determine if the contexts are comparable to theirs and use the findings of this study.

Another limitation is that the data collected were transcribed verbatim for analysis. Transcripts often reduce the data and omit details of real-time long pauses or quick answers. They are also void of the tone used within the talk whether the tone indicates assertiveness, wonder, or certainty. To limit the impact of this limitation, the researcher transcribed the data herself as she could recall the events and contexts and hence provide details and observational remarks to clarify and contextualize the transcribed data as much as possible.

In addition, another limitation could be the content of the lessons. As indicated earlier, School B closed extensively during the October 17 revolution, while School A's closure was limited. Accordingly, Teacher A was able to deliver all lessons with minimal disruption to the scheduled lessons. However, as Teacher B stated, she had to adjust the content and the order with which she covered the topics for the year. She devoted the available time for test practice and preparation while introducing new concepts within the exercises.

Finally, another limitation that may have influenced the findings of the study is that the data were collected via videotaping the classroom with the researcher present. The awareness of the participants' involvement in the study could have influenced the language they used in the classroom. The teachers could have changed their language practices to reflect the language-in-education policy implemented in their schools.

Implications

The findings of this study showed that using the students' home language in the classrooms supported more meaningful conceptual learning. Hence, these findings may help educators plan their instructional approaches taking into consideration the language constraints imposed by using the international language as the language of instruction. Concerning the science classrooms, successful practices that supported students' limited language proficiency and scaffolded meaningful conceptual understanding of scientific ideas were identified. For example, Teacher B’s use of props and examples from students’ daily lives in addition to the smooth shifts between Colloquial Arabic, English, and science terms supported students' understanding. Teacher A used examples from daily lives, analogies, and Colloquial Arabic to help students build connections among the different languages present on the social plane. These practices could be used to help bridge the scientific/everyday discourse. Systematic adoption of these practices in teacher preparation programs could prepare teachers to help students with limited English language proficiency to succeed in science. Teachers need to be provided with practices and policies that would meet the language demands of the learners while giving them access to science. Therefore, when planning teacher development, particularly in Arab countries in which schools use English (or another foreign language) as the language of instruction, the tensions between using the international language and the home language should be taken into account.

Furthermore, this study contributes to the discussion on whether the language of instruction hinders or supports understanding of science, particularly the role of the home language in this process. The findings of this study seem to support the notion that the home language positively influences students’ learning in the classroom. The home language was utilized to help students understand the scientific concepts. Hence, it seems that the home language is a resource to be utilized to help bridge the gap of the everyday/scientific discourse rather than act as a barrier for understanding. Students need to be provided with opportunities to use their home language in the meaning-making processes in the classrooms.

Recommendation for Research

Since there is a limited number of studies adopting a socioculturally framed approach to investigate the characteristics of everyday and school discourse in the Arab region (Amin, 2009), this study is a step forward toward filling this gap. However, larger-scale studies are needed to investigate the different practices teachers are currently adopting. These practices could be a starting point to identify effective strategies that would be developed and tailored for the curriculum and corresponding grade levels. Future studies could build on this study where additional case studies are observed. Moreover, additional data collection methods could be introduced where individual students' conceptual understandings could be tracked. Other studies can compare the same teacher's practices when using two different international languages to find out if the use of the home language would be different. As Lebanon has two dominant international languages (English and French), some teachers (such as Teacher A) teach chemistry in both languages, consequently investigating the teacher's practices in both contexts could provide insights regarding the possible differential effects of using English and French. Additionally, different studies could adopt different methodologies to look into the classroom talk within the classrooms, these methodologies (e.g. conversational analysis) might give insight into the consistency of the observed findings across different studies. Furthermore, future studies could investigate how the teacher facilitates conceptual understanding while acknowledging the language demands of the students.

APPENDIX I

TRANSCRIPTION LEGEND

The following acronyms, abbreviations, and symbols were used in the transcripts.

Abbreviation/ Symbol Used	**Meaning / Indication**
T -A	School A teacher
T -B	School B teacher
S1, S2, etc.	Single Student
G	More than one student
(….)	Indecipherable words
[ ]	Observational remark
Bold	Arabic utterances (colloquial Lebanese Arabic or Modern Standard Arabic) written in Latin letters
(Italic)	Translation of home language (colloquial Lebanese Arabic or Modern Standard Arabic) into English
<u>Underlined</u>	utterances that highlight a theme or trend in classroom interactions
….	Some deleted lines

APPENDIX II

TRANSLITERATION SYSTEM USED

Arabic Letter Alone	Standard Arabic standalone letter Pronunciation	Presented in Latin letters
أ	Alf or A	A or 2a
ب	B-aa	b
ت	T-aa	T
ث	Th-aa Th as in booth	Th
ج	J-eem or J	J
ح	H-aa	H or 7a
خ	Kh-aa	Kh
د	D-al	D
ذ	Th as in this	th
ر	R-aa	R
ز	Z	Z
س	S-een	S
ش	Sheen	Sh
ص	S-ad	S
ض	D	D
ط	T	T
ظ	Th as in this	Th
ع	3-ain	3a or A
غ	Gh	Gh
ف	F	F
ق	Q	Q
ك	K	K
ل	L	L
م	M	M
ن	N	N
ه	H-a	H
و	Waw	W or U
ي	Y-aa	Y or I

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