AMERICAN UNIVERSITY OF BEIRUT

THE REPRESENTATION OF NATURE OF SCIENCE (NOS) IN GRADE 6 FRENCH, AMERICAN, AND LEBANESE SCIENCE TEXTBOOKS USED IN LEBANON

by
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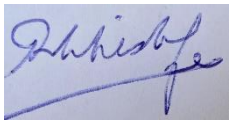

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ABSTRACT
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Title: The Representation of Nature of Science (NOS) in Grade 6 French, American, and Lebanese Science Textbooks Used in Lebanon

Textbooks are heavily relied upon as the main resource for teaching. The Nature of Science (NOS), now part of many newly developed curricula, is considered essential for students to achieve scientific literacy. To ensure the goal that curricula have for scientific literacy, textbooks now address NOS. A new framework, the Family Resemblance Approach (FRA), has been developed to give a holistic overview of NOS. The FRA to NOS framework shall be used in this study to analyze NOS in French, American, and Lebanese textbooks used in Lebanese schools.

There has been research conducted on analyzing American and Lebanese textbooks; however, to this day, no French textbooks (published in France) have been analyzed. The purpose of this study is to investigate the representation of NOS in grade 6 textbooks published by American and French publishers using the expanded FRA framework for NOS and compare the foreign textbooks to the Lebanese textbook. Following an inter-rater reliability test, three American, three French, and the Lebanese grade 6 textbooks were read in their entirety and analyzed. The frequency and percentage of representation of each NOS category were calculated, in addition to the quality of representation.

First, it was found that in American textbooks, all NOS categories were represented, except for the political power structure category. The categories under the social-institutional aspects were the ones with the highest frequencies of high-quality representation. Second, it was found that the French textbooks had many NOS categories unrepresented, except for Hachette's *Sciences et Technologie*, which had all categories represented. Third, the Lebanese textbook had four unrepresented categories, which were mostly from the social-institutional aspects. Finally, while American textbooks tend to have the highest number of occurrences for representation, French textbooks tend to have higher percentages for high-quality representation. The Lebanese textbook had the highest occurrences for the knowledge category amongst all textbooks, but it was rarely represented in high-quality. The results of this research can be used by Lebanese schools in their choice of textbooks to ensure equitable education in all classrooms. Furthermore, this study adds to the Vygotskian sociocultural theory, as new knowledge is gained from French textbooks.

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ABBREVIATIONS

NOS	Nature of Science
FRA	Family Resemblance Approach
CERD	Center for Education Research and Development

CHAPTER 1

INTRODUCTION

To engage students in the learning process, science classrooms have included more inquiry-based lesson plans and laboratory activities. However, textbooks are still heavily relied upon as the main resource for teaching (Aldahmash, Mansour, Alshamrani & Almohi, 2016; Chiapetta et. al, 2006). The Nature of Science (NOS), now part of many newly developed curricula, is considered essential for students to achieve scientific literacy (Dagher & BouJaoude, 2005). To ensure the goal that curricula have for scientific literacy, textbooks now address NOS, sometimes implicitly, other times, explicitly. Unfortunately, the components of NOS are not agreed upon by all researchers. There is a group of researchers who adopt the consensus view of NOS, which has been critiqued as too constrictive. These critiques have led to the development of a new framework, the Family Resemblance Approach (FRA), which gives a holistic overview of NOS.

In this chapter, I will summarize the theoretical framework on which this research is based, discuss teachers' reliance on textbooks for curriculum guidance, consider the importance of scientific literacy in the curriculum and its relationship to NOS, and review studies on the representation of NOS in science textbooks. Finally, I will explain the significance and rationale that have led to the development of my research questions. My research shall focus on analyzing the presence of NOS in American, French and Lebanese textbooks that are used in Lebanon.

Background of the Problem

This research subscribes to the Vygotskian sociocultural theory, which explains the necessity of social and cultural tools to mediate higher-level cognitive processes such as self-control and learning (as cited in Al-Murtadha & Feryok, 2017; and De Costa, Lantolf, & Thorne, 2007). Plut & Pesic (2003) describe textbooks as cultural supportive tools that facilitate the development of a person. Plut and Pesic (2003) further elaborate on the structure of textbooks and establish them as a genre.

Given the important role textbooks have culturally and educationally, it is expected that teachers rely heavily on them to plan their lessons, use them as resources for teaching strategies, and for curriculum guidance (Bergqvist & Chang Rundgren, 2017; Drechsler & Schmidt, 2005; Georg Eckert Institute for International Textbook Research, 2009; Mikk, 2000; Peacock & Gates, 2000; Sikorova, 2011; Tulip & Cook, 1993).

Recently, science education has seen the inclusion of scientific literacy as a learning objective for students (Education Commission, 2000; The Next Generation Science Standards Executive Summary, 2013; OECD, 2010). Scientific literacy is the use of what is known in science to inquire and to recognize the connection of technology, science, and culture with our daily life (PISA, n.d.). A scientifically literate individual understands the theories, laws, principles, and the concepts of science; understands and can use the processes of science; uses science to solve personal and societal problems; differentiates between opinion and evidence; recognizes the role and constraints of science and technology in advancing human welfare, and understands the nature of science. (Hodson & Wong, 2014; Lederman & Niess, 1998; Lederman, Abd-El-Khalick, Bell, & Schwarz., 2002).

The Nature of Science (NOS) is a prevailing area of research in science education and a vital part of scientific literacy. NOS looks at science from a philosophical and a historical lens. Abd-El-Khalick and Lederman (2000) compiled the following aspects of NOS that are important to learn during k-12 education: scientific knowledge is tentative, empirically based, theory-laden, partly the product of human inference, imagination, and creativity; and socially and culturally embedded. Three aspects were later added by Lederman, Abd-el-Khalick, Bell, and Schwartz (2002) that were found to be vital for NOS: "the distinction between observation and inference, the lack of a universal recipelike method for doing science, and the functions of and relationships between scientific theories and laws" (p. 499). This approach to NOS is referred to as the consensus view of NOS.

The aspects listed above have been the basis for a variety of research studies in science education. Indeed, classroom activities have been developed to teach specific aspects of NOS (e.g. Damli & Yavaş, 2015; Eren-Sisman & Koseoglu, 2019; Lau, 2017), students and teachers' views of NOS were assessed based on this list (e.g. Abd-El-Khalick, Bell, & Lederman, 1998; Kim & Nehm, 2011; Pelissier, Venturini, & Calmettes, 2007; Roletto, 1998), and textbooks have been analyzed for their depiction of NOS based on the consensus view (e.g. Abd-El-Khalick, Waters, & Le, 2008; Fuselier, Jackson & Stoiko, 2016; Ramnarain & Chanetsa, 2016). Khishfe (2017), recently investigated NOS views among high school students in Lebanon. The results showed that the students had inconsistent views of NOS. Based on the above, we can deduce that the consensus view is a well-established framework that is widely used in the science education community for research purposes.

The list of tenets of the consensus view has been critiqued by many science education experts (Allchin, 2011; Clough, 2007; Irzik & Nola, 2011; Duschl & Grandy, 2013; Wong & Hodson, 2009). For example, Duschl and Grandy (2013) question the implication of the list of the consensus view on k-12 education. While the tenets in the consensus view list are correct and cannot be disagreed upon, Duschl and Grandy (2013) highlight that the tenets do not focus on the methodological, cognitive, or epistemic practices of science. Duschl and Grandy (2013) advocate for the engagement of students in scientific practices so they can learn what is meant by objectivity and subjectivity, instead of assuming that the tenets of the list of the consensus view are a never-changing conclusion about science (Clough, 2007).

Clough (2007) advocates for changing the declarative statements of the list of tenets of the consensus view into questions. This would therefore encourage students to investigate the contexts in which these tenets can be applied. As a result, the investigative questions would avoid having students take on extreme positions, such as thinking that all science is tentative. By turning the statements into questions, teachers would also steer away from viewing the consensus view list as extra knowledge, and consequently, assessments would have more thoughtful questions. In addition, Allchin (2011) disputes that studying the list of tenets of the consensus view would emphasize students' recall and comprehension skills, at the expense of applying and analyzing NOS in its appropriate context.

Furthermore, Hodson and Wong (2017) argue that the oversimplification of the consensus view's tenets can be counterproductive for students. For example, the too literal interpretation of science as being tentative can mislead students to think of *all* science as only temporary without considering the robustness of scientific knowledge

that has been verified and proven (Clough, 2007; Hodson & Wong, 2017). Hodson and Wong (2017) also criticize the consensus view by underlining its failure to seize the multiple practices that generate knowledge across the subdisciplines of science and their complexities. The authors call for an enriched consensus view, one that appeals to a more authentic representation of science, taking into consideration its philosophical, sociological, and historical tenets. In the same way, the first tenet, tentativeness, was critiqued by Clough (2007) and Hodson and Wong (2017), the other tenets listed by the consensus view were also critiqued by various scholars. Below, I will summarize some of these critiques.

The second tenet differentiates between observation and inference. Hodson and Wong (2017) argue that some observations are made based on well-established theories, such as claiming that substances dissolve. Therefore, the authors found that scientific investigations would be impractical to conduct without making inferences. Furthermore, claiming that science is socially and culturally embedded is unclear. Hodson and Wong (2017) show that the knowledge that is produced by science could be affected by society and culture. However, deciding which research to work in may also be influenced by society and culture. Therefore, the consensus view does not clarify exactly how science is socially and culturally embedded. Moreover, many social and cultural processes are disregarded in the consensus view, such as the influence of the scientists' motivation, funding, biases, peer review, and others (Allchin, 2011).

Irzik and Nola (2011) point out that the consensus view has a few shortcomings, such as its seventh tenet, that of methodology. The authors note that "the issue of methodology seems to be dismissed altogether by saying that there is no single method for doing science" (p. 592), setting aside some methodological rules that generally

guide scientific practices. The authors consider excluding these general methodologies from scientific inquiry artificial. Furthermore, the tenets of the consensus view lack unity and may give rise to certain issues that are not addressed. For example, Irzik and Nola (2011) question if the objectivity of science is impossible given that the consensus view claims that science is theory-laden and subjective. Irzik and Nola (2011) also question the validity of knowledge that is accepted across cultures and societies when the consensus view claims that science is socially and culturally embedded.

The critiques mentioned above are part of a larger, more complex set of critiques that further show the limitation of the consensus view, implying that the use of the consensus view in research may result in unreliable findings. A more comprehensive, holistic, and encompassing description of NOS was needed for research. This need has led to the development of the Family Resemblance Approach (FRA) to NOS by Irzik and Nola (2011).

The idea of FRA was first developed by Wittgenstein. In his book, *Philosophical Investigations*, Wittgenstein et al.(2009) show that in a group, none of the members share the same features. Wittgenstein et al. (2009) exemplify this concept with games, which have "a complicated network of similarities overlapping and criss-crossing: similarities in the large and in the small" (p.36[e]). To characterize these similarities, Wittgenstein uses the analogy of a family. Just like in a family, there are some resemblances amongst its members such as hair color and height, there are overlapping similarities amongst games. However, there is not one feature common to all games or all family members.

Irzik and Nola (2011) explain that the basic idea of a family resemblance "turns on the fact that the members of a family can each resemble one another in some respects

but not in others" (p. 594). Applying FRA to science would entail looking for categories that are common to all sciences, thus unifying them. However, while the categories may be the same, the subsets within these categories may be different . According to Irzik and Nola (2011, p. 601)

> A family resemblance definition for an individual science will be formed by taking some subset of all these characteristics, and this may well differ from the subset of characteristics for some other individual science. When considered as pairs of sciences there will be some characteristics held in common and others not held in common.

Irzik and Nola's (2011) paper focused on the epistemic aspects of science, listing four main categories: activities, aims and values, methodologies and methodological rules, and products that are common to sciences. In the following paragraphs, these categories shall be elaborated.

To explain, the first category, "activities", including practices such as observational, material, and mathematical practices. The activities may vary depending on the scientific discipline: physics includes material and mathematical practices, while botany involves very little if at all, mathematical practices (Irzik & Nola, 2011). Later, Irzik and Nola (2014) referred to these activities as "scientific processes of inquiry" (p. 1009). This category was then modified by Dagher and Erduran (2016) to substitute the term with "scientific practices" to steer away from the cliched use of the terms associated with "scientific process skills in science education, and the generally all-encompassing sense implied by scientific activities" (p. 154).

The second epistemic category, "aims and values", outlines the different philosophical understandings of theories in science. For example, realists consider

physical theories as explanations of laws that have been established experimentally. On the other hand, anti-realists such as Pierre Duhem (1954) view theories as summaries and logical classification of experimental laws. The family resemblance approach does not take sides on these disagreements. Irzik and Nola (2011) outlined the aims that subspecialties of sciences can have following a certain philosophy and the role these stances may have characterized the subspecialty of science. In this category, the authors also state some values of science, such as simplicity and fruitfulness. Cognitively, having different values helps the development of novel knowledge and avoiding bias, which is an aim for science. For example, when craniologists claimed that men were superior to women due to their bigger-sized skulls, it took two women, who think differently than men and value women's intelligence, to prove this claim wrong. Allchin (1999) shows that a variety of values in science is one way to allow for more reliable reviews and correction of scientific claims and practices.

The third epistemic category, methodologies and methodological rules, recognizes that science cannot achieve its aims randomly, without following some methods and methodological rules. Irzik and Nola (2011) list some important rules of scientific methodology such as the rejection of inconsistent theories and avoiding *ad-hoc* revisions to theories. Methods and methodological rules ensure the reliability of scientific knowledge through self-creativeness. Supporters of the consensus view dismiss scientific methodology and rules, which can belittle how science eliminates the error.

The fourth category, “products”, is a counterargument to the consensus tenet of “scientific theories and laws”. Irzik and Nola (2011) claim that not all sciences may have laws, such as biology. Indeed, Irzik and Nola (2011) highlight that the use of

methods mentioned previously for scientific activities produces several results such as "hypotheses, laws, theories, and models as well as collections of observational reports or collections of experimental data" (p.600). In future work by the same authors, Irzik and Nola (2014) renamed this category "knowledge", which is the "end product" (p.1006) of laws, theories, and models.

Irzik and Nola (2014) reviewed their original four main components of the epistemic NOS and added a fifth component, the social-institutional dimension. They explained the fifth component as a domain of its own, science as a social system, which includes the following categories: professional activities, scientific ethos, social certification and dissemination, and social values. In the first component of the social-institutional domain, "professional activities", Irzik and Nola (2014) outline certain social functions that scientists engage in besides completing scientific research. These social activities include, but are not limited to, "attending academic meetings, presenting their findings there, publishing them, reviewing manuscripts and grant proposals, etc." (p.1006). The second component of this domain, "scientific ethos", refers to expected attitudes that scientists need to adopt when they collaborate with other scientists. These ethical codes of conduct include integrity, openness, freedom, respecting the environment and research subjects (Irzik & Nola, 2014). The third component of this domain, "social certification and dissemination of scientific knowledge", refers to the reviewing process of the scientific community once research is published, such as peer-reviewing. Irzik and Nola (2014) consider this system as "an effective *social quality control* over and above the *epistemic control* mechanisms that include testing, evidential relations, and methodological considerations" (p.1008). The fourth and last component of the social-institutional system is the "social values of

science". This component underlines the importance of the usefulness of science for the improvement of people's livelihood. The utility of science for society is an important objective of science.

In 2016, Erduran and Dagher added three categories to the framework proposed by Irzik and Nola that they see important for the science curriculum: social organizations and interactions, political power structures, and financial systems. Erduran and Dagher (2016) believe that these categories have a significant influence on how science is developed. For example, Kaiser (2002) showed that during and after World War II, funding for science research increased dramatically, and the sources of funds were mostly from agencies related to defense. However, Kaiser (2002) notes that between 1968 and 1971, the great decrease of spending for defense and space lead to "sixteen-thousand scientists and engineers, each holding advanced graduate degrees, lost their aerospace-industry jobs" (p.152). Historical examples such as Kaiser's (2002) can help demonstrate the interaction of science with society and financial systems.

Using the FRA framework, various research has been conducted: analyzing curriculum (Kaya & Erduran, 2016; Maurines, 2015; Yeh, Erduran, & Hsu, 2019), analyzing assessments for their representation of NOS (Erduran, Dagher, & McDonald, 2019), reviewing previous research (Peters-Burton, Bergeron, & Sondergeld, 2017), and analyzing textbooks (BouJaoude, Dagher, & Refai, 2017; McDonald, 2017).

Given that the FRA to NOS framework is more comprehensive and holistic in comparison to the consensus view, its research application can open more opportunities for conceptual development and further knowledge. For these reasons, the FRA to NOS framework was used in this study to analyze NOS in French, American, and Lebanese textbooks used in Lebanese schools.

Given the Lebanese context of this study, it is important to consider the goal the country's education program has for scientific literacy. The Lebanese curriculum goals have shifted towards including scientific literacy aspects (BouJaoude, 2002). However, the change in curriculum goals was not aligned with the objectives of each science subject. Indeed, BouJaoude's (2002) research showed that "there is inconsistency in the percentage distribution of the aspects of scientific literacy between the general objectives of science and the rest of the curriculum" (p.153). In addition, Olson's (2018) study scrutinized documents of science education in nine different countries, one being Lebanon. The author aimed to determine the explicit NOS learning expectations that exist in these education standards documents. In the case of Lebanon, Olson (2018) found that only 3% of the statements in the documents refer explicitly to NOS as a learning objective.

Furthermore, 51.4% of schools in Lebanon teach science in French and 48.6% of schools teach it in English (CERD, 2018). In science classrooms, teachers still rely on textbooks as a primary resource to plan their lessons, classroom activities, and teaching strategies (Drechsler & Schmidt, 2005; Edling, 2006; McDonald, 2017; Sikorova, 2011). Students enrolled in Lebanese schools, such as the ones mentioned above, have the choice to pursue either the French or the English program. In Lebanon, foreign textbooks are commonly used in classrooms, sometimes to complement the official textbook published by the Ministry of Education and Higher Education, other times to completely replace it. I have visited a couple of Lebanese bookstores and contacted some publishing houses to inquire about textbooks that are used in grade 6. I have found that the French textbooks available on the Lebanese market fall under three main French publishing houses: Bordas, Hachette, Magnard. Some publishing houses offer an

adapted version of the textbooks that are cheaper and may be preferred by parents as they pay for textbooks out of pocket. The three main American textbooks available on the Lebanese market are published by Pearson, McGraw Hill, and Houghton Mifflin Harcourt. There are several textbooks published locally, however, the Center for Education Research and Development (CERD), which is funded by the Ministry of Education and Higher Education (MEHE) has only released one official textbook for science. I shall select three French textbooks, three American textbooks, and compare them to each other and then to the Lebanese grade 6 textbook published by the CERD for their representation of NOS. Recently, BouJaoude et al. (2017) explored the grade 9 textbooks published by the Ministry of Education and Higher Education for their representation of NOS. However, to this day, no French textbooks (published in France) have been analyzed, used in Lebanon or elsewhere.

Given the curriculum objectives of Lebanon for scientific literacy and the textbooks that are used in Lebanese classrooms, research must explore the alignment between the two entities. However, besides the locally published textbooks, the foreign textbooks that are on the Lebanese market and used in classrooms have not been analyzed for their portrayal of NOS. This shows a gap in knowledge.

Statement of the Problem

Textbooks are cultural supportive tools and important resources for teachers to plan their lessons and activities (Drechsler & Schmidt 2005; Edling, 2006; Plut & Pesic, 2003; Sikorova 2011). The latest reforms in the Lebanese curriculum focus on students improving their scientific literacy (CERD, n.d.). NOS is one aspect of scientific literacy that is widely used in science education to present science as one way of knowing about the natural world (Lederman, 1992; Lederman, Lederman, & Antink, 2013). The

Expanded Family Resemblance Approach to NOS is the most comprehensive framework to use for analysis of textbooks as it considers shared aspects of science that are common across multiple disciplines of science: cognitive, epistemic, social, institutional, and financial. Given that most textbook analysis has been implemented using the consensus view, the results of these previous research studies may be restrictive. Further research is needed to investigate the representation of NOS in science textbooks using the Expanded FRA framework for NOS, which would give a more holistic view of NOS in these textbooks. While the representation of NOS has been studied in textbooks published by the Lebanese Center for Educational Research and Development (e. g. BouJaoude, Dagher, & Refai, 2017), the representation of NOS in foreign textbooks which are readily used in many Lebanese schools, especially at the elementary level, has not been investigated. Consequently, the purpose of this study was to investigate the representation of NOS in grade 6 textbooks published by American and French publishers using the expanded FRA framework for NOS and compare the foreign textbooks to the CERD textbook. Grade 6 was selected because it represents the end of the second cycle of the Lebanese educational ladder, after which students start taking science as separate subjects. Specifically, this study answered the following research questions.

Research Questions

Given that the extended FRA is a more comprehensive representation of NOS, this study answered the following research questions:

1. What NOS categories, if any, are addressed in the grade 6 American science textbooks published in the United States and used in Lebanon, and which

ones are not? If present, what is the quality of representation of these categories?

2. What NOS categories, if any, are addressed in the grade 6 French science textbooks published in France and used in Lebanon, and which ones are not? If present, what is the quality of representation of these categories?
3. What NOS categories, if any, are addressed in the grade 6 Lebanese science textbook published by CERD, and which ones are not? If present, what is the quality of representation of these categories?
4. What are the differences, if any, between the representation of NOS in American, French, and Lebanese 6th-grade science textbooks?
5. What are the similarities, if any, between the representation of NOS in American, French, and Lebanese 6th-grade science textbooks?

Rationale

Many curricula aim to increase scientific literacy in students through the study of NOS. Indeed, Maurines (2015) found that the French secondary syllabus aims at implementing NOS in the curriculum for scientific literacy. However, in science classrooms, teachers still rely on textbooks as a primary resource for the curriculum (McDonald, 2017). In France, no textbooks have been analyzed for their alignment with the curriculum. In the case of Lebanon, the curriculum goals are not properly aligned with textbook content (BouJaoude, 2002). Indeed, BouJaoude et. al. (2017) analyzed grade 9 Lebanese national textbooks using the FRA framework. Their results show that NOS is not represented in physics textbooks, rarely in chemistry, and somewhat in biology books.

In the case of Lebanon, one of the curriculum's goals is scientific literacy for students. Schools, however, are not required to use the Lebanese national textbooks. Schools can pick any textbook they would like for their classrooms and work on the curriculum goals on their own. Many schools choose to use foreign textbooks. This research is significant to the science teaching practice of these schools as it can help them pick textbooks that are better aligned with the curriculum goal of scientific literacy. In schools that cater to both French and English programs, students at the same grade level would be using different textbooks. This raises the question of equitable education within the same school. This research fills an existing gap in the literature, one that analyzes French textbooks for their representation of NOS. This is relevant in the Lebanese context, as many schools use French textbooks in their science classrooms.

Significance

Taking scientific literacy as a curriculum goal, we can compare if students at the same grade level, enrolled in the same school but using different textbooks, are receiving an equitable education. The implications of the conclusions of the study would be significant to the practice of teaching science, in all schools, especially in ones that cater to both French and English programs that use different textbooks but have the same curricular goals and objectives. Since teachers rely on textbooks for their lesson plans, students enrolled in the same schools but in different programs might be taught science differently given that the textbooks used are different. This research would allow schools that follow the Lebanese curriculum to pick textbooks that can help ensure equity among their students that are learning science in different programs (French or English). This could later serve the practice of education by looking for a

possible absence of NOS category in the textbooks and teachers may fill in those discrepancies during their practice and instruction. In addition, schools that teach using an American, French, or Lebanese textbook will be able to identify the deficiency in these textbooks regarding understanding NOS and consequently supplement the textbook with extra instructional materials.

In addition, current policies on the free use of textbooks in private Lebanese schools may be revised to ensure equitable education in all classrooms, regardless of the teaching language.

Finally, this study may also add to the theory, as new knowledge gained on French textbooks following the FRA framework has come out as a result.

CHAPTER 2

REVIEW OF LITERATURE

In this chapter, the Vygotskian theoretical framework shall be reviewed, as this study follows its conceptual basis. Then, the importance of textbooks in science education will be emphasized, which includes the teachers' heavy reliance on them. Given the worldwide educational goal of scientific literacy, it is vital to investigate the portrayal of scientific literacy in textbooks. Therefore, the following research studies some contemporary views on scientific literacy and its relationship to understanding Nature of Science (NOS). Finally, given the topic of this study, NOS would have to be clearly defined. In science education, there are disagreements on the definition of NOS. I will go over the two major views concerning NOS: the consensus view and the Family Resemblance Approach to NOS. Throughout this literature review, the latest and most relevant research that has been conducted in the field related to textbooks, scientific literacy, and NOS research shall be examined.

Theoretical Framework

Vygotskian sociocultural theory is based on the concept that higher-level cognitive processes such as learning and self-control are socially and culturally mediated by tools (Al-Murtadha & Feryok, 2017; De Costa, Lantolf, & Thorne, 2007). Textbooks are cultural supportive tools that impact society's duplication of cultural influences (Plut & Pesic, 2003; Vygotsky, 1986). A Cultural Supportive Tool (CST) is part of a cultural environment and mediates the process of development of an individual (Plut & Pesic, 2003; Vygotsky, 1983). Plut and Pesic (2003) characterize a CST as representing a culture, constituting elements that can be internalized, and encompassing

a developmental mission. Given these characteristics, Plut and Pesic (2003) consider textbooks as an intricate cultural tool that can be established as a genre. The structural elements that are part of textbooks "are seen as means for achieving [desirable] goals" that mediate social practices and cognitive development (Plut & Pesic, 2003, p. 506). These elements are represented in textbooks in two different forms: formal elements and content elements. Examples of formal structural elements of textbooks include indexes, organizers, introductions, illustrations, and dictionaries. While content elements can be introductory problems, explanations, classifications, and models of problem-solving. An example that illustrates the relationship between content elements and their developmental mission would be problems in the textbooks that relate to everyday experiences (Plut & Pesic, 2003).

CSTs serve many functions that launch key developmental processes concerning cognitive and metacognitive development (Plut, 2000; Plut & Pesic, 2003). Plut and Pesic (2003) claim that individuals cannot grow without cultural mediation, and, in addition, a "textbook is a cultural product that, in the end, serves to a cultural reproduction, the survival of certain cultural system" (p. 509). In addition to their contribution to cultural reproduction, Al-Murtadha and Feryok (2017) emphasize the importance of textbooks in socialization by claiming that "textbooks are perhaps one of the most potent means of mediation available for socializing youth into cultural and social expectations" (p. 236). The most compelling evidence of the influence of textbooks on cultural reproduction is that of Nazi Germany's reform of the educational system. The Nazis indoctrinated students by changing the curriculum to focus on racial science. As a result, new textbooks were then used in classrooms ("Education", n.d.). In a math textbook, students were asked to calculate "the cost of care for the hereditary

sick", to show students the financial burden of the disabled on the state ("Education", n.d.). These reasons stress the vitality of textbooks as a resource for education and for teachers that use them as their main resource for lesson planning and curriculum guidance.

Teachers' Reliance on Textbooks for Curriculum Guidance

Several research studies confirm that teachers rely heavily on textbooks as primary resources to support their teaching, to plan their lessons, and to use them as a curriculum resource (Bergqvist & Chang Rundgren, 2017; Drechsler & Schmidt, 2005; Georg Eckert Institute for International Textbook Research, 2009; Mikk, 2000; Peacock & Gates, 2000; Sikorova, 2011; Tulip & Cook, 1993). Mikk (2000) remarks that textbooks give a thorough representation of curricula. Indeed, teachers use textbooks to determine the content of their lessons, their teaching strategies, and their classroom activities (Edling, 2006; Sikorova, 2011). Sikorova (2011) notes that topics in the classroom are taught in the same order as the textbooks' presentation of topics. In the context of the Arab world, Aldahmash et al. (2016) observed similar findings: teachers in the Arab world still rely heavily on textbooks as a main resource. This trend is observed worldwide. Chiappetta, Ganesh, Lee, and Phillips (2006) have shown that 90% of science teachers refer to their textbooks to guide their teaching and homework assignments. In addition, McDonald (2016) surveyed 486 Australian schools teaching grades 7 through 10 and found that textbooks are used in most science lessons. Textbooks help new teachers, substitute teachers, and staff through program continuity (McDonald, 2016).

Additional research sheds light on the consequences of teachers' reliance on textbooks. Indeed, given the dependence of teachers on textbooks, some concepts, such

as chemical bonding, become difficult to understand because of the way they are presented in the textbooks (e.g., Nahum, Mamlok-Naaman, & Hofstein, 2013; Taber & Coll, 2002). Bergqvist and Chang Rundgren's (2017) study showed consistency between the models of chemical bonds depicted in textbooks and the teachers' presentation of chemical bonding models. Further research shows that textbook models do not support students' comprehension of some concepts and models (Justi & Gilbert, 2002). Teachers' dependence on textbooks can lead students to develop misunderstandings of scientific concepts. In summary, the content of textbooks may eventually dictate classroom teaching and learning. This results in a "domino" effect, as teachers and students may develop misunderstandings due to the textbook's content.

The Importance of Scientific Literacy

If teachers rely on textbooks as a curriculum resource, then there is an underlying assumption that textbooks are in line with the curriculum. Lately, curriculum development efforts have been directed towards fostering scientific literacy in students (Education Commission, 2000; The Next Generation Science Standards Executive Summary, 2013; OECD, 2010). According to the Program for International Student Assessment (PISA, n.d), scientific literacy is described as the use of scientific knowledge to be able to engage in the process of inquiry and be aware of the connection of technology, science, and culture with our everyday life. For instance, in the United States, the recent science curriculum suggests that scientific literacy is necessary for citizens to take decisions related to everyday life issues such as health matters and environmental problems for example (Next Generation Science Standards, 2013). Unfortunately, recent research shows that most college graduates do not comprehend diagrams representing information about health-related topics. Indeed, less than 30% of

college graduates understand a data table about blood pressure and physical activity (National Assessment of Adult Literacy, n.d.). The need for a scientifically literate society has never been greater. This need has evolved our perspective on what scientific knowledge is: facts that we can recite or practical ways of thinking?

In France, Morin (1996) calls for a change in mindset when it comes to scientific knowledge. The author stresses the importance of historical and sociological contexts that affect scientific knowledge formation. The author posits that in science teaching, scientific knowledge is decontextualized from its societal background due to the specialized language used in each scientific domain. This leads to a culture of specialties, where one scientific expert in a domain cannot comprehend another. However, scientific domains are related to one another, and the compartmentalization of each domain is not beneficial to the overall understanding of science. The context in which scientific knowledge was developed is undervalued. The author calls for a paradigm shift in science teaching, where the teacher would be making connections to the societal and psychological aspects that contributed to scientific knowledge production. This call for mindset shift by Morin (1996) has been picked up by educational reforms of curricula. Indeed, the French curriculum recommends that teachers familiarize their students with the history of science and engage them in inquiry activities (Maurines, 2015).

These efforts have not been limited to formal education. Indeed, advocating for scientific literacy has been picked up by popular culture. In their book, *Young people's image of science,* Driver, Leach, Millar, and Scott (1996) clarify that an understanding of science is not limited to memorizing facts, laws, and theories. On the contrary, the authors argue that understanding science includes distinguishing the norms of the

scientific community, internalizing science process skills, deciding certain socio-scientific issues, and appreciating science as a vital part of modern-day culture.

A vital component of scientific literacy is NOS (Hodson & Wong, 2014; Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002). Correspondingly, experts within the science education community have spent years advocating for the inclusion of NOS in science education curricula (Lederman, 1992; Matthews, 2014, McComas, Clough, & Almazroa 1998). Coupled with Driver et al.'s (1996) book, the popularity of NOS has generated a debate within the science education body concerning its definition and the implication of implementing it in school curricula.

NOS

Extensive research has been conducted on NOS understanding in the science education community (Abd-El-Khalick, Bell, & Lederman, 1998; Allchin, 2013; Lederman, 1992; Smith, Lederman, Bell, McComas, & Cough, 1997). Since the 1960s, efforts of defining the nature of scientific knowledge emerged, starting with Conant's (1961) book, *Science and Common Sense*, and Klopfer's (1969) work. On the one hand, Conant's (1961) goal was to give students that are not pursuing a career in science a basic understanding of it by teaching them how it works through historical case studies. On the other hand, Klopfer's work (1969) explored elements of scientific literacy. Klopfer (1969) came up with the following vital components: understanding scientists' motivations, how they come up with ideas, test them, and finally, revise them.

Following Conant's and Klopfer's lead, Showalter (1974) portrayed scientific knowledge through characteristics such as: humanistic, replicable, and empirical. Further research surfaced, describing scientific knowledge as amoral, developmental,

creative, testable, parsimonious, tentative, and revisionary (Rubba & Anderson, 1978; Cotham & Smith, 1981; Showalter, 1974).

The interest in scientists' areas of research as part of NOS has spread worldwide. Indeed, in France, Shinn and Ragouet (2005) wrote a book reporting on investigating the multiple sources of interest in scientific knowledge production. The authors found four areas in total. The first area of research emerges from the market needs for research. The second type of research was the one based on scientists' interest and curiosity in conceptual development. The third research is in response to financial and political demands from society. And finally, the fourth reason for research arises from the interest in developing generic experimental instruments that can fit into the metric system, a research interest that Shinn and Ragouet (2005) termed "transversal research" (p.394). Shinn and Ragouet's (2005) acknowledge that these are not the only four reasons scientists conduct research. The authors encourage further investigation into other forms of scientific research in contemporary science. Research into scientific knowledge development and scientists' interest in research has accumulated over time.

The efforts summarized above stimulated a wave of research that aimed to define NOS. Generally, NOS relates to the epistemology of science or the assumptions and values that lead to the production of scientific knowledge (Lederman, 1992). Lederman (2013) also adds that NOS encompasses "science as a way of knowing, or the values and beliefs inherent to scientific knowledge and its development" (p. 833). NOS mixes the perspectives from the psychology of science, history, philosophy, and sociology to come up with a definition of science, how science works, how scientists interact socially, and how society responds and guides scientific work (McComas et al., 1998). Indeed, a large number of studies has been dedicated to integrating NOS into

lessons by introducing the history and philosophy of scientific concepts (Matthews, 2014). Examples include teaching mechanics, optics, atomic and molecular structures through their corresponding historical and philosophical lenses (Chamizo & Garritz, 2014; Galili, 2014; Gauld, 2014). Gauld (2014) highlights that teaching history can "inform our attitude to the present progress of science" and can also be used "to teach the concepts of science more effectively" (p.57).

Even though the inclusion of NOS in science programs is rarely questioned nowadays, there is still an ongoing debate concerning its meaning and, consequently, the implication to curricula and programs. One group of science education researchers adopt what is now known as the consensus view, which suggests the implementation of seven to nine aspects of NOS in K-12 teaching (Lederman, 2013; McComas, 1991). Another group of researchers in the same field adopt the Family Resemblance Approach to NOS (Irzik & Nola, 2011; Erduran & Dagher, 2014) which gathered similar characteristics across all sciences and combined them into categories that unify the sciences. The consensus view and the Family Resemblance Approach to NOS are described below.

The Consensus View of NOS

According to Abd-El-Khalick and Lederman (2000), "for purposes of teaching and learning about NOS at the precollege level, we believe that at such a level of generality, some important aspects of NOS are virtually noncontroversial and also accessible to K-12 students." (p. 1063). These aspects include that scientific knowledge is tentative, empirically based, theory-laden, partly the product of human inference, imagination, and creativity; and socially and culturally embedded. Lederman, Abd-el-Khalick, Bell, and Schwartz (2002) added three aspects that they found vital for NOS: "

the distinction between observation and inference, the lack of a universal recipelike method for doing science, and the functions of and relationships between scientific theories and laws" (p. 499). The preceding conceptualization came to be known as the consensus view of NOS. Schwartz, Lederman, & Abd-El-Khalick (2012) claim that the list is not "all-inclusive, nor comprising compartmentalized or decontextualized characteristics about science" (p. 688). Abd-El-Khalick and Lederman (2000) refrain from using the definite article 'the' when referring to NOS, to show that they believe there is no unique way of defining NOS. However, even though there are still some controversies regarding definitions of NOS, Abd-El-Khalick, Bell, and Lederman (1998) find the nature of these disagreements abstract for school students. Therefore, Abd-El-Khalick et al. (1998) find the general aspects of NOS to be sufficient for school education. In addition, the generality of NOS is significant to students' everyday lives and decision-making. The list above offers general aspects of NOS that philosophers, science educators, and historians do not disagree upon (Lederman & Abd-El-Khalick, 1998). Abd-El-Khalick and Lederman (2000) also point out that these aspects of science are very hard to be rejected or argued against, especially since they are interrelated to one another. Thus, it is referred to as the consensus view list of NOS.

To explain the tenets above, the tenet that claims that science is tentative is based on the inductive reasoning used to come up with scientific knowledge (Alshamrani, 2008). Initially, data points are gathered, and since not all instances can be observed, inferences are then made that generalize findings. This allows for a possibility in the future to alter the conclusions that were previously true once new evidence emerges. In addition, new technology or different ways of thinking can lead to a reinterpretation of evidence (Lederman et al., 2002). Therefore, Lederman et al. explain

that laws, hypotheses, and theories "can never acquire a proven status" (p. 502). Lederman et al. (2002) explain the empirical aspect of NOS as follows: scientists cannot always observe most natural phenomena directly, which means that observing nature often happens through a theoretical framework lens, instrumentation, and is "filtered through our perceptual apparatus" (p. 499). In other words, Abd-El-Khalick and Lederman (2000) explain that observations of phenomena that happen in nature are directly accessible to our senses; and mindsets influence the interpretation of our observations, possibly leading to bias.

According to the third tenet of NOS of the consensus view, the scientists' personal experience and previous knowledge affect their work. This tenet is referred to as theory-laden (or theory-driven) and it acknowledges the lack of neutrality in a scientists' choice of investigation, the questions scientists seek, and the way scientists interpret evidence (Abd-El-Khalick & Lederman, 2000). Lederman et al. (2002) list the following as factors that can influence the work of scientists: "theoretical and disciplinary commitments, beliefs, prior knowledge, training, experiences, and expectations" (p.501).

A fourth NOS tenet of the consensus view list is creativity, which clarifies that science is not purely rational. Atoms, for example, are models of reality, not an exact copy of reality. The creativity of scientists has also contributed to the invention of non-observable processes such as natural selection (Abd-El-Khalick & Lederman, 2000). Lederman et al. (2002) also point out that creativity and imagination are necessary when scientists come up with interpretations and hypotheses.

The next dimension of the consensus view of NOS considers science a human enterprise that is practiced by scientists in a social and cultural environment (Abd-El-

Khalick & Lederman, 2000). Therefore, science influences and is influenced by politics, power structures, socioeconomic factors, social fabric, religion, and philosophy (Lederman et. al, 2002). In addition, scientists interact with their prior experiences and expectations when doing their work, just like any other human being (Abd-El-Khalick & Lederman, 2000). To elaborate, Paty (1999) explains that science falls into a system of economical domination. For instance, funding for a research project and not another may be affected by social or financial interests in certain topics. The last three aspects Lederman et al. (2002) found important for NOS begin with the differentiation between observations and inferences. Observations are descriptions of events using the senses, while inferences are possible explanations of events that are not attainable through the senses. Lederman et al. (2002) give the example of an object falling as an observation, and the reason for its fall being gravity as an inference. In addition, the scientific method is believed to be a myth. The consensus view explains that scientists do not follow a step-like procedure to generate knowledge even though scientists do come up with hypotheses, observe, and gather data, etc. However, these steps do not have to be followed in a sequential manner (Lederman et. al, 2002).

Lastly, the consensus view list differentiates between scientific theories and scientific laws: the former is a deep-rooted explanation while the latter is a description of a phenomenon. Theories cannot become laws and vice-versa. This final tenet highlights a common misconception in students who believe that laws are more superior theories, which is an incorrect notion (Lederman et al., 2002).

These tenets have been widely used in science education research. In the following paragraph, I summarize some studies that have been conducted using the consensus view of NOS as a theoretical basis.

Research Studies Using the Consensus View of NOS

Classroom activities. For many decades, various areas of research in science education have been conducted by viewing NOS through the list of tenets of the consensus view. As a result, a wave of research emerged to teach NOS in the classroom using the tenets listed in the consensus view.

For example, Damli and Yavaş (2015) developed an activity made up of six steps on magnetic fields so that students can learn specific aspects of the NOS, such as NOS being empirical, tentative, subjective, and creative. Damli and Yavaş (2015) were also looking for students' ability to distinguish between observation and inference through the activity prepared. During the first step of the activity, students were asked to share their thoughts on what they think a scientific model was. Damli and Yavaş (2015) found that students thought that models were a replica of the truth. During the second step of the activity, the students differentiated between "observation" and "inference" implicitly at first, because they did not know the terms even though they understood the concept. Once the terms were explained, a reflective and explicit discussion occurred. In the third step of the activity, the students were asked to draw magnetism: two students claimed that they drew the event as it occurs in the natural world, while the three other students drew a sketch similar to the one in their book. In the fourth step of this activity, the students observed magnetism with iron powder, and they were shocked that they were not able to see the direction of the magnetic field line they previously drew, although they understood its conceptual basis. At this point, Damli and Yavaş (2015) note that the students concluded "that the direction of the magnetic field was an 'assumption'" (p.33). This shows that the students were successful in their comprehension of the tenet "science is creative" and "science is

subjective". In the final two steps of this activity, the students looked back and reflected on their drawings of the third step and were able to differentiate between the three-dimensional behavior of magnetism and their two-dimensional drawings. Overall, the students were successful in learning the NOS concepts by engaging in the activity and through explicit and reflective discussions (Damli & Yavaş, 2015).

Another popular strategy to teach NOS concepts is the use of black-box activities. Eren-Sisman and Koseoglu (2019) used "the magic flask", which was a historical black box gadget that was found at the "Sultans of Science" museum exhibition. The magic flask is made up of two sides. The red liquid is poured into the right side of the flask, but it comes out from its left side, and green liquid is poured into the left side of the flask, but it comes out from its opposite side. The students either observed the magic flask in person by attending the exhibition at the museum or the teacher showed the students a video of how the magic flask works. Then, the students were asked to make their prototype of a magic flask that functions the same way as the magic flask. Students were divided into 2-3 participants per group. The activity was then followed up by an explicit and reflective discussion where science teachers scaffolded questions concerning some NOS aspects that are relevant to the activity. For example, teachers asked students why each group ended up with a different model even though they had the same initial observations. This led to a discussion about observations and inferences, the subjectivity of science, and the theory-laden NOS. Following this activity, students claimed that they had many misconceptions about NOS and that its aspects were never discussed explicitly in their classrooms. Eren-Sisman and Koseoglu (2019) believe this activity combines history, engineering, technology, and is a useful way to introduce NOS aspects into the classroom.

In Hong Kong, Lau (2017) compared grade nine students' understanding of NOS before and after a short lab activity (considered the experimental group) to another group of grade nine students that learned about different theories of dinosaur extinction (considered the control group). The short laboratory investigation used in the experimental group was that of the apple browning effect. The class came up with two different hypotheses that explain apple browning. One group suggested that oxygen is the cause of the browning while the other group suggested that enzyme action is the cause. Both groups tested their hypotheses by adding ascorbic acid to prevent the browning of the apples. Ascorbic acid can denature enzymes and it can also act as an antioxidant to prevent browning. Both groups found that their hypotheses were supported by the data.

The control group learned about two competing theories that justify the extinction of dinosaurs: "the asteroid impact theory" and "the volcanic eruption theory". The data that supports both theories were presented to the students and they learned that there is no absolute explanation for the extinction of dinosaurs. When Lau (2017) compared the pretest to the posttest results, he found that both groups have improved on their NOS comprehension of the tenet "scientific theories are tentative". However, the experimental group was able to transfer their knowledge to science in general, while the control group contextualized the concepts of NOS learned in the case of dinosaurs.

Views of NOS. In addition to developing classroom activities with the consensus view tenets of NOS as a learning objective, the most widely distributed instrument to assess the views of subjects of NOS is also based on the consensus view. For example, Abd-El-Khalick's 1998 VNOS-version C was used to compare the views of NOS of Korean and American pre-service teachers and relate it to their acceptance of

evolution (Kim & Nehm, 2011). Through a cross-cultural study, Kim and Nehm (2011) found that both American and Korean science teachers' grasp of NOS was correlated with their comprehension and acceptance of evolution. This relationship was found to cross-cultural differences.

Additionally, Roletto (1998) studied French pre-service teachers' perceptions of science through an open-ended questionnaire based on the consensus view. Overall, the results of Roletto's (1998) study show that most of the surveyed French pre-service teachers view science as a collection of facts that are a product of the scientific method. On the other hand, about half of the pre-service teachers believe that scientific knowledge is subjective and depends on the point of view of the scientists. The author then concludes that most of the subjects of his study hold mixed views of science, where knowledge production of science is not well-defined. Moreover, most French teachers hold empiricist views of the epistemology of science (prioritizing facts over theory) and naïve and positivist views (e.g. one universal stepwise method for doing science). When discussing the results of his study, Roletto (1998) claims that the training manuals for teacher training have an idealistic view of science, excluding any controversies in the development of scientific knowledge. This exclusion in the teachers' training manuals may have affected their perception of NOS.

Likewise, using a consensus view framework, Pelissier, Venturini, and Calmettes (2007) investigated the relationship between NOS views of grade 10 physics teachers in France and their teaching pedagogy. The authors were interested in finding a relationship between the teachers' beliefs of what science is, and if these beliefs affect their teaching strategies of physics. Pelissier et al. (2007) surveyed pre-service and in-service French physics teachers of grade 10. The authors found the teachers' NOS

views to be almost the same, the views were mostly naïve, and not in line with the latest education trends in NOS. According to the teachers surveyed, NOS can be taught implicitly through the instructions of physics content knowledge and its appropriate hands-on activities. The French teachers did not find epistemological teaching as an essential objective for physics education. Pelissier et al. (2007) also note that the teaching methodologies used by the teachers are more in line with their conceptions of what science is. Unfortunately, the teachers' conceptions of science are not in line with the accepted views of NOS. The authors conclude that there is a need to implement inquiry and investigative teaching to help both the teachers and the students develop acceptable views of NOS.

Textbook Analysis. In addition to investigating teachers' views of NOS, many textbooks have been analyzed by using the consensus view. Abd-El-Khalick, Waters and Le (2008) analyzed 14 high school chemistry textbooks for their portrayal of NOS. The tenets that were focused on are the "empirical, tentative, inferential, creative, theory-driven, and social NOS, in addition to the myth of 'The Scientific Method', the nature of scientific theories and laws, and the social and cultural embeddedness of science" (p.835). The books that were picked were readily available on the United States market, and five of the books were part of series that ranged from ten to forty years. Abd-El-Khalick et al. (2008) scored each textbook depending on the way NOS was addressed (implicit or explicit), the correct representation of the tenets, and their comprehensiveness. The results of the study show that the textbooks' scores were low for their portrayal of NOS. In addition, the older textbooks that were part of a series had higher scores than their newer versions.

Using the same framework that was developed by Abd-El-Khalick et al. (2008), Ramnarain and Chanetsa (2016) analyzed three South African grade nine biology textbooks for their portrayal of NOS. Their results were similar to previous findings (Abd-El-Khalick et al., 2008): the textbooks poorly represent NOS. In particular, Ramnarain and Chanetsa (2016) found that the social dimension of NOS was rarely, sometimes not at all, addressed in the South African textbooks.

Another recent study by Fuselier, Jackson, and Stoiko (2016) analyzed the representation of NOS in evolutionary biology textbooks that are used at the college level. The authors focused their study on the social aspect of NOS, and in specific how the sexual selection theory had changed through time. Fuselier et al. (2016) found that "all of the textbooks incorporated new research in the field, and some provided context about how and why the field has changed but not to the degree warranted by the rich literature available" (p. 239). For this reason, Fuselier et al. (2016) recommend further integration of the social embeddedness tenet for a precise portrayal of NOS.

Given the research studies that have been outlined above, we can infer that the consensus view has been well established in the science education community, with decades of research conducted utilizing it as a framework. While we owe the popularity and growth of NOS to Lederman et al. for establishing NOS as a prominent topic for scientific literacy, some researchers have recently critiqued the consensus view to NOS. Their main concern is the implications of its use as a theoretical framework in science education research.

Consensus View Critiques

The list of tenets of the consensus view ignited a debate among the science education community. The following paragraphs elaborate on some of the major critiques of the consensus view of NOS.

First off, many scholars reject the idea of using a list of statements to describe NOS. For instance, Duschl and Grandy (2013) claim that the consensus view list is too simplistic. Other researchers have critiqued the declarative sentence structure of the consensus view's list, highlighting that declarative sentences imply a conclusion about science (Allchin, 2011; Irzik & Nola, 2011; Smith & Scharmann, 1999). Clough (2007) suggests supplanting the declarative statements with questions that can initiate a discussion of what science is. According to Hodson and Wong (2017) by using the consensus view, science has been reduced to a to-do list, which oversimplifies teaching NOS as absolute truths, and thus confining the curriculum when we need a "more sophisticated approach to NOS" (p. 11).

In a like manner, Allchin (2011) argues that no evidence thus far has shown that memorizing and understanding the consensus view list of tenets "is adequate for applying them effectively in context" (p.523). Allchin (2011) further explains that the decontextualization of these tenets does not help students make social and personal decisions that are science-related This focus on recall and comprehension can hinder the effective application of NOS. The list of declarative statements of the components of NOS implies that there are ultimate truths about science, facts that need to be memorized. Consequently, the focus on declarative, de-contextualized tenets may hinder students' analysis of scientific claims for credibility and reliability, which is ultimately an objective of scientific literacy (Allchin, 2011).

The list also gives the impression that science stays the same. In truth, science changes and evolves (Irzik & Nola, 2011, p. 593). Indeed, science involves asking new questions and questioning new knowledge, which are both pillars of scientific inquiry. Concerned about the application of a declarative list of statements in the classroom, Smith and Scharmann (1999) encourage the use of *descriptors* instead of learning "a set of rules that demarcate science and nonscience" (p.494) to be able to judge claims and questions as scientific or nonscientific.

Equally important, the list of tenets undermines the genuineness of the work of scientists and its connection with society (Wong & Hodson, 2009). Through interviews with scientists, Wong and Hodson (2009) found categories of NOS not included in Lederman et al.'s (2002) list of tenets. These include ethics, the design of experiments, the significance of theory in scientific inquiry, and others.

Furthermore, Hodson and Wong, argued in 2009, 2010, and 2014, that NOS teaching should be enriched "with the perspectives of practicing scientists […] alongside the views of philosophers of science, sociologists of science, and historians of science" (p. 10). However, the consensus view separates the views of philosophers, sociologists, and historians from practicing scientists by encompassing the philosophers' perspectives of science in NOS and the scientists' perspectives and process of inquiry in NOSI (nature of scientific inquiry).

Several scholars critiqued the removal of scientific inquiry as part of NOS in the consensus view (Irzik & Nola, 2011). In response to this critique, Lederman (2013) advised a separation between the "nature of scientific knowledge," referred to as NOSK, and the "nature of scientific inquiry," abbreviated as NOSI (Lederman, 2013). Schwartz et al. (2012) further elaborate on the distinction between the two terms:

NOSK refers to the epistemological characteristics of scientific knowledge, while NOSI describes the practices of doing science. Schwartz et al. (2012) argue against treating NOS as a skill or practice in doing science, as it may "effectively remove any obligation teachers have to ensure students understand what makes science *science"* (p.687).

On the contrary, other researchers find inquiry and epistemology to be interrelated. For instance, Sandoval (2005) relates inquiry and epistemology by outlining the epistemological goal of inquiry. The author insists that scientific knowledge is not discovered. Sandoval (2005) exemplifies his claim by showing that predictions and arguments are persuasive forms of rhetoric that are used for knowledge production. Therefore, inquiring through argumentation is epistemological by nature, and a scientific practice as well. In addition, Ford (2008) adds to the relationship between epistemology and inquiry by showing that the enactment of epistemology happens through inquiry. In a classroom activity, Ford (2008) showed that students were successfully able to critique and evaluate scientific claims once they participated in the production of knowledge of the claims through apprenticeship activities.

The critiques mentioned above show that the consensus view of NOS devalues the process of inquiry and the work of scientists. Claiming that "there is no universal stepwise scientific method" does not clarify what methods are exactly used in science and by scientists. The tenet of the consensus view of NOS "there is no universal stepwise scientific method" is ambiguous. Furthermore, it dismisses the effective learning students experience when they repeat scientific methods and practices that are used by scientists. Indeed, Ford (2008) showed that activities that aim to reconstruct scientific knowledge by going through the methods previously used by scientists improve students' critical thinking skills. Moreover, the consensus view tenet stating

that there are no consecutive steps to practice science underestimates the importance of constructivism in science learning. Constructivism assumes that students have an active role in reconstructing scientific knowledge to learn how it was developed (Erduran & Dagher, 2014, p. 12). This would allow for a profound conceptual understanding of science by practicing science. This teaching methodology has replaced traditional scientific teaching and is commonly referred to as apprenticeship (Roletto, 1998). Furthermore, traditional teaching assumes a passive role for students and a didactical one for teachers. Not giving students the chance to learn about and perform the methods used in science might lead to "people not [acknowledging] scientists' views as rational and as products of a process" (Erduran & Dagher, 2014, p.13). By claiming that there is no universal recipelike method for doing science, the consensus view limits the image of science by not explicitly elaborating on its diverse aims and methodological rules. Irzik and Nola (2011) state that "without the idea of a scientific method or methodological rule, it is difficult to see how science can be self-corrective and provide reliable knowledge" (p. 593).

Therefore, unlike what Lederman (2013) advocates, critiques consider the activities that scientists conduct to generate knowledge as part of NOS and, consequently, need to be a learning objective for students. Indeed, Allchin (2011) reminds us that the goal of learning NOS is to grow scientifically literate and responsible citizens who "need to understand how evidence works- and where it can fail" (p. 523). The author believes that students need to know which scientific practices are established and followed to prevent errors. To do so, students need to comprehend scientific practices to become adequate judges of credibility. Many scholars question the implementation of the consensus view in the curriculum. For example, Yacoubian

(2012) asserts that it is not clear how to introduce pedagogically NOS at each grade level. Indeed, some scientific methods and methodological rules may be appropriate to introduce for some grade levels but not others.

Furthermore, the tentativeness of science has been criticized by Allchin (2011) as misleading to students, who may think of all sciences as tentative. Allchin (2011) differentiates between mature science, where the uncertainty has been resolved, and contemporary science, which has a high degree of uncertainty. Instead of teaching science as tentative, Allchin (2011) encourages the practice of scientific literacy in the classroom, which involves making clear distinctions between the latest controversial topics that are currently being researched and knowledge that is no longer in question. The latest controversial topics need to be analyzed by students for the reliability and trustworthiness of their scientific claims. This analysis will result in a judgment on behalf of the student on the credibility of these claims. Successful teaching of NOS would clarify how science works to students so that they can distinguish between mature science, where claims are well-established, and contemporary science, which holds a perturbed status due to its uncertainty. For example, case studies can be used from the latest controversies, such as the measles, mumps, and rubella (MMR) vaccine and the false claim of its relatedness to autism. Allchin (2011) argues that this differentiation between certain mature science and uncertain contemporary science is "just as important as understanding (the more familiar) 'tentativeness'" of science (p. 522). This distinction would thus avoid the misconception that all science is tentative, a vague statement made by the consensus view on NOS.

Besides the previously mentioned critiques of the consensus view statements, several tenets of NOS are found to be contradicting of one another. As Allchin (2011)

argues, the consensus view tenets describe "how science works- and at the same time how it sometimes does not work (and why)" (p. 524). This may confuse students. For example, claiming that science is empirical and that it is socially and culturally embedded. Allchin (2011) believes that students should be free and responsible to interpret scientific claims as being empirical or culturally embedded, tentative or durable, conservative or creative, depending on the context in which these scientific claims were produced.

Additionally, Hodson and Wong (2017) argue that the consensus view does not clarify which aspect of science is mostly affected by sociocultural influences: is it the methods used for inquiry, or conceptualizing theories, or research priorities? The consensus view does not explicitly state if cultural influences benefit or harm scientific knowledge production. Overall, the vagueness of this tenet leaves teachers with more confusion, hindering their ability to implement NOS in their classrooms. Hodson and Wong (2017) find the differentiation between observation and inference impractical to students doing investigative work. The authors gave examples of common observations that assume well-established theories, such as stating that substances dissolve. It would be unfeasible to state that substances disappear instead of dissolve every time students participate in an investigative activity involving solubility.

Furthermore, by claiming that observations are theory-laden, students might assume that all scientific knowledge is unreliable. Irzik and Nola (2011) encourage raising awareness about the critical scrutiny to which theories are subjected. Studying peer review, for example, can help students become skeptical critical thinkers, instead of distrusting scientific knowledge altogether. In addition, students should be able to differentiate between well-established scientific knowledge and contemporary science

whose scientific claims are still undergoing investigation and experimentation (Allchin, 2011).

By relating the various critiques mentioned above, some scholars (Allchin, 2011; Matthews, 2012) have developed their perspective of the NOS to a more comprehensive and elaborate one. Some of these scholars' definitions of NOS are summarized below.

Matthews (2012) was an advocate for the expansion of the consensus list of NOS by adding some topics that can help students and teachers engage in learning NOS. The author promotes supplanting "nature" of science with "features" of science and include the following features to NOS: experimentation, idealization, and models. Matthews (2012) also suggests an extended Features of Science (FOS) list which includes: "values and socio-scientific issues, mathematization, technology, explanation, worldviews and religion, theory choice and rationality, feminism, realism and constructivism" (p.20). The author stresses the importance of students understanding the context in which scientific knowledge is developed: the processes followed, the institutions, and the social aspect. Matthews (2012) values the contextualization of science more than the recalling of the list of tenets of the consensus view.

Similarly, some critics have pointed out that the consensus view failed to include the role of some social practices in science such as funding, peer review, the motivation of scientists, biases, fund seeking, competition, and collaboration (Allchin, 2011; Hodson & Wong, 2014). Allchin (2011) explains that ignoring these dimensions in teaching NOS would remove science from its social environment. This would then affect students' evaluation of scientific claims by not considering the role of funding, for example, which is an important component of scientific literacy. Allchin (2011)

calls for “Whole Science” as a reframing of NOS, with the aim of encompassing all dimensions of reliability as an assessment strategy for scientific literacy. By expanding science to a more diverse and holistic approach, the curriculum would then result in the engagement and inclusion of all students, no matter what their interests are (Erduran & Dagher, 2014; Matthews, 2012). In this case, a student who is interested in politics can be engaged in a science lesson when the role of fund seeking is factored into the lesson. This allows students to appreciate NOS instead of focusing on gaining declarative knowledge.

The change in defining NOS implies a change in its application for research as well. One of the most prominent examples of a change in application is the use of the VNOS instrument, which is based on the consensus view, which assesses subjects’ views of NOS. Below, an alternative assessment is suggested by Allchin (2011).

By appealing to the various interests of students through a holistic representation of the NOS, instruction, and assessment of NOS can include and account for students from different backgrounds (Erduran & Dagher, 2014). The aspects of NOS are heavily criticized, which renders the instruments the consensus view uses to assess NOS (such as the VNOS) unreliable and in need of replacement. As an alternative to the VNOS, Allchin (2011) encourages testing for the views of NOS by presenting students with case studies, which could be from the latest news or media outlets. The students would need to judge the credibility of the scientific claims in writing. A rubric is suggested by Allchin (2011), which assesses the students’ ability to take into consideration the funding for the research conducted, the methods used, the human context, and more.

In reply to Allchin’s (2011) critiques, Schwartz et al. (2012) argue that the VNOS instrument, instead of solely being a Likert-scale survey, includes short answers

and an interview. According to Schwartz et al. (2012), this allows for a more holistic approach when analyzing responses about NOS views. The authors (2012) argue that if the consensus view aims to reconcile the differences that the tenets present, then the VNOS would not have included an interview or short-answer part. However, Schwartz et al. (2012) do not address Allchin's (2011) concern about students believing in extremities, such as that all science is tentative when they are taught NOS using the consensus view.

For the above reasons, many researchers in the science education community have recently taken on the interest to develop a framework that includes the cognitive, epistemic, and social aspects of science. Armed with a new, holistic approach to NOS, educators can become better equipped to pursue their goal of spreading a culture of scientific literacy in our society.

As established above, textbooks are a cultural tool (Vygotsky, 1986) that serve to mediate the higher-cognitive development of a society. Therefore, it is important to investigate the presence of NOS in textbooks. This will further provide insight on the certain potential textbooks have (or do not have) to mediate a scientific literate society. Equally important is the framework used to analyze the textbooks. Using the consensus view as a measurement of NOS portrayal in textbooks may limit the potential presence of NOS in these textbooks, given that the consensus list of tenets is not a holistic one. In general, even though there is a consensus among science education researchers over the tenets of NOS that are appropriate to teach in schools, the consensus view list restricts NOS. As a result, research conducted using the consensus view of NOS as a framework is limited in scope. Consequently, new frameworks have been developed to provide an

all-encompassing definition of NOS. In this study, an alternative framework shall be used to analyze textbooks, namely, the family resemblance approach to the NOS.

Family Resemblance Approach to NOS

Given the multiplying number of critiques over the consensus view of the NOS, researchers (Erduran & Dagher, 2014; Irzik & Nola, 2011) have introduced a new framework for NOS to attend to these critiques. Taking Wittgenstein's Family Resemblance Approach (FRA) to NOS, a new framework has been developed, which allows us to highlight features of NOS that are common to all sciences and activities carried out within.

To elaborate on the idea of the family resemblance, we must first look back at its original developer, Ludwig Wittgenstein. In his book, *Philosophical Investigations*, Wittgenstein (1953) (as cited by Erduran & Dagher, 2014) argues that entities are not always related by one common characteristic, instead, there are series of features that may be shared by a group of entities. In addition, a characteristic does not have to be found in all entities. Wittgenstein (1953) (as cited by Erduran & Dagher, 2014) uses games as an example to elaborate on this concept. Even though there are many types of games, card games, board games, ball games, etc., there are still some similarities among all games. To characterize these similarities, Wittgenstein (1953) (as cited by Erduran & Dagher, 2014) uses the analogy of a family. Just like in a family, there are some resemblances amongst its members such as eye color, hair color, height, etc., there are overlapping similarities amongst games.

Taking Wittgenstein's family resemblance approach, Irzik and Nola (2011) applied this concept to NOS, by finding cognitive-epistemic features that are common to all sciences. The authors list scientific activities, aims and values, methodologies and

methodological rules, and products of science as part of the cognitive-epistemic dimension of NOS. In 2014, Irzik & Nola add another dimension to NOS, the social-institutional dimension.

Following Irzik and Nola's efforts, Erduran and Dagher (2014), authors of the book *Reconceptualizing the NOS for Science Education*, sought a broader, more holistic, and comprehensive approach to NOS to appeal to all of the students' interests: some may be interested in the epistemic aspect of NOS while others may be interested in its socio-political aspects. So, Erduran and Dagher (2016) added three categories that they find necessary for the science curriculum. Expanding NOS to include a holistic overview of its common features would encourage the inclusion of all students in the science classroom, even if they have different interests. Likewise, Erduran and Dagher (2014) emphasized that the consensus view focuses on "individual ideas about science" (p.25) while we need to organize NOS into a "class of ideas" with common characteristics (p.25). The authors exemplify this point by showing that the tenet differentiating laws and theories is one part of the cognitive epistemic dimension of NOS.

The FRA acknowledges both shared and unique features that make various domains scientific. Below, BouJaoude, Dagher, & Refai (2017) provide us with a description of the 11 aspects of the NOS using the family resemblance approach.

1. *Scientific Aims and Values* category comprises several cognitive values that include, among other things, objectivity, novelty, accuracy, and empirical adequacy.
2. *Scientific Practices* category involves the understanding that scientists develop, through investigations that involve questions about the world, engagement in

activities that enable them to understand it better (experiments, observation, classification), analysis of data and development of models, explanations and predictions that can be verified and further explored.

3. *Scientific Methods* category addresses the idea that scientists use many methods of true experiments involving the testing of hypotheses or not, thought experiments, or observations that include the testing of hypotheses or not.
4. *Scientific Knowledge* category pertains to addressing how scientific knowledge is expressed in multiple forms such as theories, laws, and models that are used to explain and predict phenomena. How these forms of knowledge relate to one another and to scientific methods and how practices affect the growth of knowledge over time.
5. *Scientific Ethos* category focuses on understanding that for scientific knowledge and practices to be credible and ethical, there are a number of norms that scientists are expected to abide by such as intellectual honesty, respect for and protection of human subjects, respect for colleagues, and the environment, responsible publication, etc.
6. *Social Values* category includes an understanding of respecting the environment, social utility, and freedom.
7. *Social Certification* category describes the role of peer review, evaluation, and criticism with an understanding that scientific findings are reviewed, criticized, and evaluated by peers.
8. *Professional Activities* category focuses on understanding the role of attending professional conferences, presenting findings, writing research proposals, and conducting peer reviews of papers and proposals.

9. *Financial Systems* category acknowledges the roles of funding priorities, commercial and special interests in enabling, controlling, or limiting scientific knowledge.
10. *Political Power structures* address gender issues, colonial interests, ideological influences on scientific knowledge and practices, and who benefits from them.
11. *Social Organization and Interactions* category addresses the organizational structures and relational transactions within and among scientific communities.

The FRA framework has been used in science education research, theoretically and methodologically, and in classrooms, pedagogically and practically, for curriculum development and teaching. The aim of this framework "is not to teach students individual NOS aspects, but instead to present NOS holistically in a contextualized manner" (p.5). Examples of research that has been conducted using the FRA framework include thesis dissertations, curriculum and textbook analyses, professional development resources, and investigating students' understanding of NOS. Below, I will summarize some examples of research conducted using the FRA as a framework.

Research Studies Conducted Using the FRA to NOS Framework

Curriculum Analysis Using FRA. Maurine (2015) investigated the French secondary syllabus by basing the study on four dimensions of the FRA framework: activities, aims, and values, products, methods, and methodology. The author also added more elements of NOS, such as objects, elaboration, resources, attitudes, scientific community, society, and history. Maurine (2015) found that both the physics/ chemistry and biology syllabuses were more implicit than explicit in their mentioning of the NOS. In addition, the dimensions that relate to NOS are limited, with a minimal number referring to its social aspects.

In Turkey, Kaya and Erduran (2016) compared the 2006 science curriculum to the 2013 science curriculum to explore the seven categories of NOS adopted from the FRA: social certification and dissemination, social values, scientific ethos, professional activities, financial systems, political power structures, and social organizations and interactions. Their analysis showed that both the 2006 and 2013 Turkish curricula focus on the cognitive-epistemic dimension of science, while its emphasis on the social-institutional dimension is minimal. Indeed, there were no objectives in the 2006 or 2013 curricula related to scientific ethos, professional activities, financial systems, or political power structures. However, the Turkish 2006 curriculum had no objectives related to social organizations and interactions while the 2013 curriculum did. Kaya and Erduran (2016) also compared the Turkish 2013 curriculum to the Irish and American curricula for the following social aspects: social certification and dissemination, scientific ethos, social values, professional activities, social organizations, financial systems, and political power structures. Kaya and Erduran (2016) found that all three curricula do not include professional activities, financial systems, nor political power structures in their objectives. In addition, while the Turkish 2013 curriculum mentions social organizations and interactions as an objective, neither the American nor the Irish curricula do. The Irish and Turkish 2013 curricula include social certification and dissemination as a curriculum goal while the American curriculum does not. The American and Turkish 2013 curricula do not include scientific ethos in their curriculum while the Irish curriculum does. And finally, the American and Turkish 2013 curricula include social values as an objective while the Irish curriculum does not. In general, Kaya and Erduran (2016) do not find a curriculum that highlights all of the aspects of NOS comprehensively.

In Taiwan, Yeh, Erduran, & Hsu (2019) examined the 2006 grades 1 through 9 curricula and the 2016 grades 1 through 12 curricula by using FRA. Yeh et al. (2019) investigated the following categories: aims and values, methods, scientific practices, and scientific knowledge for the cognitive-epistemic system. As for the social and institutional contexts, the authors explored the following tenets: social certification and dissemination, scientific ethos, social values, and political power structures. The authors have found that the two categories that are found the most in the curricula's benchmarks were the scientific practices and methods used by scientists. When the authors compared the older curriculum to the latest one, they have found that there is less focus on the cognitive-epistemic dimension as a central objective in the newer curriculum, and more focus on the social-institutional system. Yeh et al. (2019) advised some modifications so that the curriculum can be more comprehensive and allow for interrelations between the cognitive-epistemic and social-institutional dimensions.

Since the FRA provides us with a more comprehensive and holistic view of NOS, then it offers a possibility of not conflicting with other beliefs. This has a tremendous application in curriculum development. An example of using the FRA framework to contribute to curriculum development would be that of Dagher's (2017) research. Dagher (2017) explains that the way society thinks of science and religion impacts the education field by determining what knowledge is eventually targeted in the curriculum. As an illustration, the theory of evolution may or may not be taught in classrooms due to religious beliefs that contradict the theory, such as creationism. Using the categories of the FRA framework, Dagher (2017) highlighted the cognitive, social-institutional, and epistemic aspects of science that could be used to develop a science education curriculum. The aspects listed in the FRA framework define science as a way

of knowing, distinguishing it from religion as a different way of knowing. In this way, Dagher (2017) proposes teaching science while still being in harmony with the religious and cultural contexts in which science is taught.

Analyzing Assessments for their Representation of NOS. In contrast to the ambiguity of scientific methods in the consensus view, the FRA framework opens the opportunity to explore the diverse methodologies used in science. Erduran, Cullinane, and Wooding (2019) analyzed the scientific methods mentioned in high-stakes assessments in England. The authors focused on four categories of methodology: non-manipulative hypothesis testing, non-manipulative parameter measurement, manipulative hypothesis testing, and manipulative parameter measurement. As a result, the authors found that the methodology with the least number of test items was manipulative hypothesis testing. In contrast, the methodology with the greatest number of test items, and the highest marks, was the non-manipulative parameter measurement. Erduran et al. (2019) concluded that "this may reflect an assumption that manipulative parameter measurement is considered to be cognitively more demanding, or it may reflect a perception that is a more valuable methodology, and thus deserving more marks" (p.9).

Research on NOS in Textbooks

Recent work by Peters-Burton, Bergeron, & Sondergeld (2017) provides further proof that FRA is a more comprehensive framework to use than the consensus view. Indeed, Peters-Burton et al. (2017) re-analyzed data from an earlier study that had used the consensus view as a framework. The research compared scientists' ideas to those of middle school teachers and students' through a card sort activity. The cards had to be sorted into a map, which was then analyzed for its coherence and logical connections.

Once the data had been re-analyzed using the FRA framework, the results varied drastically in comparison to the results they had when they analyzed their data using the consensus framework. Indeed, the researchers concluded that students and teachers had no central idea in their maps, while scientists' mapped ideas were more coherent and showed connections. The evidence collected using the FRA framework was therefore more comprehensive, robust, and showed patterns that were otherwise absent when analyzed through the restrictive consensus view lens.

FRA offers a view of the culture of science by highlighting its embeddedness within a social, financial, and professional context. As mentioned previously, textbooks are cultural tools, and thus, analyzing them would indicate whether the culture of the book agrees with that of NOS. In addition, curricula may list NOS as an implicit objective. Given that textbooks are a main source of information used in the classroom, it is essential to investigate the representation of NOS in textbooks.

Analysis of Textbooks Using the Consensus View

In earlier grades, trade books are very popular in the classroom and widely used by both students and teachers. For this reason, Brunner and Abd-El-Khalick (2017) investigated elementary science trade books, given that a small percentage of elementary teachers rely on commercially published textbooks and most elementary teachers would prefer a combination of trade books and non-commercially published resources. Brunner and Abd-El-Khalick (2017) used Abd-El Khalick's 2002 framework, which is based on the consensus view of NOS, and found that only 2 out of the 50 trade books they analyzed had explicit statements of NOS.

Moving on to higher grades, Aljaber (2016) looked for the representation of NOS in textbooks used in grades 7, 8, and 9 in Saudi Arabia. The author used Alshamrani's 2008 framework to analyze the textbooks. Alshamrani (2008) assembled the aspects of NOS that are agreed upon by at least two experts. These aspects, which represent an adaptation of the consensus view are listed below:

1. Scientific knowledge is empirically based
2. There is a distinction between observations and inferences
3. Scientists use creativity
4. Scientific knowledge is not entirely objective
5. There is no universal stepwise scientific method
6. Laws and theories are distinct kinds of knowledge
7. Cooperation and collaboration are part of the development of scientific knowledge
8. Scientific knowledge is socially and culturally embedded
9. Scientific knowledge is tentative but durable
10. Science cannot answer all questions
11. There is a distinction between science and technology
12. Experiments have a role in science

Aljaber (2016) found that all aspects of NOS were included in the grade seven, eight, and nine textbooks except for the subjectivity of NOS. The grade seven science textbook was found to have 11% of its content related to NOS. In addition, the aspect of NOS that was the most focused on in this textbook was that scientific knowledge is empirically based, while the aspects "scientists use creativity" and "science is culturally and socially embedded" were the least stressed upon. On the other hand, the grade eight

science textbook had 7.7% of its content disclosing NOS aspects. The most mentioned aspect in the grade eight textbook was “there is a distinction between observations and inferences”, while the least mentioned was “the absence of a universal stepwise scientific method”. As for the grade nine textbook, it was found that 12.1% of the content was about NOS. The aspect that was the least included in this textbook was “science is culturally and socially embedded”, but “there is a distinction between scientific laws and theories” was the aspect that was the most included in the grade nine textbook. Aljaber (2016) finds that the attention given to NOS in the three textbooks of grade seven, eight, and none is inadequate, and his study provides further recommendations to include NOS in middle school textbooks.

Moreover, Ramnarain and Chanetsa (2016) analyzed three grade nine South African natural sciences textbooks for their representation of NOS by using the same framework developed by Abd-El-Khalick et al. (2008). The researchers read the textbooks in their entirety to identify the explicit or implicit representation of the 11 NOS aspects outlined by the consensus view literature. These included “empirical; inferential; creative; theory-driven; tentative; the myth of the scientific method; scientific theories; scientific laws; social dimensions of science; social and cultural embeddedness of science; and science versus pseudoscience” (p. 925). Ramnarain and Chanetsa (2016) found that all the textbooks have a poor depiction of NOS, with a limited portrayal of its social dimension. The content of the textbooks was thus found to be contradictory to the curriculum goal of teaching students about the scientific enterprise.

At higher-grade levels, Abd-El-Khalick et al. (2008) evaluated the presence of 11 target NOS aspects in 14 high school chemistry textbooks dated from 1966 until

2005. The 11 aspects are the following: theory-driven; creative; empirical, inferential; tentative; the myth of the scientific method; scientific laws; scientific theories; science versus pseudoscience; social dimensions of science; and social and cultural embeddedness of science. The authors found that most of the textbooks poorly represented NOS. When comparing older textbooks to their newer versions, Abd-El-Khalick et al. (2008) found that the representation of NOS either decreased through time or did not change.

A more recent study by Abd-El-Khalick, Belarmino, Brunner, et al. (2017) analyzed the representation of NOS in chemistry, biology, and physics textbooks used in high schools in the U.S. The authors looked for ten aspects of NOS that have been underlined in science education reform documents such as science being empirical, tentative, and theory-laden. Abd-El-Khalick et al. (2017) found that the textbooks "did not fare well in their NOS representations" (p. 43). Indeed, most of the textbooks did not mention the social aspect of NOS and paid little attention to its epistemological dimension. For example, Serway and Faughn's 2006 biology textbook consisted of 1000 pages, of which only five pages mentioned NOS. What was more disappointing is that these five pages were dedicated to teaching the steps of practicing science, which is a naïve encouragement of the myth of the scientific method.

Additionally, Greek textbooks have been analyzed using Campanile, Lederman, & Kampourakis' (2015) method, which is based on the consensus view literature. Kampourakis (2017) investigated the representation of nature of scientific inquiry (NOSI), nature of scientific knowledge (NOSK), and nature of scientific explanation (NOSE) in secondary school biology textbooks. The author explains that "NOSI" is about statements about processes of inquiry that scientists apply. Kampourakis (2017)

describes “NOSK” as “the characteristics of scientific knowledge, such as that it is subject to change” (p. 123) while “NOSE” is the explanations that have been produced as a result of inquiry and the knowledge attained. Kampourakis (2017) analyzed four Greek biology textbooks, which included an introductory chapter that focuses on NOS aspects. However, Kampourakis explains that these chapters are not assessed during final exams of any grade level, and therefore, these chapters on NOS are not taught nor studied. For this reason, Kampourakis (2017) found that these chapters provided implicit statements regarding NOS aspects, a situation that puts the responsibility on the teacher to clarify these statements. Most of the explicit references the author found in the textbooks were focused on the NOSI; the least aspects found explicitly were about NOSK and NOSE. Kampourakis (2017) recommends that the textbooks include more explicit statements, given that opportunities for teacher training (focused on NOS) in Greece are rare.

Similarly, El-Mehtar and Alameh (2017) analyzed chemistry textbooks used for the International Baccalaureate Diploma Program by adapting Abd-El-Khalick’s 2008 scoring rubric. The results showed some attention to NOS, unlike previous findings (Abd-El-Khalick et al., 2008; Abd-El-Khalick et al., 2017; Aljaber, 2016; Ramnarain & Chanetsa, 2016). However, El-Mehtar and Alameh (2017) note “a number of inadequacies in the consistency of the treatment of NOS aspects (e.g., mixed representation in terms of explicitness and quality of treatment) and distribution of NOS occurrences in the chapters” (p. 183).

Fuselier, Jackson, and Stoiko (2016) examined the depiction of NOS in 10 U.S. college evolution textbooks. In this study, Fuselier et al. (2016) were looking at investigating the representation of science in the textbooks as social, rational, and open

for criticism, but specifically, the social critiques that drove the change in the evolutionary theory by focusing on the role of the feminist movement's impact on the evolutionary theories In this way, they were looking for the "social and cultural embeddedness of science" aspect of NOS in the textbooks. For example, they found that the feminist movement contributed to the field by critiquing the androcentric or sexist language used in hominid evolution. Fuselier et al. (2016) argue that "the social critique has produced a science that is better, more objective, and thus a benefit to all" (p. 260). Their textbook analysis showed that the undergraduate textbooks include awareness of the change in the field of evolutionary biology, mostly scholarly in nature. However, the examples included in the books do not pave the way for an explicit, reflective discussion about the social and rational aspects of NOS and how they integrate scientific development. The authors recommend including the multiple and diverse perspectives that contributed to the change in the field to allow for explicit discussion about the relationship between the social and rational aspects of science.

Overall, the application of frameworks based on the consensus view of NOS to analyze textbooks is widespread and popular. Various studies were conducted on many types of textbooks and across grade levels. Findings show that most textbooks are devoid of a comprehensive, explicit representation of NOS; and even when NOS is found in textbooks, it is usually implicitly mentioned.

Analysis of NOS in Textbooks using the Family Resemblance Approach to NOS

Different from the consensus view which limits NOS in scope, new research has emerged using the FRA framework to analyze NOS representations with a holistic definition of NOS. In the following pages, I will review some research that has been conducted on textbook analysis using the FRA to NOS framework.

McDonald (2017) investigated grade 10 Australian biology textbooks for their representation of NOS. Textbooks in Australia are usually part of a series. McDonald (2017) found that the first chapter of the textbook series is usually dedicated to NOS. However, that introductory chapter may only be found in the grade seven textbook and is therefore not reprinted or repeated in the rest of the textbook series. In addition, some schools skip teaching this introductory chapter about NOS. So, a student in grade ten using a textbook that is part of a series would not have access to the introductory chapter about NOS. Therefore, the author investigated the representation of NOS in the rest of the chapters that include topics taught in grade ten. Given that one of the critiques of the consensus view was its decontextualization from the history of science, McDonald (2017) used the FRA framework in her study and limited her evaluation to one historically rich lesson: genetics. The author decided to follow a case-based qualitative analysis to ensure that NOS is contextualized to a specific topic. McDonald (2017) defends her choice of topic by showing the rich history behind genetics and its aid in learning methods used in biology. Second, picking a single topic allows for a more holistic approach to NOS aspects that are present or absent within the context of genetics. McDonald (2017) studied four biology textbooks following a three-phase analysis process. First, the chapters related to genetics were determined in each book and analyzed for their representation of the 11 NOS categories listed in the FRA wheel. Second, the structure and organization of the chapters were examined for their content, inquiry activities, historical background related to genetics, question set, and relation to contemporary issues. In the final analysis phase, the unit was rated as explicit or implicit. McDonald (2017) found only three explicit examples of NOS in all four textbooks. Most of the NOS categories in the genetics chapters were implicitly stated.

The author suggests that “school science textbooks are not capitalizing on opportunities to explicitly highlight relevant NOS aspects within content already included” (p.114).

Using the same framework, FRA to NOS, BouJaoude, Dagher, and Refai (2017) analyzed the grade nine Lebanese science textbooks. Unlike the Australian textbooks mentioned above, the Lebanese textbooks published by CERD (Center for Educational Research and Development) do not include an introductory chapter dedicated to NOS. Consequently, the authors read the biology, chemistry, and physics textbooks in their entirety and analyzed them for their depiction of the 11 NOS categories outlined in the FRA framework. In addition, reading the whole book allowed the researchers to look for any NOS storyline., BouJaoude et al. (2017) found that the textbooks “do not address NOS concepts systematically or adequately to support students’ development of scientific literacy in its broader sense” (p. 94). Indeed, the physics textbook had no representation of any of the 11 NOS categories, the chemistry and biology textbooks mentioned a maximum of 5 of the 11 NOS categories, and most of the references represented implicit depictions of NOS

Regardless of the framework used to study textbooks, most of the research conducted shows that NOS is either not represented or misrepresented in books. When categories of NOS are found in textbooks, they are often implicitly mentioned, in passing, and lacking details that make them comprehensible. In the following pages, I will review research on NOS in Lebanon in an attempt to understand the status of NOS in this country.

NOS Research in Lebanon

Following the Lebanese civil war, Lebanon went through major educational reform. A new science curriculum was developed, highlighting 15 objectives, some of

which address aspects of the NOS (CERD, 1997). For example, some objectives focus on the relationship between science and technology, scientific values, and the cultural, social, and historical elements of scientific knowledge (Dagher, 2009). This educational reform in Lebanon stimulated the implementation of several studies related to the curriculum.

BouJaoude (2002) compared aspects of scientific literacy found in the general objectives of science teaching in the Lebanese curriculum to the objectives of the different levels and subjects of the Lebanese curriculum. BouJaoude (2002) found a significant gap between the general objectives of scientific literacy and the objectives of sciences in the Lebanese curriculum. For example, BouJaoude (2002) found that "science as a way of knowing" accounted for 35% of the general objectives of science teaching in the Lebanese curriculum. However, that same aspect disappeared in the instructional objectives of Grades 1, 2, 4, 5, 7, 8, 10, and 11. Similarly, Beydoun (2002) found that the Lebanese curriculum emphasizes content knowledge and problem-solving at the expense of issues related to the interactions of science, technology, and society. By the same token, the author found that the NOS was not mentioned in the curriculum.

For her thesis dissertation, Harbali (2000) investigated aspects of scientific literacy in 18 science textbooks that followed the new Lebanese curriculum. The results showed that science as a way of investigation and as a body of knowledge was prominent in the textbooks. However, the interaction between science, technology, and society as a way of thinking was overlooked. Given the results of the above studies and the results of the study by BouJaoude et al. (2017), we can conclude that the textbooks

published locally in Lebanon do not aid the education sector in fulfilling its objective of making its students scientifically literate and knowledgeable about NOS.

Given the lack of inclusion of NOS in curricula and textbooks, the perception of NOS by teachers and students may be in jeopardy. Many studies explore the views of NOS in schools and universities. Several research studies explored possible interventions to alter naïve views of NOS. These studies are summarized below.

Views of NOS in Lebanon

Multiple research studies have been conducted between the years 1992 and 2001 that assessed students' (BouJaoude, 1999; BouJaoude & Abd-El-Khalick, 1995; Dagher & BouJaoude, 1997; Farah, 1994) and teachers' (Abd-El-Khalick, 2001) views of NOS. In addition to the surveys conducted, two studies investigated the effect of reflective and explicit NOS teaching on elementary students (Khishfe & Abd-El-Khalick, 2002). The results of these studies show that students, teachers, and university instructors hold naïve views of NOS. On a more positive note, reflective and explicit instruction change these naïve views into more acceptable ones (Yacoubian & BouJaoude, 2010). A few years later, another wave of research tested the views of NOS of university and school students, teachers, school administrators, and university instructors (Abd-El-Khalick & BouJaoude, 2003; Dagher & BouJaoude, 2005; El Khoury, BouJaoude, Favre, & El Hage n.d.). These studies had similar results to the earlier ones mentioned above: naïve or mixed views are held about science.

To elaborate, El Khoury et al. (n.d.) investigated the NOS views of instructors in privately-owned Lebanese universities and compared them to their students' views. The study also compared the professors' views, as collected in surveys, to their pedagogical practice, as observed during their teaching. The university where the instructors taught

were four in total, two of which were Anglophone and the other two were Francophone. The research included 48 hours of class observations, a survey given to 142 students and 24 university professors, and semi-structured interviews of all 9 of the observed professors and 32 students. The results of the study showed that the instructors' views were mixed, like their students' views. A misalignment existed between the professors' claimed views in the surveys and their pedagogical practices when teaching. This study also found no relationship between the university instructors' conceptual understanding of NOS and their pedagogical practice. Other studies looked at the effect of naïve views of NOS on students' comprehension of scientific concepts such as evolution. Dagher and BouJaoude (2005) found that naïve views reveal misunderstandings of the methodological aspect of NOS, which affects students' understanding of the theory of evolution.

Intervention studies conducted in Lebanon show improvement in students' views of NOS. BouJaoude, Sowwan, and Abd-El-Khalick (2005) explored the effect of using drama as a strategy to aid students' learning of NOS. The experimental group in this intervention developed a better understanding of NOS aspects than the control group. In addition, Kotob (2006) used a historical approach to teach chemical reactions, with the aim of improving students' conceptions of the empirical and tentative tenets of NOS. Results showed that the experimental group's awareness of the tentativeness of science improved as a result of the intervention. Finally, Yacoubian & BouJaoude (2010) engaged one group of students in a reflective, explicit discussion about NOS after a laboratory activity while another group experienced inquiry-based activity. He found that the students in the explicit group had a better understanding of NOS tenets.

To summarize, recent reforms in science education emphasize the teaching of the NOS Textbooks are cultural tools that mediate the development of a society's culture. Teachers rely heavily on textbooks to guide their instruction. Many textbooks have been analyzed for their representation of NOS using the consensus view. However, the consensus view may not be an appropriate tool to use to analyze curricula or textbooks given that it limits NOS in scope and that it is highly criticized. The FRA to NOS wheel is the most recently developed framework that provides a holistic view of NOS. There is a lack of research conducted using the wheel as a framework. For these reasons, my research study shall analyze textbooks using the FRA to NOS wheel as a framework.

CHAPTER 3

METHODOLOGY

Textbooks are the main resource for teachers to use for curriculum guidance and lesson planning (Aldahmash, Mansour, Alshamrani & Almohi, 2016; Chiapetta et. al, 2006). According to Vygotsky (1986) (as cited in Plut & Pesic, 2003), textbooks are cultural supportive tools that mediate learning. This research aims to explore the potential of science textbooks to prepare scientifically literate individuals, with the understanding that the Nature of Science (NOS) is fundamental for students to attain scientific literacy (Dagher & BouJaoude, 2005). In this study, the representation of NOS was examined in grade 6 science American and French textbooks used in Lebanon and the textbook published by the Center for Educational Research and Development (CERD). The textbooks were also compared to each other for their quality of depiction of NOS. Therefore, this study the following research questions were answered by this study:

1. What NOS categories, if any, are addressed in the grade 6 American science textbooks published in the United States and used in Lebanon, and which ones are not? If present, what is the quality of representation of these categories?
2. What NOS categories, if any, are addressed in the grade 6 French science textbooks published in France and used in Lebanon, and which ones are not? If present, what is the quality of representation of these categories?

3. What NOS categories, if any, are addressed in the grade 6 Lebanese science textbook published by CERD, and which ones are not? If present, what is the quality of representation of these categories?
4. What are the differences, if any, between the representation of NOS in American, French, and Lebanese 6th-grade science textbooks?
5. What are the similarities, if any, between the representation of NOS in American, French, and Lebanese 6th-grade science textbooks?

Context of the Study

Lebanon has private and public schools where the national curriculum is taught. In addition, some schools use American and French textbooks. Formal education starts at age 6 and is mandatory until grade 6 (age 11 -12) (Loo & Jessie, 2017). The educational ladder in Lebanon is divided into cycles, and each cycle is three years long. Elementary education is made up of two cycles: cycle I starts in grade 1 and ends in grade 3, and cycle II starts in grade 4 and ends at grade 6. For this study, the textbooks used in grade 6 shall be analyzed, since grade 6 is the last grade of the elementary cycles and the last compulsory grade. In addition, math and science subjects are taught in English or French in most schools. Since this study analyzes science textbooks, the languages in which these textbooks are written wasEnglish and French.

Choice of Textbooks

The Lebanese curriculum is developed by the Center for Educational Research and Development (CERD), which is monitored and funded by the Ministry of Education and Higher Education (MEHE) (Oweijane, 2020). CERD also develops and publishes textbooks. The grade 7 and 10 CERD science textbooks have been analyzed by Harbali (2000) for their scientific literacy aspects. Harbali (2000) found that the

CERD textbooks “emphasized the basic knowledge of science and the investigative nature of science” (p.23). On the other hand, Harbali (2000) found that science as a way of thinking and the interaction of technology, science, and society, were not reiterated in the textbooks. Public schools in Lebanon are required to use the CERD textbooks; however, private schools are free to choose any textbook, foreign or local.

It should be noted that the CERD textbooks are not the only ones available on the market or used by schools. The weakness of state structures and the decentralization of schooling practices has resulted in little control over textbooks that have been privately published and are currently used by Lebanese private schools (Georg Eckert Institute for International Textbook Research, 2009). Private schools in Lebanon can adopt the textbooks of their choice for each subject matter: they can choose to use the CERD textbooks, or other privately published textbooks, including foreign ones. As mentioned previously, textbooks are cultural supportive tools that enable the development of a person (Vygotsky,1986 as cited in Plut & Pesic, 2003). Therefore, it is vital to analyze the textbooks that are found on the Lebanese market.

Textbooks are used as the main resource for classroom instruction and curriculum guidance (Aldahmash et al., 2016; Chiapetta et. al, 2006). The Lebanese curriculum goals include scientific literacy (BouJaoude, 2002). To acquire scientific literacy, the Nature of Science (NOS) is essential (Dagher & BouJaoude, 2005). In this study, the representation of NOS was examined in grade 6 French and American textbooks used in Lebanon, in addition to the grade 6 textbook published by CERD.

Definition of the Nature of Science

There has been much discussion in the science education community about defining NOS. So far, there are two major bodies of research: one that adheres to a

consensus view (Abd-El-Khalick & Lederman, 2000; Lederman, Abd-el-Khalick, Bell, & Schwartz, 2002) which provides a list of tenets of NOS, and another that developed as a result of the critiques of the consensus view. The list of tenets of the consensus view has been developed by Abd-El-Khalick and Lederman (2000), who view the following aspects as important to learn in school: scientific knowledge is empirically based, theory-laden, tentative, socially and culturally embedded, partly the product of human inference, imaginative and creative. In addition, the following three aspects were were found to be vital for NOS: "the distinction between observation and inference, the lack of a universal recipelike method for doing science, and the functions of and relationships between scientific theories and laws" (p. 499). There has been a consensus in the science education community over these tenets, and this list has been widely applied for research in science education.

However, many critiques developed, questioning the relevance of the list of tenets in the classroom, for research, and assessment (Allchin, 2011; Duschl & Grandy, 2013; Yacoubian, 2012; etc.). The Expanded Family Resemblance Approach to NOS emerged as a result (Erduran & Dagher, 2014). It is a more comprehensive and encompassing manner of defining NOS, which makes the FRA to NOS more appropriate to use in this study. The consensus view list would be too restrictive, which may restrain the results of this study.

Erduran and Dagher (2014) highlighted 11 NOS categories in their FRA wheel. The textbooks were analyzed for their representation of these NOS categories. In addition, the quality of the depiction of these categories was identified (target category not addressed, reference to NOS is implicit, some detail provided when referring to NOS, or NOS category presented in an ideal way).

Given these points, this research study focused on analyzing the representation of NOS in French textbooks (published in France), American textbooks, and the CERD textbook that are used in schools in Lebanon for grade 6 science classrooms. The CERD textbook is available in both French and English. The content of the textbook is the same, it is simply translated to another language, therefore one textbook shall be analyzed, the one in French.

Textbooks that Were be Analyzed

There are no statistics about the textbooks that are used in Lebanon. Therefore, I have consulted with two bookstores and one publishing house to get an idea about the extent to which different textbooks are used in Lebanon. The first bookstore I have consulted provides textbooks to ten schools, two of which have both English and French sections for each grade level. The second bookstore is a large-scale one, providing textbooks for the Beirut, Metn, Keserwein, and Jbeil areas. I asked the first bookstore to provide me with the list of textbooks that are currently used in schools in the Keserwein and Metn area for grade 6. I went through each school's booklist (a total of 12) and took note of the name of the science textbook that is used in grade 6 for the academic year 2019-2020. When I noted the same textbook being used by two different schools or more, I tallied its frequency of use. As a result of this practice, I took note of the three most used French grade 6 science textbooks, and the three most used American grade 6 science textbooks. Following my tally, the second major bookstore and one publishing house were consulted, and they both agreed that these textbooks are indeed the ones that are most widely used in Lebanon.

It should be noted that French textbooks that are published in collaboration with a local publishing house were not included in this study. For example, Hachette

produces a textbook in collaboration with Librairie Antoine, a Lebanese publishing house and bookstore. The textbook is an adapted version of its French counterpart. The textbook is titled *Objectif Sciences*, and it is widely used as a more affordable option in comparison to the French version of the book, *Sciences et Technologie*. I will not analyze *Objectif Sciences*, as it is not published in France.

Sample

Given the sampling procedure outlined above, the sample of grade 6 science textbooks shall consist of three French textbooks, three American textbooks, and one Lebanese textbook. The three French textbooks for grade 6 are published by Bordas, Hachette, and Magnard. The three American textbooks are published by McGraw Hill, Houghton Mifflinn Harcourt, and Pearson. It should be noted that Pearson publishes the elementary and intermediate textbooks in modules, so the two modules that are used for grade 6 in Lebanon were included in this study. The Lebanese textbook used for the study is the only science textbook published by CERD, and I used its French version. Thus, the grade 6 science textbooks that were used in this study are the following:

- Buckley, D. Miller, Z., Padilla, M., Thornton, K., Wysession, M., Wiggins, G.… Daniels, H. (2011). Ecology and the environment. Boston, Massachusetts: Pearson

- Buckley, D. Miller, Z., Padilla, M., Thornton, K., Wysession, M., Wiggins, G.… Daniels, H. (2011). Diversity of life. Boston, Massachusetts: Pearson

- DiSpezio, M. A., Frank, M., Heithaus, M. R., Ogle, D. M. (2017). *Science Fusion Motion, Forces, and Energy*. Orlando, Florida: Houghton Mifflin Harcourt.

- Anderson, M., Berwald, J., Bolzan, J., Clark, R., Craig, P., Gardiner, L., Gonya, J.,… Zorn, M., (2012). *Integrated Science.* Columbus, Ohio: Macmillan/ McGraw Hill/ McGraw Hill.
- Fuchs, A. (Ed.), Azan, J., Bastonero, M., Delaire-Echard, S., Egels, C., Girault, J…. Martinez, G. (2016). Sciences et technologie. Paris, France : Magnard.
- Lizeaux, C., Baude, D. (Eds.), Audebert, V., Bobée S., Buttet, C., Chaleix, A…. Sautereau, M. (2014). Sciences de la vie et de la terre. Paris, France : Bordas.
- Charpignon, M., Collard, C. Desormes, H., Dulaurans, T., Lebrun, M., Tarride, I…. Thébœf, D. (n.d.). Sciences et technologie. Paris, France : Hachette Education
- Yaghi, M., Iskandarani, I. (Eds.), El Hajj, M., Ghazale, B., Sbeity, A., Daher, M., Wehbeh, S. (2010). Sciences pour la vie. Sin-El-Fil, Lebanon: CERD.

Description of the Textbooks

First, the American textbooks that were analyzed are described. I will start by describing the two modules published by Pearson and used in Grade 6. The two modules that are used for grade 6 are Ecology and the Environment and Diversity of Life. The first module, Ecology and the environment (Buckley et al., 2011) has 5 chapters and 234 pages. The first chapter is Populations and communities (4 lessons). The second chapter is Ecosystems and biomes (5 lessons). The third chapter is Resources and living things (5 lessons). The fourth chapter is Land, air, and water resources (5 lessons). The fifth chapter is Energy resources (3 lessons). Each chapter consists of the following parts: Lesson, Study guide and Review, Assessment, and Science Matters. The second module, Diversity of Life (Buckley et al., 2011) has 7

chapters and 312 pages. The first chapter is Introduction to living things (4 lessons). The second chapter is Viruses, bacteria, protists, and fungi (4 lessons). The third chapter is Plants (6 lessons). The fourth chapter is Introduction to animals (5 lessons). The fifth chapter is Getting around (3 lessons). The sixth chapter is Obtaining energy (3 lessons). The seventh chapter is Animal reproduction and behavior (4 lessons). Each chapter consists of the following parts: Lesson, Study guide and Review, Assessment, and Science Matters. Both textbooks' lessons start with a section named "My Planet Diary", which includes real-life applications, examples, or historical relations to the concepts covered in the lesson. The lessons include multiple figures with scaffolding questions over documents, with lines left blank for students to fill in. Each concept covered in the lesson is followed by an "Assess Your Understanding" box, which includes further questions and lines left blank for students to write in their answers. There are multiple Venn Diagrams included in the textbooks for students to fill in as well.

The Houghton Mifflin Harcourt textbook, *Science Fusion, Motion, Forces, and Energy* (DiSpezion, Frank, Heithaus, Ogle, 2017) has 3 units. The first unit is Motion and Forces (5 lessons). The second unit is Work, Energy, and Machines (3 lessons). The third unit is Electricity and Magnetism (6 lessons). Each lesson consists of the following parts: Engage Your Brain, Visual Summary, Lesson Review, My Notes, and Think Science (sometimes found in a lesson, sometimes it is not found). Each chapter in *Science Fusion* starts with a "Citizen Science" section, which includes real-life applications of the concepts taught in the chapter. "Citizen Science" takes up two pages and includes boxes titled "Define the Problem", "Think About It", and "Plan and Test Your Design" or "Make a Plan". The section ends with "Take It Home". Each lesson starts with an "Essential Question" with a visual image related to the question on the left

side. The right-side page includes two parts, “Engage you Brain” and “Active Reading” where the vocabulary words of the lesson are introduced.

The McGraw Hill textbook, *Integrated Science* (Anderson et al., 2012) has 4 units for a total of 15 chapters and 521 pages (not including glossary and index pages). The first unit is Exploring Earth (5 chapters). The second unit is Exploring Life (4 chapters). The third unit is Plants (5 chapters). The fourth unit is Understanding Matter (2 chapters). The fifth unit is Understanding Energy (3 chapters). Each chapter consists of the following parts: Explore, Launch Lab, Reading check, Mini Lab, Lesson Review, Inquiry Lab, Chapter Study Guide, and Chapter Review. Each chapter starts with a “The Big Idea” question and an “Inquiry” question on the left page, and a “Get Ready to Read” box with “What do you Think?” statements on the right page. Each lesson starts with a picture as well and a box that includes “Key Concepts Essential Questions” and the Vocabulary words with the page they can be found. A box labeled “Inquiry” question is also found on the first page of the lesson. The second page of the lesson always starts with an “Inquiry Launch Lab” activity.

As for the French textbooks that are used in Lebanon, the Magnard grade 6 *Sciences et Technologie* textbook (Fuchs, Azan et al., 2016) is 258 pages long and has four units, called *Thèmes*, for a total of 14 chapters. *Thème A, Matière, mouvement, énergie, information* (4 chapters), *Thème B, Le vivant, sa diversité et les fonctoins qui le caractérisent* (4 chapters), *Thème C, Matériaux et objets techniques* (3 chapters), and *Thème D, La planète Terre. Les êtres vivants dans leur environnement* (3 chapters). Each chapter is divided into the following: *Activité, Je formule une hypothèse* (sometimes found in a lesson, sometimes it is not found), *J’extrais les informations, J’exploite les informations (*sometimes combined together to form *J’extrais et j’exploite*

les informations, Je conclus, Bilan, and *Exercices* (Fuchs, Azan et al., 2016). Each chapter begins with a « Avant de Commencer » (Before beginning) section which includes pictures followed by multiple choice questions. The next page has a picture followed by the objectives of the lesson outlined in the form of questions. Each activity starts with a document or experiment, followed by scaffolding steps such as asking students to extract information, formulate a hypothesis, and conclude. The activity ends with a « vocabulary » word box.

The Bordas grade 6 *Science de la Vie et de la Terre* (SVT) textbook (Lizeaux, Baude et al., 2014) is 216 pages long and consists of four units, called *Parties*, for a total of ten chapters. *Partie 1, Caractéristiques de l'environment et peuplement du milieu* (4 chapters), *Partie 2, L'origine de la matière des êtres vivants* (2 chapters), *Partie 3, Des pratiques au service de l'alimentation humaine* (2 chapters), and *Partie 4, Diversité, parentés et unité des êtres vivants* (2 chapters). Each chapter is divided into the following: *Activité, Le bilan des activités, Le schema-bilan, Le socle commun de connaissances et de compétences, Le coin des curieux, and Exercises* (Lizeaux et al., 2014)**.** Each chapter starts with a picture followed by a descriptive paragraph and a question. Each activity includes one or more documents, which can be pictures, maps, drawings, schemas or graphs. A box near the documents titled « Je réalise » is found to scaffold the students' analysis of the documents step by step. The lesson ends with a « vocabulaire » box and « pistes de travail » box, which includes analysis and conclusion questions over the documents presented in the lesson.

The Hachette Éducation grade 6 *Sciences et Technologie* textbook (Charpignon, Collard et al., n.d.) is 247 pages long and divided into four units, for a total of 16 chapters. The first unit, *Matière, movement, énergie, information* (5 chapters), the

second unit, *Le vivant, sa diversité et les fonctions qui le caractérisent* (4 chapters), the third unit, *Matériaux et objets techniques* (5 chapters), and the fourth unit, *La planète Terre Les êtres vivants dans leur environments* (2 chapters). Each chapter is divided into the following: *Activité, Bilan, Exercises,* and *Lire des sciences* (Charpignon et al., n.d.)**.** Each chapter begins with a "Lire des sciences" part which describes a historical or current application of the concepts taught in the lesson. The next page includes pictures and the titles of the activities in the lesson. Some activities are broken down to parts A and B. Part A includes one or more documents followed by scaffolding questions or instructions. Part B usually includes analysis, application, and concluding questions. Some activities are not divided into parts A and B, but rather include one or more documents and scaffolding questions on the document(s). A "vocabulaire" box may be found after one or two activities.

The national grade 6 science textbook published in Lebanon by CERD (Yaghi, Iskandarani, El Hajj, Ghazale, Sbeity, Daher, & Wehbeh, 2010) is 202 pages long and has six units, called *Unité,* for a total of 20 chapters. *Unité 1, Organisation des êtres vivants* (2 chapters), *Unité 2, La reproduction* (5 chapters), *Unité 3, L'homme et sa santé* (3 chapters), *Unité 4, L'homme et l'environment* (3 chapters), *Unité 5, La matière et l'énergie* (4 chapters), and *Unité 6, La terre et l'univers* (3 chapters). Each chapter is divided into the following: *Leçon, Activité,* and *Exercises* (Yaghi et al., 2010). Each chapter is introduced with a picture or drawing, followed by the objectives of the lessons in the form of a question, and a box outlining the lessons of the chapter. Each lesson includes one or more documents, sometimes followed by a "Le sais-tu?" bullet-point paragraph with information about the documents. The lessons usually include an activity, with the materials and procedure outline. The activity is followed by

“J’observe et je deduis” questions and a “J’infere” questions. A “mots clés” box is found at the end of the lesson but does not include the definitions of the vocabulary words.

Instrument

The instrument used was based on the one developed by BouJaoude et al.’s (2017) for textbook analysis (attached in the appendix). This instrument was chosen because it is based on the expanded Family Resemblance Approach (FRA) to NOS wheel by Erduran and Dagher (2014). The FRA wheel (Erduran & Dagher, 2014) is the latest developed framework for NOS, and it is the most comprehensive view of NOS. This allows for more reliable results as the 11 categories included in the FRA to NOS framework encapsulate a comprehensive range of aspects of NOS, which are not accounted for in previous theoretical frameworks like the consensus view. A short explanation of these categories is adapted from BouJaoude, Dagher, and Refai (2017) below:

1. *Scientific Aims and Values* category comprises several cognitive values that include, among other things, objectivity, novelty, accuracy, and empirical adequacy.
2. *Scientific Practices* category involves the understanding that scientists develop, through investigations that involve questions about the world, engagement in activities that enable them to understand it better (experiments, observation, classification), analysis of data and development of models, explanations and predictions that can be verified and further explored.

3. *Scientific Methods* category addresses the idea that scientists use many methods of true experiments involving the testing of hypotheses or not, thought experiments, or observations that include the testing of hypotheses or not.
4. *Scientific Knowledge* category pertains to addressing how scientific knowledge is expressed in multiple forms such as theories, laws, and models that are used to explain and predict phenomena. How these forms of knowledge relate to one another and to scientific methods and how practices affect the growth of knowledge over time.
5. *Scientific Ethos* category focuses on understanding that for scientific knowledge and practices to be credible and ethical, there are a number of norms that scientists are expected to abide by such as intellectual honesty, respect for and protection of human subjects, respect for colleagues, and the environment, responsible publication, etc.
6. *Social Values* category includes an understanding of respecting the environment, social utility, and freedom.
7. *Social Certification* category describes the role of peer review, evaluation, and criticism with an understanding that scientific findings are reviewed, criticized, and evaluated by peers.
8. *Professional Activities* category focuses on understanding the role of attending professional conferences, presenting findings, writing research proposals, and conducting peer reviews of papers and proposals.
9. *Financial Systems* category acknowledges the roles of funding priorities, commercial and special interests in enabling, controlling, or limiting scientific knowledge.

10. *Political Power structures* address gender issues, colonial interests, ideological influences on scientific knowledge and practices, and who benefits from them.
11. *Social Organization and Interactions* category addresses the organizational structures and relational transactions within and among scientific communities.

The instrument consists of a table to be used for tallying the 11 NOS categories as described by Erduran and Dagher (2014). The left-hand column of the instrument lists the 11 categories described above and groups them based on their domains. The cognitive-epistemic domain includes aims and values, practices, methods, and knowledge. The social-institutional domain-A (internal to science) consists of the following categories: scientific ethos, social values, social certification, and professional activities. The last domain, social-institutional- B (external to science), consists of these categories: financial systems, political power structures, and social organizations and interactions. Next, each category is divided into two rows: one labeled "presence of NOS category" and the other labeled "quality of NOS representation". The first row was used to tally if the appropriate NOS category is found, and the row below it was used to indicate the quality of representation of the NOS category. The top row indicates the page number of the book and the chapter it is from. Therefore, there were two filled in this table for each NOS category: one with a tally mark to show the presence or absence of the NOS category in each page of the textbooks, and the second box indicating the quality of the representation, if found.

Data Collection Procedure

Each of the seven textbooks was read in full following the natural flow of the themes in the textbooks (lessons that are part of a chapter). Reading the textbooks in full is preferred over a random sample of chapters because some topics may lend themselves

to more inclusion of NOS while others may not. In addition, if there was a NOS storyline in the textbook, we were able to examine it. Specifically, the textbooks were read page by page in their entirety, and following each page from each chapter, a tally was taken of the presence or absence of a reference to the 11 NOS categories highlighted by Erduran and Dagher (2014). If no representation of the category was found, the box labelled "quality of NOS representation" was left blank, indicating the failure to address the target category. If a representation of the category was found, then the reference was classified as follows: "1-(S) reference to NOS category was *s*uperficial, was implicit, or mentioned in passing, 2-(D) refers to NOS category in some *d*etail, 3-(E) refers to the NOS category in an *e*xemplary way" (BouJaoude et al., 2017, p. 87). It should be noted that if a category is represented over a number of pages, then the tally was taken once, and consequently, classified once. For example, timelines in Houghton Mifflin Harcourt's *Science Fusion* take up two consecutive pages. Therefore, the material represented in both pages as it relates to the appropriate NOS category(ies) were counted once, and given the rating for quality of representation once. In addition, if a page has more than one representation for the same NOS category, then more than one tally was noted. For example, in Pearson's *Diversity of Life* module, the chapter reviews would consist of multiple exercises. Some exercise would draw on the practices category, but at a low quality; while others would draw on the same category, but in a higher quality. In such case, a tally was taken for each exercise, indicating the quality of each representation, resulting in two different tallies for the same page, each at a different quality of representation.

To calculate the total frequency of representation of each NOS category, the number of tallies taken was counted using Microsoft Excel and the "COUNTA"

function. All the cells where the tally was taken were selected for the "COUNTA" function, therefore, only the cells with a tally were counted, while the blank ones were not counted. For example, if cells E5 and F5 had a tally (marked by an "x"), but cell D5 was empty, the "COUNTA" function for cells D5, E5, and F5 would be 2.

To calculate the total frequency for a quality of 1, 2, or 3, the Excel function "COUNTIF" was used. For example, if cells E6 and F6 had the number 3, noting a high-quality representation, but cell D6 was equal to 1, the "COUNTIF" function for cells D6, E6, and F6 for "=COUNTIF(D6:F6, = "1") resulted in 1, indicating that for cells D6, E6, and F6, only cell D6 had a low-quality representation.

In order to calculate the percentage of each type of quality representation, the total number of quality representation for each NOS category was divided by the total number of representations. For example, Houghton Mifflin Harcourt's *Science Fusion* textbook had 74 occurrences of a quality of 1 for the knowledge category, while the total number of frequencies for the knowledge category was 212. Hence, 74 was divided by 212, which resulted in 34.9% for the representation of the knowledge category for a quality of 1. Accordingly, out of all of the representations for the knowledge category in Houghton Mifflin Harcourt's *Science Fusion* textbook, 34.9% of the 212 representations were low-quality. Therefore, the unit of analysis used was the frequency of representation of a NOS category.

As for the total percentage for each category, the sum of the frequency of all NOS representations was first calculated using the "SUM" function and manually selecting the cells with the calculated total frequencies of each NOS category (where the "COUNTA" function was used, mentioned above). Next, the total frequency of each NOS category was divided by the sum of all frequencies. For example, in Hachette's

Sciences et Technologie, there were 127 representations of the practices category. The total amount of representations of all categories was 569. Therefore, 127 divided by 569 gives 22.3%. Thus, 22.3% of all 569 NOS representations in Hachette's *Sciences et Technologie* were representations of the practices category.

In the following table, examples from the analyzed textbooks are provided for each NOS category and a quality of 1, 2, or 3.

NOS aspect	NOS category	1	2	3
Cognitive-epistemic aspects (CE)	Aims & values	"Infer: Is hibernation an adaptation to life in a deciduous forest?" Explain your answer." (Buckley et. al., 2011, p.63).	"Infer: Which process is responsible for the droplets visible on the glass below? Explain." (Buckley et. al., 2011, p.77).	"How did a potato crop without a variety of different genes lead to the Irish potato famine of 1845?" (Buckley et. al., 2011, p.112).
	Practices	"Calculate: What percentage of species shown on the pie graph do insects represent? Round your answer to the nearest tenth." (Buckley et. al., 2011, p.109).	"Compare and contrast: As you read about temperate and tropical rain forests, fill in the Venn diagram." (Buckley et. al., 2011, p.60).	"What could farmers do to prevent another potato famine?" (Buckley et. al., 2011, p.112).
	Methods	"How do you think land should be used?" (Buckley et. al., 2011, p.128).	"Sequence: In the frames below, draw a comic strip or describe a situation that shows the order of events in the nitrogen cycle." (Buckley et. al., 2011, p. 55).	"Larger populations use more resources. Why do you think some countries are still encouraging population growth?" (Buckley et. al., 2011, p.100).

	Knowledge	"The atmosphere is the envelope of gases that surrounds the planet" (Buckley et. al., 2011, p.126).	"Reuse refers to finding another use for an object rather than discarding it, such as refilling resusable bottles with drinking water instead of buying a new bottled water." (Buckley et. al., 2011, p.137).	"Scientists are stull searching for methods that will provide safe and permanent disposal of radioactive wastes." (Buckley et. al., 2011, p.141).
Social-Institutioal aspects- A	Scientific Ethos	"[Aldo Leopold] believed people should use land in a way that protects it for all living things as well as for future gnerations. Leopold called his idea the "land ethic." (Buckley et. al., 2011, p.128).	"As you see on the map, ocean resources are not evenly distributed among nations." (Buckley et. al., 2011, p.162).	"[…] A singing canary indicated that all was well. If the canary stopped singing and died, the miners knew that they needed to quickly leave the mine. […]Do you think it was ethical, or fair, to use canaries this way? Explain." (Buckley et. al., 2011, p.50.
	Social Values	" Losing the important food source to overfishing would hurt the populations of bears, wolves, birds, and many other animals." (Buckley et. al., 2011, p.42).	"Arguing Over Antarctica: Some people want to leave Antarctica wild. Oters want it developed. Summarize: Fill in the boxes with points outlining each	" […] A company wants to buy a piece of land outside the city and build a factory on it. […] How would you decide what to do with the land?" (Buckley et. al., 2011, p.90).

			argument." (Buckley et. al., 2011, p.87).	
	Social Certification	"Communicate: Discuss the question with a group of classmates." (Buckley et. al., 2011, p.160).	"Communicate: Some of the members of Congress do not think acid rain causes real damage. What do you tell them?" (Buckley et. al., 2011, p.144).	" Find three articles describing Cousteau's interaction with the sharks. Write your own article comparing and reviewing the science presented in the articles." (Buckley et. al., 2011, p.200).
	Professional Activities	"Now I know that environmental decisiona are made by weighing the costs and benefits of a proposal." (Buckley et. al., 2011, p.91).	"Communicate: Write a letter to the editor that describes how food and space may be limiting factors for the giant pand species. Add a headline to your letter." (Buckley et. al., 2011, p.17).	"Create a poster display or multimedia presentation that explains your findings." (Buckley et. al., 2011, p.172).
Social-Institutioal aspects- B	Financial Systems	"Drilling deep wells is very expensive." (Buckley et. al., 2011, p.191).	"What is the best use of Antarctica? […] Some people propose building hotels, parks, and ski resorts." (Buckley et. al., 2011, p.87).	"Weighing Costs and Benefits: Once you have identified the potential costs and benefits of a decision, you must analyze them." (Buckley et. al., 2011, p.91).
	Political Power Structures	"Governments and industries greatly affect resource conservation."	"Some countries have passed laws to stop farmers, miners,	"[…] write a brief letter to your senator explaining your opinion either

		(Buckley et. al., 2011, p.97).	loggers, and ranchers from cutting down the forests." (Buckley et. al., 2011, p.102).	in favor or against offshore drilling." (Buckley et. al., 2011, p.91).
	Social Organizations and Interactions	"[…] some organizations are replanting trees." (Buckley et. al., 2011, p.102).	"AN engineer named Michael Bernitsas has developed a device that uses this effect to generate electricity." (Buckley et. al., 2011, p.207).	"Scientists and chegs are working together to introduce people to deep-water species such as monkfish and tile fish, as easy-to-farm freshwater fish such as tilapa." (Buckley et. al., 2011, p.107).

Reliability

Reliability was ascertained as follows through inter-rater agreement at the beginning of textbook analysis:

1. Step One Two raters met to discuss and practice analyzing the material. One chapter was picked randomly from one of the textbooks, and the two raters read the chapter page by page together, tallying the presence or absence of the 11 NOS categories, and rating the quality of their representation (0, 1, 2, or 3).

2. Step Two Following this practice, two chapters were selected at random, and each rater analyzed them independently. After, the two raters compared their results and took note of the findings they had in common, and those that were different. The interrater reliability was calculated to be 94%. Since there was no huge difference between the raters (interrater reliability was more than 85%), , the researcher moved on to the second step. The first coder was the researcher, and the second was a science

educator and a graduate student who had completed research using the FRA to NOS wheel and was familiar with it.

3. Step Three A full analysis of all the textbooks was completed by the researcher following the practiced chapters. The representation of the 11 NOS categories outlined in the FRA to NOS wheel (Erduran & Dagher, 2014) in the textbooks was tallied with a mark, followed by the rating of the quality of the representation. All the textbooks were read in their entirety, following the normal flow of the textbooks, chapter by chapter starting with the first chapter.

CHAPTER 4

RESULTS

The goal of this study was to analyze textbooks for their representation of NOS, using a comprehensive framework based on the Expanded Family Resemblance Approach to NOS. The analyzed textbooks were grade 6 American and French science textbooks that are available on the Lebanese market. The Lebanese Center for Educational Research and Development (CERD) has published one national grade 6 science textbook that was also analyzed in this study. The analyzed textbooks used were published by Pearson, Houghton Mifflin Harcourt, McGraw Hill, Magnard, Bordas, Hachette, and CERD. Specifically, this study investigated the following research questions:

1. What NOS categories, if any, are addressed in the grade 6 American science textbooks published in the United States and used in Lebanon, and which ones are not? If present, what is the quality of representation of these categories?
2. What NOS categories, if any, are addressed in the grade 6 French science textbooks published in France and used in Lebanon, and which ones are not? If present, what is the quality of representation of these categories?
3. What NOS categories, if any, are addressed in the grade 6 Lebanese science textbook published by CERD, and which ones are not? If present, what is the quality of representation of these categories?
4. What are the differences, if any, between the representation of NOS in American, French, and Lebanese 6^{th} grade science textbooks?

5. What are the similarities, if any, between the representation of NOS in American, French, and Lebanese 6th grade science textbooks?

This chapter is organized as follows: first, the results of the American textbooks are presented for each book. The American textbooks are then compared to each other for the presence or absence of each NOS category and the quality of their representation. These results answer the first research question. Second, the results of each French textbook are outlined. A comparison of the extent of representation of NOS and its quality for each NOS category in all French textbooks follows. These results answer the second research question. Third, the Lebanese textbook was analyzed for the representation of each NOS category and its quality. The results answer the third research question. Finally, all textbooks' results are compared by presenting the findings in tables, and outlining similarities and differences between American, French, and Lebanese textbooks. These cumulative comparisons answer the fourth and fifth research questions.

To ensure reliability, an inter-rater reliability was performed. The inter-rater reliability was determined to be 94%. Accordingly, the researcher then read and analyzed the rest of the textbooks in their entirety. The data of this study were collected using Microsoft Excel.

First, the presence or absence of an NOS category was investigated. When the category was represented, it was then categorized as 1, 2, or 3. A quality of "1" indicates the category was mentioned in passing. A quality of "2" shows some detail provided, or a supporting document given with the category mentioned such as pictures, diagrams, and graphs. Finally, a quality of "3" presents an exemplary representation of the category, with explicit references to the students' context and environment. The

frequency and percentages of representation based on occurrence and quality were calculated on the Excel sheets.

The collected data were used to generate comparative tables showing the frequencies and percentages of the presence of an NOS category and the quality of its representation. The last comparative tables, 11.1, 11.2, 12.1, and 12.2, allowed for the interpretation of the similarities and differences between all the analyzed textbooks. The frequency and percentage of representation of each NOS category of all textbooks are presented in two tables, preceded by a description of the results. The first table shows the frequency of each NOS category, the second table shows the percentage of each NOS category. Each table contains the total frequency or percentage of each category, followed by a breakdown of the quality of representation of each category.

First Research Question

What NOS categories, if any, are addressed in the grade 6 American science textbooks published in the United States and used in Lebanon, and which ones are not? If present, what is the quality of representation of these categories?

To answer the first research question, the three textbooks' results are outlined below. The Pearson textbook is divided into modules, two of which are used in grade 6 and have been analyzed. Pearson's *Ecology and the Environment* module's results are presented in tables 1.1 and 1.2. Pearson's *Diversity of Life* module's results are presented in tables 2.1 and 2.2. Houghton Mifflin Harcourt's *Science Fusion* textbook's results are presented in tables 3.1 and 3.2. McGraw Hill's *Integrated Science* textbook's results are presented in tables 4.1 and 4.2. The tables show the frequency and percentage of representation of each category. In addition, the quality of representation is reported.

Following each American textbook's individual analysis, two comparative tables, tables 5.1 and 5.2, were generated to show the similarities and differences between these. Table 5.1 presents the frequencies of representation of each NOS category per American textbook while table 5.2 presents the percentage of representation of each NOS category per American textbook. The tables are preceded by a description of the results.

Pearson's Ecology and the Environment Module

Table 1.1 presents the frequency of each NOS category along with its quality in Pearson's *Ecology and the Environment* module while table 1.2 presents the percentages of the NOS categories and the quality indicators of each category. Tables 1.1 and 1.2 show that the NOS categories emphasized in the Pearson's *Ecology and the Environment* module were mainly in the cognitive-epistemic aspect of NOS, namely knowledge (165 occurrences, 32.9%), practices (151, 30.1%), methods (46, 9.2%), and aims and values (18, 3.6%). Tables 1.1 and 1.2 also show that the social values category was the highest frequency (38, 7.6%) in the social-institutional aspect (SI- A) followed by social certification (16, 3.2%), professional activities (10, 2%), and scientific ethos (7, 1.4%). The lowest frequencies are in the SI-B category with the financial system being the highest (23, 4.6%), followed by political power structures (16, 3.2%), and social organizations and interactions (11, 2.2%).

In addition, tables 1.1 and 1.2 show the quality of each NOS category in Pearson's *Ecology and the Environment* module. In Pearson's *Ecology and the Environment* module and for the cognitive-epistemic aspect of NOS, the methods category had the highest frequency of 3 (8 occurrences, 17.4%), followed by the aims and values category (3, 16.7%), then knowledge (20, 12.1%), and practices (16, 10.6%).

As for the social-institutional aspect – A, the professional activities had the highest frequency of 3 (6 occurrences, 60%), followed by social values (12, 31.6%), then scientific ethos (1, 14.3%), and social certification (1, 6.3%). For the last aspect, social-institutional-B, the financial systems category had the highest frequency of the highest quality of representation (7 occurrences, 30.4%), followed by political power structures (4, 25%) and social organizations and interactions (2, 18.2%).

Table 1.1

Frequency of each NOS Category in Pearson's Ecology and the Environment Module

NOS Aspect	NOS category	Total Frequency	Quality of representation by frequency		
			1	2	3
CE	Aims and values	18	10	5	3
	Practices	151	98	37	16
	Methods	46	26	12	8
	Knowledge	165	66	79	20
SI-A	Scientific ethos	7	2	4	1
	Social values	38	13	13	12
	Social certification	16	9	6	2
	Professional activities	10	2	2	6
SI-B	Financial systems	23	10	6	7
	Political power structure	16	4	8	4
	Social organizations and interactions	11	5	4	2

CE: cognitive-epistemic aspects of NOS; SI-A: social-institutional aspects (A) internal to science; SI-B: social institutional aspects (B) external to science

Table 1.2

Percentage of each NOS Category in Pearson's Ecology and the Environment Module

NOS aspect	NOS category	Total Percentage	Quality of Representation by Percentage		
			1	2	3
CE	Aims and values	3.6	55.6	27.8	16.7
	Practices	30.1	64.9	24.5	10.6
	Methods	9.2	56.5	26.1	17.4
	Knowledge	32.9	40.0	47.9	12.1
SI-A	Scientific ethos	1.4	28.6	57.1	14.3
	Social values	7.6	34.2	34.2	31.6
	Social certification	3.2	56.3	37.5	6.3
	Professional activities	2.0	20.0	20.0	60.0
SI-B	Financial systems	4.6	43.5	26.1	30.4
	Political power structure	3.2	25.0	50.0	25.0
	Social organizations and interactions	2.2	45.5	36.4	18.2

CE: cognitive-epistemic aspects of NOS; SI-A: social-institutional aspects (A) internal to science; SI-B: social institutional aspects (B) external to science

As revealed in the tables, all NOS categories were addressed in Pearson's *Ecology and the Environment* module. However, results indicate a low frequency of representation for the social-institutional aspects A and B in comparison to the cognitive-epistemic aspect. The categories with the highest frequencies of high-quality representation were practices, knowledge, and social values (16, 20, and 12 occurrences, respectively). The professional activities category had the highest percentage of representation in high quality (60%); however, the frequency was low (7 occurrences).

Pearson's Diversity of Life Module

Table 2.1 presents the frequency of each NOS category along with its quality in the Pearson's *Diversity of Life* module while table 2.2 presents the percentages of the NOS categories and the quality indicators of each category. Tables 2.1 and 2.2 show that the NOS categories emphasized in the Pearson's *Diversity of Life* module were mainly in the cognitive-epistemic aspect of NOS, namely knowledge (339 occurrences, 44.6%), practices (299, 39.3%), methods (34, 4.5%), and aims and values (33, 4.3%). Tables 2.1 and 2.2 also show that the social values category was the highest frequency (18, 2.4%) in the social-institutional aspect (SI- A) followed by professional activities (17, 2.2%), social certification (7, 0.9%), and scientific ethos (2, 0.3%). The lowest frequencies are in the SI-B category with social organizations and interactions being the highest (8, 1.1%), followed by the financial system (2, 0.3%), and political power structures (1, 0.1%).

In addition, tables 2.1 and 2.2 show the quality of each NOS category in Pearson's *Diversity of life* module. For the cognitive-epistemic aspect of NOS, the methods category had the highest frequency of 3 (14 occurrences, 41.2%), followed by the aims and values category (9, 27.3%), then knowledge (80, 23.6%), and practices (50, 16.7%). As for the social-institutional aspect – A, the scientific ethos had the highest frequency of 3 (2 occurrences, 100%), followed by professional activities (12, 70.6%), then social values (10, 55.6%), and social certification (1, 14.3%). For the last aspect, social-institutional-B, the two categories with the highest frequency of the highest quality of representation were the financial systems (2 occurrences, 100%) and political power structures categories (1, 100%), followed by social organizations and interactions (7, 87.5%).

Table 2.1

Frequency of each NOS Category in Pearson's Diversity of life Module

NOS aspect	NOS category	Total Frequency	Quality of representation by frequency		
			1	2	3
CE	Aims and values	33	12	12	9
	Practices	299	115	134	50
	Methods	34	5	15	14
	Knowledge	339	110	149	80
SI-A	Scientific ethos	2	0	0	2
	Social values	18	6	2	10
	Social certification	7	4	2	1
	Professional activities	17	3	2	12
SI-B	Financial systems	2	0	0	2
	Political power structure	1	0	0	1
	Social organizations and interactions	8	1	0	7

CE: cognitive-epistemic aspects of NOS; SI-A: social-institutional aspects (A) internal to science; SI-B: social institutional aspects (B) external to science

Table 2.2

Percentage of each NOS Category in Pearson's Diversity of Life Module

NOS aspect	NOS category	Total percentage	Quality of representation by percentage		
			1	2	3
CE	Aims and values	4.3	36.4	36.4	27.3
	Practices	39.3	38.5	44.8	16.7
	Methods	4.5	14.7	44.1	41.2
	Knowledge	44.6	32.4	44.0	23.6
SI-A	Scientific ethos	0.3	0.0	0.0	100.0
	Social values	2.4	33.3	11.1	55.6
	Social certification	0.9	57.1	28.6	14.3
	Professional activities	2.2	17.6	11.8	70.6
SI-B	Financial systems	0.3	0.0	0.0	100.0
	Political power structure	0.1	0.0	0.0	100.0
	Social organizations and interactions	1.1	12.5	0.0	87.5

CE: cognitive-epistemic aspects of NOS; SI-A: social-institutional aspects (A) internal to science; SI-B: social institutional aspects (B) external to science

The results of analyzing Pearson's *Diversity of Life* module indicate that all NOS categories were addressed. However, some categories were not represented at each qualitative level. For example, the NOS categories of the scientific ethos, financial systems, and political power structure had no representations for the qualities of 1 nor 2. The tables also indicate a low frequency of representation for the social-institutional aspects A and B in comparison to the cognitive-epistemic aspect. The three NOS categories with the highest occurrences of high-quality representation are practices, methods, and knowledge (50, 14, and 80 occurrences, respectively). The three NOS categories with the highest percentages of representation of the highest quality are the scientific ethos, financial systems, and political power structures (100% each) but their frequencies were low.

Houghton Mifflin Harcourt's Science Fusion Textbook

Table 3.1 presents the frequency of each NOS category along with its quality in Houghton Mifflin Harcourt's *Science Fusion* textbook while table 3.2 presents the

percentages of the NOS categories and the quality indicators of each category. Tables 3.1 and 3.2 show that the NOS categories emphasized in Houghton Mifflin Harcourt's *Science Fusion* textbook were mainly in the cognitive-epistemic aspect of NOS, namely knowledge (212 occurrences, 37.3%), practices (257, 45.2%), methods (25, 7.7%), and aims and values (21, 3.7%). Tables 3.1 and 3.2 also show that the professional activities category was the highest frequency (16, 2.8%) in the social-institutional aspect (SI- A) followed by social values (7, 1.2%), social certification (1, 0.2%), and scientific ethos (1, 0.2%). The lowest frequencies are in the SI-B category with social organizations and interactions being the highest (8, 1.4%), followed by the financial system (1, 0.2%), and none for political power structures (0, 0.0%).

In addition, tables 3.1 and 3.2 show the quality of each NOS category in Houghton Mifflin Harcourt's *Science Fusion* textbook. For the cognitive-epistemic aspect of NOS, the methods category had the highest frequency of 3 (25 occurrences, 56.8%), followed by the aims and values category (13, 61.9%), then knowledge (69, 32.5%), and practices (73, 28.4%). As for the social-institutional aspect A, the two categories with the highest frequency of 3 were scientific ethos (1 occurrence, 100%) and social certification (1, 100%), then social values (6, 85.7%), and professional activities (9, 56.3%). For the last aspect, social-institutional-B, the two categories with the highest frequency of the highest quality of representation were the financial systems (1 occurrence, 100%) and social organizations and interactions (8, 100%). There were no occurrences for the political power structures category (0, 0.0%).

Table 3.1

Frequency of each NOS Category in Houghton Mifflin Harcourt's Science Fusion textbook

NOS aspect	NOS category	Total Frequency	Quality of representation by frequency		
			1	2	3
CE	Aims and values	21	0	8	13
	Practices	257	71	113	73
	Methods	44	0	19	25
	Knowledge	212	74	69	69
SI-A	Scientific ethos	1	0	0	1
	Social values	7	0	1	6
	Social certification	1	0	0	1
	Professional activities	16	1	6	9
SI-B	Financial systems	1	0	0	1
	Political power structure	0	0	0	0
	Social organizations and interactions	8	0	0	8

CE: cognitive-epistemic aspects of NOS; SI-A: social-institutional aspects (A) internal to science; SI-B: social institutional aspects (B) external to science

Table 3.2

Percentage of each NOS Category in Houghton Mifflin Harcourt's Science Fusion textbook

NOS aspect	NOS category	Total percentage	Quality of representation by percentage		
			1	2	3
CE	Aims and values	3.7	0.0	38.1	61.9
	Practices	42.2	27.6	44.0	28.4
	Methods	7.7	0.0	43.2	56.8
	Knowledge	37.3	34.9	32.5	32.5
SI-A	Scientific ethos	0.2	0.0	0.0	100.0
	Social values	1.2	0.0	14.3	85.7
	Social certification	0.2	0.0	0.0	100.0
	Professional activities	2.8	6.3	37.5	56.3
SI-B	Financial systems	0.2	0.0	0.0	100.0
	Political power structure	0.0	0.0	0.0	0.0
	Social organizations and interactions	1.4	0.0	0.0	100.0

CE: cognitive-epistemic aspects of NOS; SI-A: social-institutional aspects (A) internal to science; SI-B: social institutional aspects (B) external to science

The results of analyzing Houghton Mifflin Harcourt's *Science Fusion* textbook indicate that all NOS categories were addressed except for the political power structure category. In comparison to the Pearson modules, the categories were not diversely represented at each qualitative level. The tables also indicate a low frequency of representation for the social-institutional aspects A and B in comparison to the cognitive-epistemic aspect. The three NOS categories with the highest occurrences of high-quality representation are practices, methods, and knowledge (73, 25, and 69 occurrences, respectively). The four NOS categories with the highest percentages of representation of the highest quality are the scientific ethos, social certification, financial systems, and social organizations and interactions (100% each) but their frequencies were low.

McGraw Hill's Integrated Science Textbook

Table 4.1 presents the frequency of each NOS category along with its quality in McGraw Hill's *Integrated Science* textbook while table 4.2 presents the percentages of the NOS categories and the quality indicators of each category. Tables 4.1 and 4.2 show that the NOS categories emphasized in McGraw Hill's *Integrated Science* textbook were mainly in the cognitive-epistemic aspect of NOS, namely knowledge (802 occurrences, 40.2%), practices (729, 36.5%), methods (239, 12.0%), and aims and values (142, 7.1%). Tables 5.1 and 5.2 also show that the professional activities category was the highest frequency (40, 2.0%) in the social-institutional aspect (SI- A) followed by social values (17, 0.9%), social certification (9, 0.5%), and scientific ethos (2, 0.1%). The lowest frequencies are in the SI-B category with social organizations and interactions being the highest (12, 0.6%), followed by the financial system (5, 0.3%), and none for political power structures (0, 0.0%).

In addition, tables 4.1 and 4.2 show the quality of each NOS category in McGraw Hill's *Integrated Science* textbook. For the cognitive-epistemic aspect of NOS, the aims and values category had the highest frequency of 3 (74 occurrences, 52.1%), followed by methods (106, 12.0%), then practices (131, 18%), and knowledge category (103, 12.8%). As for the social-institutional aspect – A, the category with the highest frequency of 3 was professional activities (28 occurrences, 70%) and social certification (6, 66.7%), then social values (6, 35.3%), and none for scientific ethos (0, 0.0%). For the last aspect, social-institutional-B, the category with the highest frequency of the highest quality of representation was the financial systems (5 occurrences, 100%) and social organizations and interactions (5, 41.7%). There were no occurrences for the political power structures category (0, 0.0%).

Table 4.1

Frequency of each NOS Category in the McGraw Hill's Integrated Science Textbook

NOS aspect	NOS category	Total Frequency	Quality of representation by frequency		
			1	2	3
CE	Aims and values	142	42	26	74
	Practices	729	440	158	131
	Methods	239	52	81	106
	Knowledge	802	389	310	103
SI-A	Scientific ethos	2	2	0	0
	Social values	17	3	8	6
	Social certification	9	2	1	6
	Professional activities	40	7	5	28
SI-B	Financial systems	5	0	0	5
	Political power structure	0	0	0	0
	Social organizations and interactions	12	1	6	5

CE: cognitive-epistemic aspects of NOS; SI-A: social-institutional aspects (A) internal to science; SI-B: social institutional aspects (B) external to science

Table 4.2

Percentage of each NOS Category in McGraw Hill's Integrated Science Textbook

NOS aspect	NOS category	Total percentage	Quality of representation by percentage		
			1	2	3
CE	Aims and values	7.1	29.6	18.3	52.1
	Practices	36.5	60.4	21.7	18.0
	Methods	12.0	21.8	33.9	44.4
	Knowledge	40.2	48.5	38.7	12.8
SI-A	Scientific ethos	0.1	100.0	0.0	0.0
	Social values	0.9	17.6	47.1	35.3
	Social certification	0.5	22.2	11.1	66.7
	Professional activities	2.0	17.5	12.5	70.0
SI-B	Financial systems	0.3	0.0	0.0	100.0
	Political power structure	0.0	0.0	0.0	0.0
	Social organizations and interactions	0.6	8.3	50.0	41.7

CE: cognitive-epistemic aspects of NOS; SI-A: social-institutional aspects (A) internal to science; SI-B: social institutional aspects (B) external to science

The results of analyzing McGraw Hill's *Integrated Science* textbook indicate that all NOS categories were addressed except for the political power structure category, which is a similarity to the Houghton Mifflin Harcourt's *Science Fusion* textbook. Most categories were diversely represented at each qualitative level, except for the financial system category. The tables also indicate a low frequency of representation for the social-institutional aspects A and B in comparison to the cognitive-epistemic aspect. The three NOS categories with the highest occurrences of high-quality representation are practices, methods, and knowledge (131, 106, and 103 occurrences, respectively). The three NOS categories with the highest percentages of representation of the highest quality are the social certification, professional activities, and financial systems category (66.7%, 70%, and 100% each, respectively) but their frequencies were low.

Comparison of American Textbooks: Tables 5.1 and 5.2

Table 5.1 presents the frequency of the quality of representation of each NOS category in the American textbooks, while table 5.2 presents the percentages of the quality of representation of each NOS category.

Tables 5.1 and 5.2 show that the cognitive-epistemic aspect of NOS had the widest range of quality of representation across qualities 1, 2, and 3. In all analyzed American textbooks, the occurrences for a quality of 1 ranged from 0 (Houghton Mifflin Harcourt's *Science Fusion* for the aims and values category) to 440 (McGraw Hill's *Integrated Science* for the practice category) and percentages ranged from 0.0% (Houghton Mifflin Harcourt's *Science Fusion* for the aims and values category) to 64.9% (Pearson's *Ecology and the Environment* for the practices category). For the quality of 2, the occurrences ranged from 5 (Pearson's *Ecology and the Environment* for the aims and values category) to 310 (McGraw Hill's *Integrated Science* for the knowledge category) and percentages ranged from 18.3% (McGraw Hill's *Integrated Science* for the aims and values category) to 47.9% (Pearson's *Ecology and the Environment* for the knowledge category). For the quality of 3, the occurrences ranged from 3 (Pearson's *Ecology and the Environment* for the aims and values category) to 131 (McGraw Hill's *Integrated Science* for the practices category) and percentages ranged from 10.6% (Pearson's *Ecology and the Environment* for the practices category) to 61.9% (Houghton Mifflin Harcourt's *Science Fusion* for the aims and values category).

The textbook with the most percentages of a quality of 1 in the cognitive-epistemic aspect was Pearson's *Ecology and the Environment*. The textbook with the most percentages of a quality of 2 in the cognitive-epistemic aspect was Pearson's

Diversity of Life. The textbook with the most percentages of a quality of 3 in the cognitive-epistemic aspect was Houghton Mifflin Harcourt's *Science Fusion*. All textbooks had a mid-to-high-quality representation of the cognitive-epistemic aspect categories. All three textbooks had the highest frequencies of representations for the categories of practices, methods, and knowledge.

As for the social-institutional aspects A and B, all American textbooks had a low frequency in comparison to the cognitive-epistemic aspect. Indeed, the highest occurrence for a category was 28 (McGraw Hill's *Integrated Science* for the professional activities category). The financial systems category had no representations in both Houghton Mifflin Harcourt's *Science Fusion* and McGraw Hill's *Integrated Science* (0 occurrences, 0%). Most of the representations were classified at a quality of 3.

Both of Pearson's modules, *Ecology and the Environment* and *Diversity of Life,* were the only books that had all NOS categories of the social- institutional aspects A and B represented at the highest quality, 3, at least once.

On the other hand, McGraw Hill's *Integrated Science* had the highest number of categories (2) with no representations at the highest quality, 3. The unrepresented categories were scientific ethos and political power structure. Houghton Mifflin Harcourt's *Science Fusion* had one category with no high-quality representation: the political power structure category of the social-institutional aspect.

Table 5.1

Comparison Table: Frequency of the of the Quality of Representation of each NOS Categories in the American Textbooks

NOS aspect	NOS category	Quality of representation by frequency											
		1				2				3			
		Pearson's *Ecology and the Environment*	Pearson's *Diversity of Life*	Houghton Mifflin Harcourt's *Science Fusion*	McGraw Hill's *Integrated Science*	Pearson's *Ecology and the Environment*	Pearson's *Diversity of Life*	Houghton Mifflin Harcourt's *Science Fusion*	McGraw Hill's *Integrated Science*	Pearson's *Ecology and the Environment*	Pearson's *Diversity of Life*	Houghton Mifflin Harcourt's *Science Fusion*	McGraw Hill's *Integrated Science*
CE	Aims and values	10	12	0	42	5	12	8	26	3	9	13	74
	Practices	98	115	71	440	37	134	113	158	16	50	73	131
	Methods	26	5	0	52	12	15	19	81	8	14	25	106
	Knowledge	66	110	74	389	79	149	69	310	20	80	69	103
SI-A	Scientific ethos	2	0	0	2	4	0	0	0	1	2	1	0
	Social values	13	6	0	3	13	2	1	8	12	10	6	6
	Social certification	9	4	0	2	6	2	0	1	2	1	1	6
	Professional activities	2	3	1	7	2	2	6	5	6	12	9	28
SI-B	Financial systems	10	0	0	0	6	0	0	0	7	2	1	5
	Political power structure	4	0	0	0	8	0	0	0	4	1	0	0
	Social organizations and interactions	5	1	0	1	4	0	0	6	2	7	8	5

CE: cognitive-epistemic aspects of NOS; SI-A: social-institutional aspects (A) internal to science; SI-B: social institutional aspects (B) external to science

Table 5.2

Comparison Table: Percentage of the Quality of Representation of each NOS Categories in the American Textbooks

NOS aspect	NOS category	Quality of representation by percentages											
		1				2				3			
		Pearson's *Ecology and the Environment* %	Pearson's *Diversity of Life* %	Houghton Mifflin Harcourt's *Science Fusion* %	McGraw Hill's *Integrated Science* %	Pearson's *Ecology and the Environment* %	Pearson's *Diversity of Life* %	Houghton Mifflin Harcourt's *Science Fusion* %	McGraw Hill's *Integrated Science* %	Pearson's *Ecology and the Environment* %	Pearson's *Diversity of Life* %	Houghton Mifflin Harcourt's *Science Fusion* %	McGraw Hill's *Integrated Science* %
CE	Aims and values	55.6	36.4	0.0	29.6	27.8	36.4	38.1	18.3	16.7	27.3	61.9	52.1
	Practices	64.9	38.5	27.6	60.4	24.5	44.8	44.0	21.7	10.6	16.7	28.4	18.0
	Methods	56.5	14.7	0.0	21.8	26.1	44.1	43.2	33.9	17.4	41.2	56.8	44.4
	Knowledge	40.0	32.4	34.9	48.5	47.9	44.0	32.5	38.7	12.1	23.6	32.5	12.8
SI-A	Scientific ethos	28.6	0.0	0.0	100.0	57.1	0.0	0.0	0.0	14.3	100.0	100.0	0.0
	Social values	34.2	33.3	0.0	17.6	34.2	11.1	14.3	47.1	31.6	55.6	85.7	35.3
	Social certification	56.3	57.1	0.0	22.2	37.5	28.6	0.0	11.1	6.3	14.3	100.0	66.7
	Professional activities	20.0	17.6	6.3	17.5	20.0	11.8	37.5	12.5	60.0	70.6	56.3	70.0
SI-B	Financial systems	43.5	0.0	0.0	0.0	26.1	0.0	0.0	0.0	30.4	100.0	100.0	100.0
	Political power structure	25.0	0.0	0.0	0.0	50.0	0.0	0.0	0.0	25.0	100.0	0.0	0.0
	Social organizations and interactions	45.5	12.5	0.0	8.3	36.4	0.0	0.0	50.0	18.2	87.5	100.0	41.7

CE: cognitive-epistemic aspects of NOS; SI-A: social-institutional aspects (A) internal to science; SI-B: social institutional aspects (B) external to science

Second Research Question

What NOS categories, if any, are addressed in the grade 6 French science textbooks published in France and used in Lebanon, and which ones are not? If present, what is the quality of representation of these categories?

To answer the above question, the three French textbooks' results shall be outlined below. Magnard's *Sciences et Technologie* textbook's results are presented in tables 6.1 and 6.2. Bordas' *Sciences de la Vie et de la Terre* textbook's results are presented in tables 7.1 and 7.2. Hachette's *Sciences et Technologie* textbook's results are presented in tables 8.1 and 8.2. The tables show the frequency and percentage of representation of each category. In addition, the quality of representation is reported.

Following each French textbook's analysis, two comparative tables, tables 9.1 and 9.2, were generated to show the similarities and differences between the French textbooks. Table 9.1 presents the total frequencies of representation of each NOS category per French textbook while table 9.2 presents the total percentage of representation of each NOS category per French textbook. The tables are preceded by a description of the results.

Magnard's Sciences et Technologie Textbook

Table 6.1 presents the frequency of each NOS category along with its quality in Magnard's *Sciences et Technologie* textbook while table 6.2 presents the percentages of the NOS categories and the quality indicators of each category. Tables 6.1 and 6.2 show that the NOS categories emphasized in Magnard's *Sciences et Technologie* textbook were mainly in the cognitive-epistemic aspect of NOS, namely knowledge (217 occurrences, 39.8%), practices (185, 33.9%), methods (101, 18.5%), and aims and values (22, 4.0%).

Tables 6.1 and 6.2 also show that the professional activities category was the highest frequency (12, 2.2%) in the social-institutional aspect (SI- A) followed by social values (5, 0.9%), and no representations for social certification (0, 0.0%) nor scientific ethos (0, 0.0%). The lowest frequencies are in the SI-B category with political power structures being the highest (3, 0.6%), and no representations for financial system (0, 0.0%) nor social organizations and interactions (0, 0.0%).

In addition, tables 6.1 and 6.2 show the quality of each NOS category in Magnard's *Sciences et Technologie* textbook.-For the cognitive-epistemic aspect of NOS, the practices category had the highest frequency of 3 (58 occurrences, 31.4%), followed by knowledge (54, 24.9%), then methods (39, 38.6%), and aims and values category (4, 18.2%). As for the social-institutional aspect – A, the category with the highest frequency of 3 was social values (1 occurrence, 20%). All other categories in SI-A had no representations (0, 0.0% for professional activities, social certification, and scientific ethos). For the last aspect, social-institutional-B, no category had a representation of the highest quality (0 occurrences, 0.0% for financial systems, social organizations and interactions, and political power structures).

Table 6.1

Frequency of each NOS Category in Magnard's Sciences et Technologie Textbook

NOS aspect	NOS category	Total Frequency	Quality of representation by frequency		
			1	2	3
CE	Aims and values	22	0	18	4
	Practices	185	23	104	58
	Methods	101	17	45	39
	Knowledge	217	63	100	54
SI-A	Scientific ethos	0	0	0	0
	Social values	5	2	2	1
	Social certification	0	0	0	0
	Professional activities	12	4	8	0
SI-B	Financial systems	0	0	0	0
	Political power structure	3	2	1	0
	Social organizations and interactions	0	0	0	0

CE: cognitive-epistemic aspects of NOS; SI-A: social-institutional aspects (A) internal to science; SI-B: social institutional aspects (B) external to science

Table 6.2

Percentage of each NOS Category in Magnard's Sciences et Technologie Textbook

NOS aspect	NOS category	Total percentage	Quality of representation by percentage		
			1	2	3
CE	Aims and values	4.0	0.0	81.8	18.2
	Practices	33.9	12.4	56.2	31.4
	Methods	18.5	16.8	44.6	38.6
	Knowledge	39.8	29.0	46.1	24.9
SI-A	Scientific ethos	0.0	0.0	0.0	0.0
	Social values	0.9	40.0	40.0	20.0
	Social certification	0.0	0.0	0.0	0.0
	Professional activities	2.2	33.3	66.7	0.0
SI-B	Financial systems	0.0	0.0	0.0	0.0
	Political power structure	0.6	66.7	33.3	0.0
	Social organizations and interactions	0.0	0.0	0.0	0.0

CE: cognitive-epistemic aspects of NOS; SI-A: social-institutional aspects (A) internal to science; SI-B: social institutional aspects (B) external to science

The results of analyzing Magnard's *Sciences et Technologie* textbook indicate that 4 of the 11 NOS categories were not addressed. The most diverse representation of the qualitative levels was found in the cognitive-epistemic aspect. The tables also indicate a low frequency of representation for the social-institutional aspects A and B in comparison to the cognitive-epistemic aspect. The three NOS categories with the highest occurrences of high-quality representation are practices, methods, and knowledge (58, 39, and 54 occurrences, respectively). The three NOS categories with the highest percentages of representation of the highest quality are also practices, methods, and knowledge (31.4%, 38.6%, and 24.9%, respectively).

Bordas' Sciences de la Vie et de la Terre Textbook

Table 7.1 presents the frequency of each NOS category along with its quality in Bordas' *Sciences de la Vie et de la Terre* textbook while table 7.2 presents the percentages of the NOS categories and the quality indicators of each category. Tables 7.1 and 7.2 show that the NOS categories emphasized in Bordas' *Sciences de la Vie et de la Terre* textbook were mainly in the cognitive-epistemic aspect of NOS, namely knowledge (150 occurrences, 35.8%), practices (146, 34.8%), methods (92, 22.0%), and aims and values (1, 0.2%). Tables 7.1 and 7.2 also show that the social values category was the highest frequency (18, 4.3%) in the social-institutional aspect (SI- A) followed by professional activities (8, 1.9%), social certification (1, 0.2%), and scientific ethos (1, 0.2%). The lowest frequencies are in the SI-B category with social organizations and interactions tied with political power structures (1, 0.2%), and no representations for the financial systems category (0, 0.0%).

In addition, tables 7.1 and 7.2 show the quality of each NOS category in Bordas' *Sciences de la Vie et de la Terre* textbook. For the cognitive-epistemic aspect of NOS, the practices category had the highest frequency of 3 (45 occurrences, 30.8%), followed by methods (35, 38.0%), then knowledge (16, 10.7%), and no representations of high quality for the aims and values category (0, 0.0 %). As for the social-institutional aspect – A, the category with the highest frequency of 3 was social values (2 occurrences, 11.1%), the rest of the categories in this aspect were not represented (0 occurrences, 0.0% for professional activities, scientific ethos, and social certification). For the last aspect, social-institutional-B, the categories with the highest frequency of the utmost quality of representation were political power structures and social organizations and interactions (1, 0.2% for both categories). There were no occurrences for the financial systems category (0, 0.0%).

Table 7.1

Frequency of each NOS Category in Bordas' Sciences de la Vie et de la Terre Textbook

NOS aspect	NOS category	Total Frequency	Quality of representation by frequency		
			1	2	3
CE	Aims and values	1	0	1	0
	Practices	146	7	94	45
	Methods	92	0	57	35
	Knowledge	150	38	96	16
SI-A	Scientific ethos	1	0	1	0
	Social values	18	2	16	0
	Social certification	1	0	1	0
	Professional activities	8	0	8	0
SI-B	Financial systems	0	0	0	0
	Political power structure	1	0	0	1
	Social organizations and interactions	1	0	0	1

CE: cognitive-epistemic aspects of NOS; SI-A: social-institutional aspects (A) internal to science; SI-B: social institutional aspects (B) external to science

Table 7.2

Percentage of each NOS Category in Bordas' Sciences de la Vie et de la Terre Textbook

NOS aspect	NOS category	Total percentage	Quality of representation by percentage		
			1	2	3
CE	Aims and values	0.2	0.0	100.0	0.0
	Practices	34.8	4.8	64.4	30.8
	Methods	22.0	0.0	62.0	38.0
	Knowledge	35.8	25.3	64.0	10.7
SI-A	Scientific ethos	0.2	0.0	100.0	0.0
	Social values	4.3	0.0	88.9	11.1
	Social certification	0.2	0.0	100.0	0.0
	Professional activities	1.9	0.0	100.0	0.0
SI-B	Financial systems	0.0	0.0	0.0	0.0
	Political power structure	0.2	0.0	0.0	100.0
	Social organizations and interactions	0.2	0.0	0.0	100.0

CE: cognitive-epistemic aspects of NOS; SI-A: social-institutional aspects (A) internal to science; SI-B: social institutional aspects (B) external to science

The results of analyzing Bordas' *Sciences de la Vie et de la Terre* textbook indicate that all NOS categories were addressed except for the financial systems category. There was little diversification in the quality of representation, especially at the social-institutional aspects A and B. The tables also indicate a low frequency of representation for the social-institutional aspects A and B in comparison to the cognitive-epistemic aspect. The three NOS categories with the highest occurrences of high-quality representation are practices, methods, and knowledge (45, 35, and 16 occurrences, respectively). The three NOS categories with the highest percentages of representation of the highest quality are political power structure, social organizations and interactions, and methods (100%, 100%, and 38%, respectively).

Hachette's Sciences et Technologie Textbook

Table 8.1 presents the frequency of each NOS category along with its quality in Hachette's *Sciences et Technologie* textbook while table 8.2 presents the percentages of the NOS categories and the quality indicators of each category. Tables 8.1 and 8.2 show that the NOS categories emphasized in Hachette's *Sciences et Technologie* textbook were mainly in the cognitive-epistemic aspect of NOS, namely knowledge (198 occurrences, 34.8%), practices (127, 22.3%), methods (117, 20.6%), and aims and values (29, 5.1%). Tables 8.1 and 8.2 also show that the social values category was the highest frequency (45, 7.9%) in the social-institutional aspect (SI- A) followed by professional activities (28, 4.9%), social certification (7, 1.2%), and scientific ethos (3, 0.5%). The lowest frequencies are in the SI-B category with social organizations and interactions (8 occurrences, 1.4%), followed by political power structures (4, 0.7%) and the financial systems category (3, 0.5%).

In addition, tables 8.1 and 8.2 show the quality of each NOS category in Hachette's *Sciences et Technologie* textbook. For the cognitive-epistemic aspect of NOS, the knowledge category had the highest frequency of 3 (96 occurrences, 48.5%), followed by practices (88, 69.3%), then methods (86, 20.6%), and finally, the aims and values category (21, 5.1 %). As for the social-institutional aspect – A, the category with the highest frequency of 3 was social values (38 occurrences, 84.4%), followed by professional activities (25, 89.3%), social certification (7, 100%), and scientific ethos, (3, 100%). For the last aspect, social-institutional-B, the category with the highest frequency of the utmost quality of representation was social organizations and interactions (7 occurrences, 87.5%),

followed by political power structures (4, 100%), and the financial systems category (3, 100.0%).

Table 8.1

Frequency of each NOS Category in Hachette's Sciences et Technologie Textbook

NOS aspect	NOS category	Total Frequency	Quality of representation by frequency		
			1	2	3
CE	Aims and values	29	1	7	21
	Practices	127	9	30	88
	Methods	117	3	28	86
	Knowledge	198	7	95	96
SI-A	Scientific ethos	3	0	0	3
	Social values	45	3	4	38
	Social certification	7	0	0	7
	Professional activities	28	0	3	25
SI-B	Financial systems	3	0	0	3
	Political power structure	4	0	0	4
	Social organizations and interactions	8	0	1	7

CE: cognitive-epistemic aspects of NOS; SI-A: social-institutional aspects (A) internal to science; SI-B: social institutional aspects (B) external to science

Table 8.2

Percentage of each NOS Category in Hachette's Sciences et Technologie Textbook

NOS aspect	NOS category	Total percentage	Quality of representation by percentage		
			1	2	3
CE	Aims and values	5.1	3.4	24.1	72.4
	Practices	22.3	7.1	23.6	69.3
	Methods	20.6	2.6	23.9	73.5
	Knowledge	34.8	3.5	48.0	48.5
SI-A	Scientific ethos	0.5	0.0	0.0	100.0
	Social values	7.9	6.7	8.9	84.4
	Social certification	1.2	0.0	0.0	100.0
	Professional activities	4.9	0.0	10.7	89.3
SI-B	Financial systems	0.5	0.0	0.0	100.0
	Political power structure	0.7	0.0	0.0	100.0
	Social organizations and interactions	1.4	0.0	12/5	87.5

CE: cognitive-epistemic aspects of NOS; SI-A: social-institutional aspects (A) internal to science; SI-B: social institutional aspects (B) external to science

The results of analyzing Hachette's *Sciences et Technologie* textbook indicate that all NOS categories were addressed. The quality of representation was diverse for the cognitive-epistemic aspects. As for the social-institutional aspects A and B, the quality of representation was mostly at a 3. The tables also indicate a low frequency of representation for the social-institutional aspects A and B in comparison to the cognitive-epistemic aspect. The three NOS categories with the highest occurrences of high-quality representation are practices, methods, and knowledge (88, 86, and 96 occurrences, respectively). The four NOS categories with the highest percentages of representation of the highest quality are the scientific ethos, social certification, financial systems, and the political power structures categories (100%), but their occurrences were low.

Comparison of French Textbooks: Tables 9.1 and 9.2

Table 9.1 presents the frequency of the quality of representation of each NOS category in the French textbooks, while table 9.2 presents the percentages of the quality of representation of each NOS category. The similarities between the French textbooks shall be outlined first followed by the differences among them.

Tables 9.1 and 9.2 show that the cognitive-epistemic aspect of NOS had the most diverse range of quality of representation. In all analyzed French textbooks, the occurrences for a quality of 1 ranged from 0 (Bordas' *Sciences de la Vie et de la Terre* and Magnard's *Sciences et Technologie* for the aims and values category) to 63 (Magnard's *Sciences et Technologie* for the knowledge category) and percentages ranged from 0.0% (Bordas' *Sciences de la Vie et de la Terre* and Magnard's *Sciences et Technologie* for the aims and values category) to 29.0% (Magnard's *Sciences et Technologie* for the aims and values

category). For a quality of 2, the occurrences ranged from 1 (Bordas' *Sciences de la Vie et de la Terre* for the aims and values category) to 104 (Magnard's *Sciences et Technologie* for the practices category) and percentages ranged from 23.6% (Hachette's *Sciences et Technologie* for the practices category) to 100.0% (Bordas' *Sciences de la Vie et de la Terre* for the aims and values category). For a quality of 3, the occurrences ranged from 0 (Bordas' *Sciences de la Vie et de la Terre* for the aims and values category) to 96 (Hachette's *Sciences et Technologie* for the knowledge category) and percentages ranged from 0.0% (Bordas' *Sciences de la Vie et de la Terre* for the aims and values category) to 73.5% (Hachette's *Sciences et Technologie* for the methods category).

The textbook with the most percentages of a quality of 1 in the cognitive-epistemic aspect was Magnard's *Sciences et Technologie*. The textbook with the most percentages of a quality of 2 in the cognitive-epistemic aspect was Bordas' *Sciences de la Vie et de la Terre*. The textbook with the most percentages of a quality of 3 in the cognitive-epistemic aspect was Hachette's *Sciences et Technologie*. All textbooks had a high-quality representation of the cognitive-epistemic aspect categories except for Bordas' *Sciences de la Vie et de la Terre*, which had no high-quality representation for the aims and values category.

As for the social-institutional aspects A and B, all three French textbooks had most of their representations at a quality of 2 or 3. However, the frequency and percentages of the representations are much smaller in the social-institutional aspects in comparison to the cognitive-epistemic aspect. Hachette's *Sciences et Technologie* was the only textbook that had 4 NOS categories represented at the highest quality, 3; the categories being: scientific

ethos, social certification, financial systems, and political power structure (occurrences of 3, 7, 3, and 4, respectively; all 100%). Hachette's *Sciences et Technologie* was also the only textbook with all categories represented at least three times at the highest quality of 3 (no 0% representation at quality 3).

On the other hand, Magnard's *Sciences et Technologie* had the highest number of categories (6) with no representations at the highest quality, 3. In addition, 4 categories of the social-institutional aspects A and B had no representations at all (0 occurrences, 0%), those being the scientific ethos, social certification, financial systems, and social organizations and interactions.

Bordas' *Sciences de la Vie et de la Terre* had one category with no representation: the financial systems category of the social-institutional aspect. However, 4 categories of the social-institutional aspects A and B had no representations of the highest quality, 3 (scientific ethos, social certification, professional activities, and financial systems). The occurrences of the political power structure (1 occurrence) and social organizations and interactions (1 occurrence) categories were represented at the highest quality, 3. The scientific ethos (1 occurrence), social certification (1 occurrence), and professional activities (8 occurrences) categories were all represented at a quality of 2.

Table 9.1

Quality *of Representation of each NOS Categories in the French Textbooks*

Comparison Table: Frequency of the of the Qu

NOS aspect	NOS category	Quality of representation by frequency								
		1			2			3		
		Magnard's *Sciences et Technologie*	Bordas' *Sciences de la Vie et de la Terre*	Hachette's *Sciences et Technologie*	Magnard's *Sciences et Technologie*	Bordas' *Sciences de la Vie et de la Terre*	Hachette's *Sciences et Technologie*	Magnard's *Sciences et Technologie*	Bordas' *Sciences de la Vie et de la Terre*	Hachette's *Sciences et Technologie*
CE	Aims and values	0	0	1	18	1	7	4	0	21
	Practices	23	7	9	104	94	30	58	45	88
	Methods	17	0	3	45	57	28	39	35	86
	Knowledge	63	38	7	100	96	95	54	16	96
SI-A	Scientific ethos	0	0	0	0	1	0	0	0	3
	Social values	2	2	3	2	16	4	1	0	38
	Social certification	0	0	0	0	1	0	0	0	7
	Professional activities	4	0	0	8	8	3	0	0	25
SI-B	Financial systems	0	0	0	0	0	0	0	0	3
	Political power structure	2	0	0	1	0	0	0	1	4
	Social organizations and interactions	0	0	0	0	0	1	0	1	7

CE: cognitive-epistemic aspects of NOS; SI-A: social-institutional aspects (A) internal to science; SI-B: social institutional aspects (B) external to science

Table 9.2

Comparison Table: Percentage of the of the Quality of Representation of each NOS Categories in the French Textbooks

NOS aspect	NOS category	Quality of representation by percentages								
		1			2			3		
		Magnard's *Sciences et Technologie* %	Bordas' *Sciences de la Vie et de la Terre* %	Hachette's *Sciences et Technologie* %	Magnard's *Sciences et Technologie* %	Bordas' *Sciences de la Vie et de la Terre* %	Hachette's *Sciences et Technologie* %	Magnard's *Sciences et Technologie* %	Bordas' *Sciences de la Vie et de la Terre* %	Hachette's *Sciences et Technologie* %
CE	Aims and values	0.0	0.0	3.4	81.8	100.0	24.1	18.2	0.0	72.4
	Practices	12.4	4.8	7.1	56.2	64.4	23.6	31.4	30.8	69.3
	Methods	16.8	0.0	2.6	44.6	62.0	23.9	38.6	38.0	73.5
	Knowledge	29.0	25.3	3.5	46.1	64.0	48.0	24.9	10.7	48.5
SI-A	Scientific ethos	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	100.0
	Social values	40.0	0.0	6.7	40.0	88.9	8.9	20.0	11.1	84.4
	Social certification	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	100.0
	Professional activities	33.3	0.0	0.0	66.7	100.0	10.7	0.0	0.0	89.3
SI-B	Financial systems	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
	Political power structure	66.7	0.0	0.0	33.3	0.0	0.0	0.0	100.0	100.0
	Social organizations and interactions	0.0	0.0	0.0	0.0	0.0	12.5	0.0	100.0	87.5

CE: cognitive-epistemic aspects of NOS; SI-A: social-institutional aspects (A) internal to science; SI-B: social institutional aspects (B) external to science

Third Research Question

What NOS categories, if any, are addressed in the grade 6 Lebanese science textbook published by CERD, and which ones are not? If present, what is the quality of representation of these categories?

To answer the above question, the results of the Lebanese textbook shall be outlined below. CERD's *Sciences pour la Vie* textbook's results are presented in tables 10.1 and 10.2. Given all of the textbook's analysis, and the comparison tables for the American and French textbooks, two comparative tables, tables 11.1 and 11.2, were generated to show the similarities and differences between the American, French and Lebanese textbooks. Table 11.1 presents the total frequencies of representation of each NOS category per textbook. Table 11.2 presents the total percentage of representation of each NOS category per textbook. The tables are preceded by a description of the results.

CERD's Sciences pour la Vie Textbook

Table 10.1 presents the frequency of each NOS category along with its quality in CERD's *Sciences pour la Vie* textbook while table 10.2 presents the percentages of the NOS categories and the quality indicators of each category. Tables 10.1 and 10.2 show that the NOS categories emphasized in CERD's *Sciences pour la Vie* textbook were mainly in the cognitive-epistemic aspect of NOS, namely knowledge (161 occurrences, 47.5%), practices (107, 31.6%), methods (55, 16.2%), and aims and values (0, 0.0%). Tables 10.1 and 10.2 also show that the social values category was the highest frequency (11, 3.2%) in the social-institutional aspect (SI- A) followed by professional activities (2, 0.6%), scientific ethos (1, 0.3%), and social certification (0, 0.0%). The lowest frequencies are in

the SI-B category with political power structures (2, 0.6%), while social organizations and interactions and financial systems was the same as with and no representations (0, 0.0%).

In addition, tables 10.1 and 10.2 show the quality of each NOS category in CERD's *Sciences pour la Vie* textbook. For the cognitive-epistemic aspect of NOS, the practices category had the highest frequency of 3 (32 occurrences, 29.9%), followed by methods (26, 47.3%), then knowledge (23, 14.3%), and no representations of high quality for the aims and values category (0, 0.0 %). As for the social-institutional aspect – A, the category with the highest frequency of 3 was social values (11 occurrences, 100.0%), followed by professional activities (2, 100.0%), then scientific ethos (1, 100.0%), and no representation for social certification (0, 0.0%). For the last aspect, social-institutional-B, the categories with the highest frequency of the utmost quality of representation were political power structures (1, 50.0%). There were no occurrences for the financial systems nor and the social organizations and interactions categories (0, 0.0%)

Table 10.1

Frequency of each NOS Category in CERD's Sciences pour la Vie Textbook

NOS aspect	NOS category	Total Frequency	Quality of representation by frequency		
			1	2	3
CE	Aims and values	0	0	0	0
	Practices	107	10	65	32
	Methods	55	5	24	26
	Knowledge	161	57	81	23
SI-A	Scientific ethos	1	0	0	1
	Social values	11	0	0	11
	Social certification	0	0	0	0
	Professional activities	2	0	0	2
SI-B	Financial systems	0	0	0	0
	Political power structure	2	0	1	1
	Social organizations and interactions	0	0	0	0

CE: cognitive-epistemic aspects of NOS; SI-A: social-institutional aspects (A) internal to science; SI-B: social institutional aspects (B) external to science

Table 10.2

Percentage of each NOS Category in CERD's Sciences pour la Vie Textbook

NOS aspect	NOS category	Total percentage	Quality of representation by percentage		
			1	2	3
CE	Aims and values	0.0	0.0	0.0	0.0
	Practices	31.6	9.3	60.7	29.9
	Methods	16.2	9.1	43.6	47.3
	Knowledge	47.5	35.4	50.3	14.3
SI-A	Scientific ethos	0.3	0.0	0.0	100.0
	Social values	3.2	0.0	0.0	100.0
	Social certification	0.0	0.0	0.0	0.0
	Professional activities	0.6	0.0	0.0	100.0
SI-B	Financial systems	0.0	0.0	0.0	0.0
	Political power structure	0.6	0.0	50.0	50.0
	Social organizations and interactions	0.0	0.0	0.0	0.0

CE: cognitive-epistemic aspects of NOS; SI-A: social-institutional aspects (A) internal to science; SI-B: social institutional aspects (B) external to science

The results of analyzing CERD's *Sciences pour la Vie* textbook indicate that 4 of the 11 NOS categories were not addressed. The quality of representation was diverse for the cognitive-epistemic aspects, except for the aims and values category, which was not represented. As for the social-institutional aspects A and B, the quality of representation was mostly at a 3. The tables also indicate a low frequency of representation for the social-institutional aspects A and B in comparison to the cognitive-epistemic aspect. The three NOS categories with the highest occurrences of high-quality representation are practices, methods, and knowledge (32, 26, and 23 occurrences, respectively). The three NOS categories with the highest percentages of representation of the highest quality are the scientific ethos, social values, and financial systems categories (100%), but their occurrences were low.

Fourth and Fifth Research Questions

- What are the differences, if any, between the representation of NOS in American, French, and Lebanese 6th-grade science textbooks?
- What are the similarities, if any, between the representation of NOS in American, French, and Lebanese 6th-grade science textbooks?

Given all the presented findings for the American, French, and Lebanese textbooks used in Lebanon, the differences and similarities between the analyzed textbooks shall be outlined in the section below.

Comparison of American, French, and Lebanese Textbooks: Tables 11.1, 11.2, 12.1, and 12.2

Table 11.1 presents the frequency of each NOS category in all the analyzed textbooks, while table 11.2 presents the percentages of the NOS categories. Table 12.1 presents the frequency of each high-quality representation of the NOS categories in all the analyzed textbooks, while table 12.2 shows the percentages of the high-quality representations. The similarities and differences between American, French, and Lebanese textbooks as it relates to the representation of NOS categories shall be outlined first. Next, the similarities and differences between the quality of the representation of NOS categories will be highlighted.

Apart from Houghton Mifflin Harcourt's *Science Fusion* textbook, tables 11.1 and 11.2 show that the most represented NOS category in all of the textbooks was in the knowledge category of the cognitive-epistemic aspect of NOS, with occurrences ranging from 150 (Bordas' *Sciences de la Vie et de la Terre*) to 802 (McGraw Hill's *Integrated*

Science) and percentages ranging from 32.9% (Pearson's *Ecology and the Environment*) to 47.5% (CERD's *Sciences pour la Vie*).

The second most represented NOS category in all textbooks (except for Houghton Mifflin Harcourt's *Science Fusion* textbook) was "practices", with occurrences ranging from 107 (CERD'S *Sciences pour la Vie*) to 729 (McGraw Hill's *Integrated Science*) and percentages ranging from 22.3% (Hachette's *Sciences et Technologie*) to 42.2 % (the highest percentage for a category in Houghton Mifflin Harcourt's *Science Fusion* textbook).

The third similarity between all textbooks analyzed is that the aims and values category was the lowest in percentage and occurrences for the cognitive-epistemic aspect. The occurrences in the aims and values category ranged from 0 (CERD'S *Sciences pour la Vie*) to 142 (McGraw Hill's *Integrated Science*) and percentages ranged from 0.0% (CERD'S *Sciences pour la Vie*) to 7.1% (McGraw Hill's *Integrated Science*).

The fourth similarity between all textbooks was that for the social-institutional aspects A and B, the highest occurrences and percentages were found in the social values and professional activities categories. The social values' occurrences ranged from 45 (Hachette's *Sciences et Technologie*) to 5 (Magnard's *Sciences et Technologie*). The percentages of the social values categories ranged from 0.9% (McGraw Hill's *Integrated Science*) to 7.9% (Hachette's *Sciences et Technologie*). As for professional activities occurrences, the range was from 2 (CERD's *Sciences pour la Vie*) to 40 (McGraw Hill's *Integrated Science*). While the percentages of the professional activities, ranged from 0.6% (CERD's *Sciences pour la Vie*) to 4.9% (Hachette's *Sciences et Technologie*).

There were several similarities between the American and French textbooks. First, all the categories in the cognitive-epistemic aspect were represented in the American and French textbooks. On the other hand, the Lebanese textbook, CERD's *Sciences pour la Vie*, was the only one with no representation for the aims and values category.

In addition, most of the American and French textbooks (except for Magnard's *Sciences et Technologie*) had at least two of the three categories of the social institutional-B aspect represented, with a focus on the social organizations and interactions category overall. However, CERD's *Sciences pour la Vie* textbook and Magnard's *Sciences et Technologie* textbooks had no representation in two of three categories of the social institutional – B aspect. CERD's *Sciences pour la Vie* and Magnard's *Sciences et Technologies* had no representation of the financial systems and social organizations and interactions categories (0 occurrences, 0% for both textbooks).

Another similarity between the Lebanese textbook and Magnard's *Sciences et Technologie* was that both textbooks had the most categories with no representations overall. Magnard's *Sciences et Technologie* had no representation for the following categories: scientific ethos, social certification, financial systems, and social organizations and interactions. CERD's Sciences pour la Vie had no representations for the following categories: aims and values, social certification, financial systems, and social organizations and interactions.

The American textbooks were different from all other textbooks in their lack of representation of the political power structure category, except for Pearson's *Ecology and*

the Environment module, which had the highest representation out of all textbooks (16 occurrences, 3.2%).

The French textbooks were different from all other textbooks in their lack of representation of the financial systems category. Magnard's *Sciences et Technologie* and Bordas' *Sciences de la Vie et de la Terre* had no representations of the category (0 occurrences, 0% for both textbooks). Hachette's *Sciences et Technologie* had a small representation of the financial systems category (3 occurrences, 0.5%).

The final difference was noted in the Lebanese textbook. CERD's *Sciences pour la Vie* was different from all other textbooks in that it had the highest representation of the knowledge category (161 occurrences, 47.5%). The American and French textbooks' representation of the same category ranged from 150 occurrences (Bordas' *Sciences de la Vie et de la Terre*) to 802 (McGraw Hill's *Integrated Science*). In percentages, the American and French textbooks' representation of the knowledge category ranged from 32.9% (Pearson's *Ecology and the Environment*) to 44.6% (Pearson's *Diversity of Life*).

Table 11.1

Comparison Table: Frequency of each NOS Category per Textbook

NOS aspect	NOS category	Representation by frequency							
		Pearson's *Ecology and the environment*	Pearson's *Diversity of life*	Houghton Mifflin Harcourt's *Science Fusion*	McGraw Hill's *Integrated Science*	Magnard's *Sciences et Technologie*	Bordas' *Sciences de la Vie et de la Terre*	Hachette's *Sciences et Technologie*	CERD's *Sciences pour la Vie*
CE	Aims and values	18	33	21	142	22	1	29	0
	Practices	151	299	257	729	185	146	127	107
	Methods	46	34	44	239	101	92	117	55
	Knowledge	165	339	212	802	217	150	198	161
SI-A	Scientific ethos	7	2	1	2	0	1	3	1
	Social values	38	18	7	17	5	18	45	11
	Social certification	16	7	1	9	0	1	7	0
	Professional activities	10	17	16	40	12	8	28	2
SI-B	Financial systems	23	2	1	5	0	0	3	0
	Political power structure	16	1	0	0	3	1	4	2
	Social organizations and interactions	11	8	8	12	0	1	8	0

CE: cognitive-epistemic aspects of NOS; SI-A: social-institutional aspects (A) internal to science; SI-B: social institutional aspects (B) external to science

Table 11.2

Comparison Table: Percentage of each NOS Category per Textbook

NOS aspect	NOS category	Representation by percentages							
		Pearson's *Ecology and the environment, %*	Pearson's *Diversity of life, %*	Houghton Mifflin Harcourt's *Science Fusion %*	McGraw Hill's *Integrated Science %*	Magnard's *Sciences et Technologie %*	Bordas' *Sciences de la Vie et de la Terre %*	Hachette's *Sciences et Technologie %*	CERD's *Sciences pour la Vie %*
CE	Aims and values	3.6	4.3	3.7	7.1	4.0	0.2	5.1	0.0
	Practices	30.1	39.3	42.2	36.5	33.9	34.8	22.3	31.6
	Methods	9.2	4.5	7.7	12.0	18.5	22.0	20.6	16.2
	Knowledge	32.9	44.6	37.3	40.2	39.8	35.8	34.8	47.5
SI-A	Scientific ethos	1.4	0.3	0.2	0.1	0.0	0.2	0.5	0.3
	Social values	7.6	2.4	1.2	0.9	0.9	4.3	7.9	3.2
	Social certification	3.2	0.9	0.2	0.5	0.0	0.2	1.2	0.0
	Professional activities	2.0	2.2	2.8	2.0	2.2	1.9	4.9	0.6
SI-B	Financial systems	4.6	0.3	0.2	0.3	0.0	0.0	0.5	0.0
	Political power structure	3.2	0.1	0.0	0.0	0.6	0.2	0.7	0.6
	Social organizations and interactions	2.2	1.1	1.4	0.6	0.0	0.2	1.4	0.0

CE: cognitive-epistemic aspects of NOS; SI-A: social-institutional aspects (A) internal to science; SI-B: social institutional aspects (B) external to science

Tables 12.1 and 12.2 show that the most represented NOS aspect in high quality for all analyzed textbooks was in the cognitive-epistemic aspect of NOS, with occurrences ranging from 0 (Bordas' *Sciences de la Vie et de la Terre* and CERD's *Sciences pour la Vie*) to 131 (McGraw Hill's *Integrated Science*) and percentages ranging from 0.0% (Bordas' *Sciences de la Vie et de la Terre* and CERD's *Sciences pour la Vie*) to 73.5% (Hachette's *Sciences et Technologie*). In all textbooks, the lowest represented aspect in high quality was the social-institutional one.

The most represented NOS category in high quality for all textbooks (except for Pearson's *Ecology and the Environment* and *Diversity of Life* modules and Hachette's *Sciences et Technologie* textbook) was "practices", with occurrences ranging from 16 (Pearson's *Ecology and the Environment*) to 131 (McGraw Hill's *Integrated Science*). The third similarity between all textbooks analyzed is that the highest percentage of NOS category representation of high quality was the methods category (except for Houghton Mifflin Harcourt's *Science Fusion* textbook and McGraw Hill's *Integrated Science* textbook). The percentages in the methods category ranged from 17.4% (Pearson's *Ecology and the Environment*) to 73.5% (Hachette's *Sciences et Technologie*).

The fourth similarity between all textbooks was that for the cognitive-epistemic aspect, the lowest occurrences in high quality representation were found in the aims and values category. The aims and values frequencies ranged from 0 (Bordas' *Sciences de la Vie et de la Terre* and CERD's *Sciences pour la Vie*) to 74 occurrences (McGraw Hill's *Integrated Science*).

There were a couple of similarities between the American and French textbooks. First, Hachette's *Sciences et Technologie* and Houghton Mifflin Harcourt's *Science Fusion*

textbooks had the most categories with 100% high quality representations. For Hachette's *Sciences et Technologie*'s textbook, those categories were scientific ethos, social certification, financial systems, and political power structure. For Houghton Mifflin Harcourt's *Science Fusion* textbook, those categories were scientific ethos, social certification, financial systems, and social organizations and interactions.

Furthermore, the Pearson modules, *Ecology and the Environment* and *Diversity of Life* share a similarity with Hachette's *Sciences et Technologie*'s textbook. The textbooks are the only ones with all NOS categories of the social-institutional aspects A and B represented in high-quality. All other textbooks have a few categories that are not represented at all.

The last similarity between the American and French textbooks was that the lowest percentages in high quality representation for the cognitive-epistemic aspects occurred in Pearson's *Ecology and the Environment* textbook and Bordas' *Sciences de la Vie et de la Terre.*

There was one similarity between the French Bordas' *Sciences de la Vie et de la Terre* textbook and the Lebanese CERD's *Sciences pour la Vie*, in that there were no representations for the aims and values category of the cognitive-epistemic aspect of NOS. There were no similarities between the Lebanese and American textbooks as it relates to high quality representation of NOS categories.

There are couple of data points that distinguish the American textbooks from the others. First, McGraw Hill's *Integrated Science* had the highest frequency for practices, with 131 occurrences. This could be due to the large number of pages in the textbook. Second, the American textbooks are the ones with the least unrepresented NOS categories

of the social-institutional aspects in high quality. Indeed, Houghton Mifflin Harcourt's *Science Fusion* had one category with no high-quality representation, the political power structure category. In addition, McGraw Hill's *Integrated Science h*ad two categories with no high-quality representation, the scientific ethos and political power structure categories. Except for Hachette's *Sciences et Technologie* textbook, all other French and Lebanese textbooks had at least 3 NOS categories of the social-institutional aspects unrepresented in high-quality.

As for the French textbooks, Hachette's *Sciences et Technologie* textbook is unique from all other textbooks. First, the highest frequency for most NOS categories in high-quality for the social-institutional -A aspects are found in Hachette's *Sciences et Technologies*, with the highest frequency for the social values category (38 occurrences). Second, for the cognitive-epistemic aspects, the highest percentages of high-quality representation are also found in Hachette's *Sciences et Technologies*, with 73.5% for the methods category, and 69.3% for the NOS category of practices.

On the other hand, Magnard's *Sciences et Technologie* does not parallel with Hachette's high-quality representation. Indeed, there are 6 NOS categories that were unrepresented in high-quality for the social-institutional aspect, which is the most unrepresented categories in all analyzed textbooks. The second textbook with the most unrepresented NOS categories in high-quality is Bordas' *Sciences de la Vie et de la Terre* (4 unrepresented high-quality NOS categories in the social-institutional aspects), the third being CERD's *Science pour la Vie* (3 unrepresented high-quality NOS categories in the social-institutional aspects).

Table 12.1

Comparison Table: Frequency of each NOS Category per Textbook for a Quality of 3

NOS aspect	NOS category	Representation of high quality by frequency							
		Pearson's *Ecology and the environment*	Pearson's *Diversity of life*	Houghton Mifflin Harcourt's *Science Fusion*	McGraw Hill's *Integrated Science*	Magnard's *Sciences et Technologie*	Bordas' *Sciences de la Vie et de la Terre*	Hachette's *Sciences et Technologie*	CERD's *Sciences pour la Vie*
CE	Aims and values	3	9	13	74	4	0	21	0
	Practices	16	50	73	131	58	45	88	32
	Methods	8	14	25	106	39	35	86	26
	Knowledge	20	80	69	103	54	16	96	23
SI-A	Scientific ethos	1	2	1	0	0	0	3	1
	Social values	12	10	6	6	1	0	38	11
	Social certification	2	1	1	6	0	0	7	0
	Professional activities	6	12	9	28	0	0	25	2
SI-B	Financial systems	7	2	1	5	0	0	3	0
	Political power structure	4	1	0	0	0	1	4	1
	Social organizations and interactions	2	7	8	5	0	1	7	0

CE: cognitive-epistemic aspects of NOS; SI-A: social-institutional aspects (A) internal to science; SI-B: social institutional aspects (B) external to science

Table 12.2

Comparison Table: Percentage of each NOS Category per Textbook for a Quality of 3

NOS aspect	NOS category	Representation of high quality by percentages							
		Pearson's Ecology and the environment, %	Pearson's Diversity of life, %	Houghton Mifflin Harcourt's Science Fusion %	McGraw Hill's Integrated Science %	Magnard's Sciences et Technologie %	Bordas' Sciences de la Vie et de la Terre %	Hachette's Sciences et Technologie %	CERD's Sciences pour la Vie %
CE	Aims and values	16.7	27.3	61.9	52.1	18.2	0.0	72.4	0.0
	Practices	10.6	16.7	28.4	18.0	31.4	30.8	69.3	29.9
	Methods	17.4	41.2	56.8	44.4	38.6	38.0	73.5	47.3
	Knowledge	12.1	23.6	32.5	12.8	24.9	10.7	48.5	14.3
SI-A	Scientific ethos	14.3	100.0	100.0	0.0	0.0	0.0	100.0	100.0
	Social values	31.6	55.6	85.7	35.3	20.0	11.1	84.4	100.0
	Social certification	6.3	14.3	100.0	66.7	0.0	0.0	100.0	0.0
	Professional activities	60.0	70.6	56.3	70.0	0.0	0.0	89.3	100.0
SI-B	Financial systems	30.4	100.0	100.0	100.0	0.0	0.0	100.0	0.0
	Political power structure	25.0	100.0	0.0	0.0	0.0	100.0	100.0	50.0
	Social organizations and interactions	18.2	87.5	100.0	41.7	0.0	100.0	87.5	0.0

CE: cognitive-epistemic aspects of NOS; SI-A: social-institutional aspects (A) internal to science; SI-B: social institutional aspects (B) external to science

CHAPTER 5

CONCLUSION AND DISCUSSION

Textbooks are heavily relied upon as a main resource for teaching. The Nature of Science (NOS), now part of many newly developed curricula, is considered essential for students to achieve scientific literacy. To ensure the goal that curricula have for scientific literacy, textbooks now address NOS. A new framework, the Family Resemblance Approach (FRA), has been developed by Erduran and Dagher (2014) to give a holistic overview of NOS. The framework assumes that there are series of features that are shared by the sciences; however, there is no one characteristic that must be found in all types of sciences. The FRA framework consists of three aspects of NOS: the cognitive-epistemic aspect, and the social-institutional aspects A and B. Under the cognitive-epistemic aspect, there are four NOS categories, which are: scientific aims and values, scientific practices, scientific methods, and scientific knowledge. Under the social-institutional- A aspect, there are four NOS categories, which are: scientific ethos, social values, social certification, and professional activities. Under the social-institutional- B aspect, there are three NOS categories, which are: financial systems, political power structure, and social organizations and interactions. The FRA framework was used in this study to analyze the representation of NOS in French, American, and Lebanese textbooks used in Lebanese schools. Specifically, the study concentrated on the following research questions:

1. What NOS categories, if any, are addressed in the grade 6 American science textbooks published in the United States and used in Lebanon, and which ones are not? If present, what is the quality of representation of these categories?

2. What NOS categories, if any, are addressed in the grade 6 French science textbooks published in France and used in Lebanon, and which ones are not? If present, what is the quality of representation of these categories?

3. What NOS categories, if any, are addressed in the grade 6 Lebanese science textbook published by CERD, and which ones are not? If present, what is the quality of representation of these categories?

4. What are the differences, if any, between the representation of NOS in American, French, and Lebanese 6th-grade science textbooks?

5. What are the similarities, if any, between the representation of NOS in American, French, and Lebanese 6th-grade science textbooks?

The analyzed textbooks were the following: *Ecology and the environment* and *Diversity of life* modules published by Pearson, *Science Fusion* published by Houghton Mifflin Harcourt, *Integrated Science* by McGraw Hill, *Sciences et Technologie* by Magnard, *Sciences de la Vie et de la Terre* by Bordas, *Sciences et Technologie* by Hachette, and *Sciences pour la Vie* by CERD.

The purpose of this study was therefore to analyze grade 6 science textbooks that are available on the Lebanese market, compare them to each other in terms of representation of NOS, and evaluate the quality of representations. The chapter is organized as follows: the first part presents a summary of the research findings. The summary is followed by a discussion of the results in light of previous research on the same topic. Four assertions related to the similarities and differences between all analyzed textbooks are presented. Next, implications for science education research concerning Vygotskian theory are discussed. Moreover, implications for the choice of

textbooks in Lebanese schools are considered. Third, recommendations for further research are outlined.

Summary of Findings

This study answered five research questions related to the representation of NOS in textbooks used in Lebanon. First, it was found that in American textbooks, all NOS categories were represented, except for the political power structure category, which had no representation in Houghton Mifflin Harcourt's *Science Fusion* and McGraw Hill's *Integrated Science* textbooks. The categories under the social-institutional aspects were the ones with the highest frequencies of high-quality representation. This could be due to the low number of occurrences of representations in these categories. Second, it was found that in French textbooks, Magnard's *Sciences et Technologie* had four NOS categories unrepresented, Bordas' *Sciences de la Vie et de la Terre* had one category unrepresented, while Hachette's *Sciences et Technologie* had all categories represented. Hachette's *Sciences et Technologie* stood out amongst all textbooks as it had the most high-quality representations. Third, CERD'S *Sciences pour la Vie* had four unrepresented categories, which were: aims and values, social certification, financial systems, and social organizations and interactions. The knowledge category was the most represented but had the lowest percentage of high-quality representation amongst all represented categories. Finally, the answers to the fourth and fifth research questions show that while American textbooks had the highest number of occurrences for representation, the French textbook by Hachette, *Sciences et Technologie*, had the most categories with the highest percentages for high-quality representation. The Lebanese textbook had the highest occurrences for the knowledge category amongst all textbooks,

but it was rarely represented in high-quality. Bordas' Sciences de la Vie et de la Terre had the most unrepresented NOS categories both in occurrences and percentages.

By answering these research questions, five assertions are made, which are listed below:

1. The most represented aspect of NOS in American, French, and Lebanese grade 6 textbooks is the cognitive-epistemic aspect.
2. Within the cognitive-epistemic aspect, the knowledge category has the highest number of occurrences and percentage amongst all textbooks except for Houghton Mifflin Harcourt's *Science Fusion*, in which the practices category is the highest in occurrences and percentage.
3. Amongst all textbooks, the social-institutional aspects A (scientific ethos, social values, social certification, professional activities) and B (financial systems, political power structure, social organizations, and interactions) are the least represented.
4. The quality of representation of the social-institutional aspects A (inner to science) and B (outer to science) is high.
5. The Lebanese textbook has four unrepresented categories: aims and values, social certification, financial systems, and social organizations and interactions.

Discussion of Findings

First, the most represented aspect of NOS in American, French, and Lebanese grade 6 textbooks is the cognitive-epistemic aspect. Out of all the cognitive-epistemic categories, the knowledge category has the highest percentage of representation (47.5%) in CERD's *Sciences pour la Vie*. However, only 14.3% of the representations for the

knowledge category for CERD's *Sciences pour la Vie* were of high-quality representation. This finding is similar to previous research that found a focus on scientific knowledge in textbooks (Aljaber, 2016), but some attention is still given to NOS (El-Mehtar and Alameh, 2017).

Indeed, even though the cognitive-epistemic aspect is the most prominent in all textbooks, the representation of its categories is not always of high quality. Indeed, the average percentage of high-quality representation in the cognitive-epistemic categories is about 32%. Hachette's *Sciences et Technologie* has the highest percentage of high-quality representation for all cognitive-epistemic categories amongst all textbooks. Pearson's *Ecology and the Environment* and Bordas' *Sciences de la Vie et de la Terre* have the lowest percentages of high-quality representation. Similar findings have also been reported in the past, and coonsequenttly, explicit statements regarding the cognitive-epistemic aspect were recommended to be included in textbooks (Fuselier et al., 2016; Kampourakis, 2017; McDonald, 2017).

This first assertion is important to the study's aims as it shows the main difference between American, French, and Lebanese textbooks. The American textbooks tend to have many pages, while the French and Lebanese textbooks are usually smaller in size. The large American textbooks consequently increase the probability of having more representations of NOS categories, such as in the McGraw Hill textbook, which results in higher reported occurrences. In fact, McGraw Hill's *Integrated Science*, which is made up of 521 pages, has 6 out of 11 NOS categories with the highest occurrences amongst all textbooks. However, more high-quality representations are found in the French textbook, Hachette's *Sciences et Technologie,* with 8 out of 11 categories with the highest percentages of high-quality representation.

As for the Lebanese textbook, even though it is similar to the French ones in size, it does not have the same high-quality representation. Specifically, 4 out of 11 NOS categories have no high-quality representations at all in the Lebanese grade 6 textbook published by CERD.

Second, within the cognitive-epistemic aspect, the knowledge category has the highest number of occurrences and percentage amongst all textbooks except for Houghton Mifflin Harcourt's *Science Fusion*, where the practices category is the highest in occurrences and percentage. Nevertheless, the greatest percentage of high-quality representation in the cognitive-epistemic aspect is for the aims and values category in American textbooks (except for Pearson's *Ecology and the Environment* module, where it was methods) and the methods category for the French and Lebanese textbooks, respectively. In addition, five out of the seven textbooks have the greatest frequency of high-quality representation in the "practices" category (Pearson's modules and Hachette's *Sciences et Technologie* textbook have their greatest occurrences of high-quality representation in the "knowledge" category). This further shows that the quantity of representation does not always align with the quality of representation.

The second assertion is crucial to this study as it highlights similarities amongst all grade 6 science textbooks. First, all textbooks emphasize the representation of the knowledge category, regardless of the quality of representation. In addition, the frequent occurrences of high-quality representation of the "practices" category in 5 out of the 7 textbooks show another similarity across all textbooks.

Third, amongst all textbooks, the social-institutional aspects A (inner to science) and B (outer to science) are the least represented, with an average of 1.3% representation amongst all textbooks, in comparison to an average of 22.57%

representation for the cognitive-epistemic aspect. This finding has been repeatedly reported by past researchers (Abd-El-Khalick et al., 2017; Aljaber 2016; BouJaoude et al., 2017; Ramnarain and Chanetsa, 2016). The most unrepresented category in the social-institutional aspects A and B is the financial systems categories, with no representations in Magnard's *Sciences et Technologie*, Bordas' *Sciences de la Vie et de la Terre*, and CERD's *Sciences pour la Vie*. The category under the social-institutional aspects that is represented in all textbooks was the social values category. This assertion is relevant to the aim and purpose of this study as it outlines a similarity amongst all textbooks: a negligible representation of the categories in the social-institutional aspects A (scientific ethos, social values, social certification, and professional activities) and B (financial systems, political power structure, social organizations, and interactions). Amongst all textbooks, the least represented category is the financial systems category.

The fourth assertion that can be made is concerning the quality of representation of the social-institutional aspects A (inner to science) and B (outer to science). The average percentage of high-quality representation in all analyzed textbooks is about 50% for the social-institutional aspects A and B, while it is approximately 32% for the cognitive-epistemic aspects. This finding is akin to what El-Mehtar and Alameh's (2017) found. Specifically, that there are some representations of NOS in textbooks, however, these representations are of mixed quality.

One reason for this difference could be the tendency to represent the social-institutional aspect as a separate section, following or preceding lessons in all analyzed textbooks. When presented separately, the categories are given as part of a historical, social, or political context. This allows for the NOS categories to be shown explicitly and contextually. For example, the Pearson textbook starts the lessons with a section

named “My Planet Diary”, where NOS aspects are often addressed by either referring to the historical background of the lesson or current social, economic, or political issues. Similar trends are noted in the other textbooks, such as Hachette’s *Sciences et Technologie* ending each chapter with a section labeled “*Lire des Sciences*”, which addresses NOS aspects explicitly in their social, cultural, or historical backgrounds.

Nevertheless, it is important to note that for a grade 6 level, the presence of explicit and contextual references to the social-institutional categories is impressive. The only textbook that is an exception is Magnard’s *Sciences et Technologie*, as it has the least represented categories in the social-institutional aspects (4 categories were not represented at all). This final assertion is imperative to show that there are more similarities amongst all textbooks rather than differences. Indeed, most textbooks represent the social-institutional categories in high quality.

The last assertion concerns the Lebanese textbook, where four categories had no representations, which are: aims and values, social certification, financial systems, and social organizations and interactions. Most unrepresented categories are under the social-institutional aspects. Out of the represented categories, five were represented in high-quality, which are: methods, scientific ethos, social values, professional activities, and political power structure. The category with the most representation in CERD’s *Sciences pour la Vie* is the knowledge category (47.5%), however; its high-quality representation is low, at 14.3%. These results are similar to BouJaoude et al.’s research (2017), where the grade 9 Lebanese science textbooks were found that the “NOS concepts [were not addressed] systematically or adequately to support students’ development of scientific literaty in its broader sense” (p.94).

Comparing the results of this research to the two previous studies that used the same framework, we can find more similarities than differences in the reports. Overall, there is a lack of representation of the social dimension of NOS, and a poor quality of representation of the aspects. Using the Expanded Family Resemblance Approach to NOS, McDonald (2017) found that grade 10 biology textbooks do not represent NOS categories as explicitly as they could. This research also shows that the occurrences of high-quality representations of NOS are low. Using the same framework, BouJaoude, Dagher, and Refai (2017) found that grade 9 Lebanese textbooks published by CERD had low representations of NOS. This study has similar findings for the grade 6 Lebanese science textbook. The results are also similar to Herbali's (2000) findings, whose research showed that Lebanese textbooks focus on knowledge in science, but deemphasize the relationship between science, technology, and society.

Finally, using the consensus view framework, Abd-El-Khalick et. al. (2008) also showed that NOS aspects are underrepresented in American textbooks published in the last 40 years. In addition, Abd-El-Khalick et. al. (2008) found that the portrayal of the NOS categories represented was mostly implicit, which is also a finding of this current study. Furthermore, Ramnarain and Chanetsa (2016) used the same framework as Abd-El-Khalick et al. (2008) and found that the social dimension of NOS was seldom addressed in South African textbooks, which is also a result of this research.

This research adds knowledge to the science education field by analyzing French textbooks for their representation of NOS, which have not been analyzed before. Even though the study found some differences among the French, American, and Lebanese textbooks, we cannot generalize these findings to represent all textbooks published in

France, the United States, and Lebanon. This is mainly due to the small sample size of textbooks used in this study.

Implications for Practice

Given that teachers depend on textbooks to plan their lessons, use them as resources for teaching strategies, and for curriculum guidance (Bergqvist & Chang Rundgren, 2017; Drechsler & Schmidt, 2005; Georg Eckert Institute for International Textbook Research, 2009; Mikk, 2000; Peacock & Gates, 2000; Sikorova, 2011; Tulip & Cook, 1993), then this research study can benefit the science education practice by facilitating the choice of science textbooks to use in schools. In the context of Lebanon, some schools may offer the same curriculum in two languages, either French or English. This research study may help educators choose textbooks for both language programs that are like each other rather than different, promoting the same quality education in both programs.

In addition to the input for the practice of science education, this study has also supports the Vygotskian sociocultural theory. Since textbooks are cultural support tools that impact society's duplication of cultural influences (Plut & Pesic, 2003), this research study can show a clear difference amongst textbooks that are published in different countries. Indeed, the French textbooks are characterized by a metacognitive format that walks the student through scientific methodology in each lesson, naming lessons "Activities", and therefore, focusing on the practice of science rather than scientific facts. On the other hand, American textbooks introduce scientific practices and methodologies as warm-up or concluding activities, spending much of the lesson explaining and elaborating on knowledge. This shows a clear difference in the cultural values of the textbooks. The similarity between CERD's *Sciences pour la Vie* and most

of the French textbooks shows the remaining influence of the French culture in Lebanon, post-colonization. Indeed, this study found that CERD's *Sciences pour la Vie* and Magnard's *Sciences et Technologie* were two textbooks that had the most similarities out of all analyzed textbooks.

Implications for Research

French science textbooks have never been analyzed for their representation of NOS before this research study. The sample size of this study (3 French textbooks) is not large enough to grasp the sociocultural aspects of the French science textbooks. More research is needed on French textbooks, especially since they are widely used in Lebanon, in contrast to the heavily analyzed American textbooks. In addition, this research did not collect data on the format of the textbooks, however; this might be a good area of research that may give further evidence to the sociocultural theory of Vygotsky.

On the other hand, the use of the Expanded FRA framework to analyze textbooks had led to aspects of NOS that were found in the textbooks that were not previously accounted for when using a different framework. Such aspects include scientific ethos, social values, and political power structures. Some categories were less represented than others, however, the presence of at least one representation in one of the textbooks analyzed proved to be encouraging and optimistic.

Conclusion

This study analyzed three American textbooks, three French textbooks, and the Lebanese grade 6 textbooks for their representation of NOS. It has been found that all textbooks relied heavily on the cognitive-epistemic aspects of science. In addition, the quality of representation was often low. The representations of the social-institutional

aspects of NOS were seldom, but usually of high quality. The results of this study are similar to previous ones. However, this research contributes additional knowledge on French textbooks, which were never analyzed previously. There were more high-quality representations in French textbooks in comparison to the American textbooks, and the Lebanese textbook had the least high-quality representations. These results highlight sociocultural differences between the three different countries where the textbooks were published.

Textbooks could further develop the representations of NOS that exist already by adding explicit statements and contextualizing the content. This would help in increasing the quality of representation of the NOS aspects. In addition, textbooks need to capitalize on opportunities to include the social-institutional aspects of NOS in the content, either as part of the lesson if possible or at the end of the lesson. Educators in Lebanon can benefit from this research as it helps them choose textbooks for their science classrooms.

APPENDIX

Instrument: Textbook analysis for NOS representation

NAME OF TEXTBOOK

Cognitive-Epistemic Aspects (CE)							
			Page #... from chapter …	**Page #... from chapter …**	**Page #... from chapter …**	**Page #... from chapter …**	**Page #... from chapter …**
CE	**Aims & values**	Presence of NOS category					
		Quality of NOS representation					
	Practices	Presence of NOS category					
		Quality of NOS representation					
	Methods	Presence of NOS category					
		Quality of NOS representation					
	Knowledge	Presence of NOS category					
		Quality of NOS					

		represent ation					

Social-Institutional Aspects: (A) internal to science (inner circle); (B) external to science (outer circle)							
			Page #... from chapter …	**Page #... from chapter …**	**Page #... from chapter …**	**Page #... from chapter …**	**Page #... from chapter …**
SI-A	**Scientific Ethos**	Presence of NOS category					
		Quality of NOS representation					
	Social Values	Presence of NOS category					
		Quality of NOS representation					
	Social Certification	Presence of NOS category					
		Quality of NOS representation					
	Professional Activities	Presence of NOS category					
		Quality of NOS representation					

SI-B	**Financial Systems**	Presence of NOS category					
		Quality of NOS representation					
	Political Power Structures	Presence of NOS category					
		Quality of NOS representation					
	Social Organizations and Interactions	Presence of NOS category					
		Quality of NOS representation					

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