

THE DISCURSIVE CHOICES OF THE SCIENCE AND ELEMENTARY  
SCIENCE EDUCATION EPISTEMIC COMMUNITIES: A CRITICAL  
DISCOURSE ANALYSIS

A THESIS SUBMITTED TO  
THE GRADUATE SCHOOL OF SOCIAL SCIENCES  
OF  
MIDDLE EAST TECHNICAL UNIVERSITY

BY

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IN PARTIAL FULFILLMENT OF THE REQUIREMENTS  
FOR  
THE DEGREE OF DOCTOR OF PHILOSOPHY  
IN  
THE DEPARTMENT OF ELEMENTARY EDUCATION

AUGUST 2022



Approval of the thesis:

**THE DISCURSIVE CHOICES OF THE SCIENCE AND ELEMENTARY  
SCIENCE EDUCATION EPISTEMIC COMMUNITIES: A CRITICAL  
DISCOURSE ANALYSIS**

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## **ABSTRACT**

### **THE DISCURSIVE CHOICES OF THE SCIENCE AND ELEMENTARY SCIENCE EDUCATION EPISTEMIC COMMUNITIES: A CRITICAL DISCOURSE ANALYSIS**

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Ph.D., The Department of Elementary Education

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August 2022, 322 pages

This critical research aimed to investigate the discursive choices of science education and elementary science education epistemic communities to reveal the characteristics of their promoted discourses, the power differences, and how these differences were created by their discursive choices. The lack of prior research on epistemic communities in science education led this research to investigate epistemic communities in two contexts, science and elementary science education, and to conduct a co-citation analysis guided by the definition of epistemic communities to locate these communities in the literature. Two epistemic communities were located with this analysis forming around the same theoretical framework; nature of science. Therefore, the located epistemic communities were named as the nature of science epistemic community of science education and elementary science education. An article representing each epistemic community was sampled among the most influential articles identified in the co-citation analysis, and these two articles constituted the sample of this research. Critical discourse analysis was employed to investigate the discursive choices of the located epistemic communities. Findings revealed many ways to create power differences with discursive choices and showed

that actors of science education can be positioned in hierarchies, and even particular objectives or terminologies can be put in the position of power with these choices. Suggesting that critical paradigm can also be utilized for emancipatory goals that are not particularly addressing the struggles of the oppressed, this research showed a way to study subtle power structures and reveal numerous questions for future researchers to investigate from its critical perspective.

**Keywords:** epistemic communities, discursive choices, critical discourse analysis, science education, elementary science education

## ÖZ

# FEN VE İLKÖĞRETİM FEN EĞİTİMİ EPİSTEMİK TOPLULUKLARININ SÖYSEL SEÇİMLERİ: BİR ELEŞTİREL SÖYLEM ANALİZİ

SOYADI, Adı

Doktora, İlköğretim Bölümü

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Ağustos 2022, 322 sayfa

Bu eleştirel araştırma, fen eğitimi ve ilköğretim fen eğitimi epistemik topluluklarının söylemsel seçimlerini araştırmayı, öne sürdükleri söylemlerin özelliklerini, güç farklılıklarını ve bu farklılıkların söylemsel seçimleri tarafından nasıl yaratıldığını ortaya çıkarmayı amaçlamıştır. Fen eğitiminde epistemik topluluklar hakkında yapılmış önceki araştırmaların yeterli olmaması, bu araştırmayı epistemik toplulukları fen ve ilköğretim fen eğitimi olmak üzere iki bağlamda incelemeye ve bu toplulukları literatürde konumlandırmak için ‘epistemik topluluklar’ tanımı rehberliğinde bir ortak alıntı analizi yapmaya yöneltmiştir. Bu analizle aynı teorik çerçeve, bilimin doğası, etrafında şekillenen iki epistemik topluluk konumlandırılmıştır. Bu nedenle konumlandırılan epistemik topluluklar, fen eğitiminin ve ilköğretim fen eğitiminin bilimin doğası epistemik topluluğu olarak adlandırılmıştır. Ortak atif analizinde belirlenen en etkili makaleler arasından her epistemik topluluğu temsil eden bir makale örneklenmiş ve bu iki makale bu araştırmanın örneklemesini oluşturmuştur. Konumlandırılan epistemik toplulukların söylemsel seçimlerini araştırmak için eleştirel söylem analizi kullanılmıştır. Bulgular, söylemsel seçimlerle güç farklılıklarını yaratmanın birçok yolunu ortaya koymuş ve bu seçimlerle fen eğitimi aktörlerinin

hiyerarşik olarak konumlanabileceğini ve hatta belirli hedeflerin veya terminolojilerin güçlü bir konuma yerleştirilebileceğini göstermiştir. Eleştirel paradigmın özellikle ezilenlerin mücadelelerine hitap etmeyen özgürleştirici amaçlar içinde kullanılabilceğini öne sürerek, bu araştırma, hemen göze çarpmayan güç yapılarını incelemenin bir yolunu göstermiş ve gelecekteki araştırmacıların incelemesi için eleştirel bakış açısıyla çok sayıda soru ortaya koymuştur.

**Anahtar Kelimeler:** epistemik topluluklar, söylemsel seçimler, eleştirel söylem analizi, fen eğitimi, ilköğretim fen eğitimi

*It is with gratitude and deepest longing that I dedicate this work to Kevser ORHUN.*

## **ACKNOWLEDGMENTS**

First and foremost, I am extremely grateful to my supervisor Prof. Dr. Semra Sungur, and my co-supervisor, Prof. Dr. Jale Çakıroğlu, for their invaluable advice, continuous support, and patience during my Ph.D. study. Their immense knowledge and experience in the field have encouraged me in all my academic endeavors, and their confidence in me enabled me to pursue my passion and creativity. My gratitude extends to the esteemed committee members of my thesis Prof. Dr. Mustafa Serdar Köksal, Assoc. Prof. Dr. Serap Emil, Assoc. Prof. Dr. Yasemin Özdem Yılmaz and Assist. Prof. Dr. Şerife Şevinç, for their valuable feedback and comments. Additionally, I would like to thank my dear friends, Assist. Prof. Dr. Canan Aydoğan Avcı, Dr. Halime Özge Bahar Güner, Dr. Susan Kowalski, and my wonderful brother Köksal Akıllıoğlu for their continuous professional support in my thesis, and Prof. Dr. Cynthia Lewis, Prof. Dr. Roger Johnson, Prof. Dr. David Johnson, Prof. Dr. Baskar Upadyay, for the inspirations that started this process.

My appreciation also goes out to my family and friends, especially my aunt Aynel Sır and cousin Tayfun İlidi for their patience, love, and constant reminders, and Prof. Dr. Müge Taşkın Aydin, Prof. Dr. Selda Mant, Assist. Prof. Dr. Mücahit Köse, Handan Özdemirel, Ferhan Yedidağ, and Bingül Konya for being there as true friends for some of the turning points of my life during this long journey. I am particularly thankful to my office mates, Dr. İlknur Gülşen Turgut, Gamze İnci, and Dr. Samet Demir, for their encouragement and support throughout my studies. I also would like to thank Prof. Dr. Hüseyin Çavdar, Assoc. Prof. Dr. Özge Aydin Şengül, Assoc. Prof. Dr. Metin Demir, Assoc. Prof. Dr. Muhammet Özden, for all the wonderful intellectual conversations that kept my mind sharp.

I must also thank all my mentors, friends, students, and people who have influenced and inspired me. Thank you for every step you've taken beside me and for helping me go further than I could have imagined.

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## **LIST OF ABBREVIATIONS**

CDA	Critical Discourse Analysis
MR	Member Resources
NOS	Nature of Science
NOSK	Nature of Scientific Knowledge
RA	Research Article
RWA	Review Articles
TA	Theoretical Articles

## **CHAPTER 1**

### **INTRODUCTION**

The effects of discourse theory and research have been felt more and more in education literature since the end of the 20th century. In particular, classroom discourse has become a prominent topic in educational research. According to Cazden and Beck (2003), classroom discourse gained attention in the late 20th century in response to the educational reforms' focus on the ability to communicate to meet the demands of the new era. To improve students' ability to communicate, the unidirectional and question-answer-oriented classroom talk needed to be replaced with classroom discussions facilitated by teachers. Thus, reform efforts prioritized practices promoting higher-order thinking and reasoning and enabling more student interactions that support the development of communication skills as part of effective teaching (Cazden & Beck, 2003; Walsh, 2006). Consequently, it has become necessary to understand what is taking place in the classrooms discursively.

On the other hand, increasing discussions on gender, race, and cultural differences led the researchers to look at not only the classroom discourse but also the role of discourse in curriculum and how it legitimizes different forms of segregation (Hoffman, 1996; Hughes, 2000, 2001; Solorzano & Yosso, 2001). Though the studies were few in number, these concerns also led to investigations focusing specifically on the discursive properties of textbooks as well (van Dijk & Atienza, 2011). Furthermore, discourse theory and research provided new tools for policy research to study the different contexts influencing policy (e.g., social, historical, and political contexts) and their implications for power hierarchies and emancipation (Anderson & Holloway, 2020; Fairclough, 2013). Thus, educational policies also became a topic of interest, expanding the scope of research on discourse in education. Considering this substantial effect on education literature, it can be argued that discourse theory and research have drawn significant attention for the last few decades because they have brought a new

comprehensive perspective to the literature and met the changing needs of educational research. However, they appear to have more to offer for educational researchers.

The recent studies on classroom discourse (Nystrand et al., 2003; Wells & Arauz, 2006; Kelly, 2007; Kayi-Aydar & Miller, 2018; Bae et al., 2021), curriculum (Bazzul, 2014; Sharma & Buxton, 2015), policy, and standards (Hufnagel et al., 2018, Thomas. 2011) gave us some valuable information about what is taking place in learning environments. These studies revealed that sociocultural contexts affect discourse (Nystrand 2006), and teachers and students are positioned by discourse in and outside the classrooms (Bazull, 2014). Also, they showed the ways educational practices can be shaped by such positions (Hufnagel et al., 2018). As van Dijk (1980; 2011) suggests, educational events are discursive in nature. Language plays a significant role in educational events by assuming and creating social relations, even before these events occur (Wortham, 2008; 2003). Considering not only the educational events and interactions in learning environments but also outside of these environments are discursive in nature, discourse studies also showed us that all communications taking place in educational contexts were interconnected, and the intricate relationship among them requires much more research on this topic.

As many prominent linguistic and social theorists stated (Fowler et al., 1979; Fairclough, 1989; Bakhtin, 1981; Volosniov, 1973), discourse creates norms and expectations within social groups and institutions, which in return ensures the permanence of these social groups and institutions, as the set norms and expectations influence discursive practices. In other words, what we observe in classrooms, curriculums, and policy documents in terms of discursive choices represents the norms and expectations of the social groups and institutions that have reciprocal interactions with these choices. Therefore, in addition to the effects of the classroom, curriculum, and policy discourses that have been the focus of educational research, the discourses of the social groups and institutions influencing and being influenced by these discourses should be studied. As a result, there is a significant gap regarding the macro-level interactions and an overlooked need to understand the role of discourse in education from a broader and more dualistic perspective in the literature. Therefore, to draw attention to the gap in the literature and to meet this need to some extent, this

research aims to explore the macro-level interactions through prominent epistemic communities' discursive choices within the science education context. This research particularly focused on epistemic communities in science education since the discursive choices of these communities have a direct effect on policy, curriculum, and teacher-student interactions taking place in classrooms due to their prevailing position in the construction and dissemination of scientific knowledge. Regrettably, epistemic communities and their discursive choices are rare topics in educational research, and even discourse can be considered a new topic in this field. Therefore, providing some background information about the role of discourse and epistemic communities in education before presenting the research questions will be beneficial in clarifying the rationale and motivation behind this research.

### **1.1. Discourse in Education**

Discourse in any context is a complicated topic for researchers since studying and communicating about discourse can only be possible through discourse. Researchers face many challenges due to this very nature of discourse. The first challenge they face is to answer the question, "What does the study of discourse mean?". Wetherell et al. (2001) suggest a concise and direct answer to this question; they state that "the study of discourse is the study of language in use" (p.3). This simple definition allows us to get a sense of discourse studies, yet what constitutes 'language in use' becomes another question that needs to be answered. Gee (2004) approaches this challenge from a different perspective and focuses on the functions of human language and suggests that there are two connected primary functions; "to support the performance of social activities and social identities, and to support human affiliation with cultures, social groups, and institutions" (p.1). From this perspective, Gee (2004) emphasizes the functionality of discourse since "we fit our language to a situation that our language, in turn, helps to create in the first place" (p.10). Therefore, language use can be perceived as a dualistic tool used both for the performance of activities and affiliations with groups.

As Fairclough (2001) states, "language is a part of society, linguistic phenomena are social phenomena of a special sort, and social phenomena are (in part) linguistic

phenomena” (p.19). In other words, the way we use language is determined by social conditions, and at the same time, it affects and shapes these same conditions. However, we often overlook this reciprocal relationship and the fact that “language rests upon common-sense assumptions, and the ways in which these common-sense assumptions can be ideologically shaped by relations of power” (Fairclough, 2001, p.3). Consequently, the multi-faceted, socially embedded, and power-bound presence of discourse in our lives creates various, not so easily predictable challenges for researchers. Taking all these into account, it is not surprising that educational researchers did not pay much attention to discourse for a very long time. Discourse became a topic of interest to educational researchers only after linguistic anthropologists unveiled the role of language within educational contexts and provided practical tools for investigation (Agha, 2006; Wortham, 2008).

Linguistic studies helped open the path for discourse studies in education. First, studies of the ethnography of communication (Gumperz & Hymes, 1964; Hymes, 1972) revealed the central role of discourse in sociocultural contexts. Afterward, sociolinguistics researchers like Gumperz (1982), Labov (1972), and Sinclair & Coulthard (1975) provided ways for conversation and semantic analysis. Finally, linguistic anthropology (Silverstein & Urban, 1996) urged educational researchers to pay attention to discourse. For example, Sinclair and Coulthard’s (1975) coding system for teacher and student talk provided a useful tool to investigate discourse in classroom talk. Additionally, studies on linguistic anthropology of education gave us a glimpse of the role of educational institutions in regulating ideologies and associating “educated” and “uneducated” language use with varying social positions (Gonzalez & Arnot-Hopffer 2003; Wortham, 2008; Zentella 1997). This key point paved the way for the increased attention to discourse theory and research in education literature in the late 20th century, as the ability to communicate effectively was associated with educated language use.

Discourse theory showed educational researchers that through language, we do not simply communicate referential messages. With all its linguistic (syntax, semantics, etc.) and paralinguistic (intonation, articulation, etc.) components, language also provides relational information with constructed subject positions and implied power

structures (Bucholtz & Hall, 2003; Evans, 2006; Fairclough, 1995, 2001, 2013; Gee, 2004; Wetherell et al., 2001). Any form of communication (oral, written, etc.) between teachers and students involves more than the information about the subject matter. These communications reveal both teachers' and students' affiliations with social groups, regardless of whether these groups are inside or outside of the speech events (Wortham, 2008; Hsu & Roth, 2014). Being perceived as a member of a specific discursive community also regulates the way students learn a subject matter (Delpit, 1993; McVittie, 2004) and shapes their life trajectories. To a degree, students' understanding of a subject or their life, in general, translates into the way they express their ideas. Individuals communicate more than the intended information by using certain words (lexical), preferring a specific 'order of the words' (syntax), or choosing a specific 'meaning of the words or sentences' (semantic) over others.

Linguistic studies not only encouraged educational researchers to study discourse but also showed how discourse connects different fields. Researchers studying how we know what we know and how we make sense of the world were also paying attention to language for decades, especially the researchers utilizing the social cognitive theories of language and thought (Chomsky, 1993; Piaget, 1959; Vygotsky, 1962). Indeed, researchers studying the cognitive processes had a lot to say about the role of discourse in education. However, the way that they approached language was considerably different from linguistic anthropologists' approach. Early educational researchers studying cognitive processes considered language as a tool, a medium of thought, that aided cognitive processes (Johnson-Laird, 1983). Different explanations of the cognitive process like Piaget's (1959) stages of cognitive development, Carey (1985; 2000) and Vosniadou's (1994; 2007) conceptual change models, and other cognitive theories (Nelson, 1998) heavily relied on the assumption that language assists individuals as they form, organize and re-organize their thought structures. Soon after the translation and republication of Vygotsky's (1962) work, however, as the sociocultural theories gained more popularity in the field, the researchers shifted their focus from the representational function of language to the social and communicative functions of language (Wells, 1999; Mercer, 2000). As a result, discourse theory and research gained more footing in education literature by providing

a new perspective and needed tools to investigate language's social and communicative functions in educational contexts.

For over two decades, discourse studies contributed significantly to the educational research literature and provided a deeper understanding of the reciprocal relationship between knowledge construction and discursive activity. These studies revealed that discourse plays a significant role in social practice, either supporting students or constraining students' access to the promoted knowledge in educational settings (Christie, 2002; Colins & Blot, 2003; Murphy et al., 2018; Rogers, 2004). As they extensively investigated the complex and dynamic nature of the relationship among discourse, social practice, and learning, these studies showed us that within and across educational events, it was the discourse that determined "what counts as knowing" and the acceptable ways of "doing things" and "being" (Anderson & Holloway, 2020; Gee & Green, 1998). Therefore, it is not surprising that all forms of language use, interactions, and their participants (e.g., classroom, curriculum, policy discourses, and teacher-student, student-student interactions) attracted researchers' attention (Flowerdew & Richardson, 2017; Lim, 2019; Wetherell et al., 2001), and 'the study of language-in-use' (Wetherell et al., 2001) became so prolific for educational researchers.

As discourse became an important topic of educational research, by allowing researchers to pay attention to the relationship among discourse, socially produced knowledge, practice, and power (Fairclough, 1995) and emphasize "the role of individuals' values, beliefs, attitudes, and social identities" (Gee, 2004) in knowledge construction within a social context, the science education researchers focusing on knowledge construction and development of understandings in science classrooms adopted this research framework (Duit & Treagust 1998; 2003). In the following section, the effects of discourse theory and research on science education research will be presented.

## **1.2. Discourse in Science Education**

Science has its own special language and established norms for how to write, symbolize, communicate and talk about scientific knowledge. This special language directly affects what is taking place in science classrooms and provides ample sources for discourse studies (do Nascimento, 2013; Hsu & Roth, 2014; Roth, 2004). Consequently, influenced by the popularity of the discourse theory and research in recent years, researchers in science education pay close attention to the classroom discourse as a crucial part of the meaning-making processes in science classrooms (Kelly, 2007). However, discourse theory and research encourage researchers to study knowledge construction as well as the dissemination of scientific knowledge and how particular knowledge or information is shared and made available to others through language in use (Pérez-Llantada, 2012; 2018). Therefore, they open even more doors for researchers to explore the role of discourse in science education.

In the late 20th century, Lemke's (1990) influential work Talking Science introduced the classroom discourse as a topic in science education literature and gave us a glimpse of how discourse can be used to maintain power by the teacher in science classrooms. Influenced by this research and recognizing the potential of discourse for learning and instruction, many researchers developed their own discursive approaches. Therefore, to assist science learning through discourse, different frameworks emerged like 'transformative communication' (Polman & Pea, 2001), 'Toulmin's argumentation pattern' (Erduran et al., 2004), 'improvisational science discourse' (Jurow & Creighton, 2005), 'heuristics for progressive disciplinary discourse' (Windschitl et al. 2008). Although the effectiveness and popularity of these frameworks in the field vary, they helped discourse theory and research to find their place in science education literature.

On the other hand, progressively more studies in science education show that students struggle with scientific discourse because there are substantial differences between what is promoted in the classrooms and 'students' everyday discursive repertoire' (Hsu & Roth, 2014; Kelly, 2014; Roth, 2004). The wide range and variation of semiotic communicative forms of scientific discourse are challenging to students since they

have very little prior experience with these forms. The particular linguistic forms of science, including the use of passive voice and conditionals, technical vocabulary, interlocking taxonomies, abstraction and nominalization, and complex symbols and notational systems (Halliday & Martin, 1993), are often alienating to students. It also leads students to think that science is difficult, it is reserved for cognitive elites (Lemke, 1990), and who can access what science education offers is strictly controlled (Kelly, 2015).

Findings of discourse studies in science education showed that students need to ‘talk science’ and make the language of science their own (Lemke, 1990; Varelas et al., 2008). If teachers put too much emphasis on scientific discourse in its most strict form endorsed by the scientific communities, this may cause students to lose interest in science (Lemke, 1990; Moje, 1995, 1997). Such emphasis could also create hierarchical roles for students and teachers, giving more power to science teachers as authorities within the classrooms (Moje, 1997). The discourse of science promoted in the classroom influences the views of science made available to students (Carlsen, 1991; Moje, 1997). Teachers’ questions and the way they use scientific discourse mediate the social context in the classroom (Roth, 1996; 2004). Teachers can make complex concepts like the nature of science or socio-scientific issues accessible to students through certain discursive choices (Lemke, 1990; van Zee & Minstrell, 1997; Walker, & Zeidler, 2007) or prevent students from gaining access to scientific knowledge (Varelas et al., 2008). More current studies also showed that discourse plays a significant role in science classrooms in terms of reasoning (Convertini, 2021), meaning-making (Franco & Munfold, 2021; Wilmes & Siry, 2021), and how norms created by discourse affect agency (Sandoval, Kawasaki, & Clark, 2021).

Research shows that scientific discourse can be used to transcend the barriers of power asymmetries (Gallas, 1995; Kelly, Brown, & Crawford, 2000). However, scientific discourse promoted in science classrooms usually reinforces the power asymmetries, which is a great threat to equity in science learning (Kelly, 2014). The community that creates this discourse and enforces power asymmetries also controls students’ access to scientific knowledge and establishes norms of communication for prospective members. Doing so acts as gatekeepers (Billig, 2008) for all the stakeholders in science

education. For this reason, this research preferred to use the term epistemic communities instead of scientific communities to emphasize that scientific discourse promoted in and out of classrooms is influenced by communities, members of which have not only a shared paradigm but also a shared episteme. Epistemic communities and the philosophical roots of this term are explained in detail in the next section.

### **1.3. Epistemic Communities**

‘Epistemic community’ is not a widely used term in education or science education literature. Even though it is gaining some recognition (Glazer & Peurach, 2015; Kelly, 2014), there is no research readily available in science education or education literature defining this term or providing any information about the philosophical roots of the epistemic community (communities) concept. This gap in education literature can be attributed to the popularity of the early science philosophers’ works on the formation of communities in science which are still in use today in science education literature. Two names especially stand out among these philosophers, Ludwick Fleck and Thomas Kuhn. Ludwick Fleck was one of the first names to refer to scientists as a social group and gave them the name ‘thought collectives’ (Fleck, 1979). According to Fleck (1979), when a community of scientists adopts ‘a thought style’, a certain way of thinking and perceiving based on a set of rules determining the acceptable ways to communicate and cooperate, which is characteristic to that specific community, this adopted ‘thought style’ forms ‘a thought collective.’ Influenced by Fleck’s early works on thought collectives, in 1962, Thomas Kuhn combined the idea of paradigm with scientific community notion and provided a fundamentally new explanation about how science progresses and changed the way we see science. With this new explanation, Kuhn (1996) tied the definition of the scientific community and paradigm together; “Paradigm is what the members of a scientific community share, and, conversely, a scientific community consist of men who share a paradigm” (Kuhn, 1996, p.176). This dualistic definition gave scientific communities a prominent role in his theory of science and positioned them as both the producer and validators of scientific knowledge. In his work, *The Structure of Scientific Revolutions* (Kuhn, 1996), the scientific communities were portrayed to have well-defined boundaries. Even though communications occur, occasionally beyond the members of the same community, the

consensus and the homogeneity of the scientific communications among the members of the same community characterized the Kuhnian scientific communities.

The reciprocal interaction between language and communities was not an unfamiliar topic for philosophy of science. Ludwick Fleck's notion of 'thought collectives' and Thomas Kuhn's 'paradigm shift' both referred to how shared norms of communication support the formations of scientific communities and vice versa. Therefore, this relationship is recognized in science education literature but, unfortunately, not studied extensively. Moreover, even though political science researchers are the ones who pay considerable attention to epistemic communities, they are heavily influenced by the works of science philosophers.

The theoretical roots of the notion of epistemic communities can be traced back to the philosophy of science, again most notably Ludwick Fleck's (1979) idea of 'thought collectives', and Thomas Kuhn's (1962) idea of 'scientific communities, and paradigms. However, the notion of epistemic communities is also heavily influenced by Michel Foucault's (1973) concept of 'episteme.' Foucault (1973) defines episteme as 'a principled system of understanding' and examines the embedded nature of epistemic assumption in historical contexts. He proposes that different historical periods have different epistemic assumptions, and these assumptions determine what is considered truth and acceptable discourse. He also claims that as the epistemic assumptions change in time, so do the truth claims and discourse.

Influence by these three philosophers, Burkhard Holzner introduced the term epistemic communities for the first time in his book 'Reality Construction in Society,' (first published in 1968) which proposes a sociology of knowledge to analyze the process of knowledge formation, its organization, and diffusion in society. Holzner (1972) defined epistemic communities as communities "unified by a common epistemology and frame of reference, such as the scientific community, religious communities, work communities, some ideological movements and the like" (p. 69). Even though Burkhard Holzner (1972) is considered to be one of the primary sources of this term, the popularity of the term epistemic communities in current literature, especially in the international relations literature, is attributed to a political scientist, Peter Haas (1992).

Haas (1992) defines an epistemic community as “a network of professionals with recognized expertise and competence in a particular domain and authoritative claim to policy-relevant knowledge within that domain or issue-area” (p.3). He points out that epistemic community not only refers to scientific communities or scientists, and professionals from different disciplines could be part of an epistemic community.

Giving an example from science education, how the notion of epistemic community relates to this field, researchers of science education can be considered as an epistemic community. They use discourse, more specifically scientific discourse, to define what scientific knowledge is. Through education given by a selected few, individuals become proficient with scientific discourse, which is essentially constructed by the discursive choices of the epistemic community. Hence, by using the discourse, individuals gain access to scientific knowledge. What is being taught (knowledge made available) and how it is being taught (discursive choices) in science education are also determined by the epistemic community. Moreover, to participate in science education either as a researcher, an instructor, or a student, individuals must meet some clear standards again established by the epistemic community and the discourse they use. Ultimately the individuals’ level of proficiency in scientific discourse determines the level at which they could participate in the epistemic community. In this multidimensional dynamic structure, through discourse practices, individuals enact their beliefs, identities, and activities (Gee, 2004; Roth, 2004). Therefore, examining discourse patterns that are used by epistemic communities provides a way to understand the nature of these communities and the reciprocal relationships among individuals’ beliefs, identities, actions, and discourse.

The specialized nature of the epistemic communities constructing discourse processes and practices determines the distinctive characteristics of the discourse (Kelly, 2014). Therefore, considering the particular characteristics of science and scientific knowledge, it is logical to assume that discourses promoted by the epistemic communities of science education have their own unique features. Consequently, investigating these features could also help us understand these communities and the effects of their discursive choices in the field.

#### **1.4. Purpose and Research Questions**

Science learning has been increasingly conceptualized as students' ability to participate in educational events by gaining knowledge of how to use scientific discourse. For the last few decades, researchers have urged us to pay attention to the fact that scientific discourse exercised within academic settings reinforces the culture of power (Delpit, 1995; Aikenhead, 2001; Ogbu, 2004) and determines whether individuals access the social goods (Gee, 2006) science education provides. Discourse studies in science education mainly focus on classroom dialog (Hanrahan, 2005, 2006, Kelly, 2007; Moje, 1997), policy documents (Hufnagel et al., 2018, Thomas. 2011), or curriculum materials (Bazull, 2014; Sharma & Buxton, 2015), yet neglect to investigate the discourses promoted by the epistemic communities of science education at its source. Researchers of science education constitute epistemic communities and have influential voices that determine the characteristics of promoted discourses in science education through their discursive choices. There are numerous studies investigating scientific communities. Especially the scientometric studies focusing on descriptive and quantitative characteristics of scholarly literature gaining recognition (Fernández-Cano, & Bueno, 1999; Konur, 2012) and increasing interest in networking relations within the educational research community (Tuire & Erno, 2001) is clear. However, there is limited research investigating these influential communities' discursive choices and whether these choices create power difference and reinforce the culture of power in science education.

To address this significant gap, some fundamental exploratory questions need to be asked to get a better understanding of the epistemic communities' discursive choices and their role in the promoted power difference in the field. Since there is no previous research on epistemic communities in the literature, this research lacks a referential ground to clarify its findings with the support of previous knowledge in the field. Therefore, relying on the embedded nature of discourses and epistemic communities, this research investigates two contexts, science education and elementary science education literature, to create a comparative reference point for its findings. The reasoning behind this choice will be explained further in Chapter III. As a result, by answering the questions stated below, this research aims to understand how epistemic

communities' discursive choices, both in science education and elementary science education literature, mediate the relationship between power and privilege.

What are the characteristics of discourses promoted by the epistemic communities of science education?

Do the discursive choices of the epistemic communities of science education create power differences? If so...

How do the discursive choices of the epistemic communities of science education create power differences?

What are the characteristics of discourses promoted by the epistemic communities of elementary science education?

Do the discursive choices of the epistemic communities of elementary science education create power differences? If so...

How do the discursive choices of the epistemic communities of elementary science education create power differences?

### **1.5. Discursive Choices**

This research aims to investigate the discourses and their promoted power structures in the relevant literature through discursive choices of the epistemic communities of science and elementary science education. Naturally, this aim dictated adopting an exploratory perspective. Therefore, this research was oriented around two main concepts, discourse, and discursive choices. As Gee (2004) suggests that two fundamental functions of human language, to "perform social activities and social roles" and "affiliate with cultures, social groups, and institutions" (p.1), are actualized with discourse. If we apply this perspective to academic writing, writers of academic texts make various discursive choices to "perform social activities" (e.g., write an article) and "social roles" (e.g., researcher, reviewer) and "affiliate with social groups" (e.g., a field of research, scientific communities, discursive communities, epistemic communities). Therefore, through the discursive choices, researchers display their

identities (Yang, 2013) and affiliate with not only social groups but also the discourses of these groups by “developing the capability to participate in discourse communities” (Duff, 2007, p.01.4). Also, considering the way we use language determines the social conditions while being determined by them, it also affects and shapes these same conditions (Fairclough, 2001). The discursive choices of the researchers also shape the discourse of the group they affiliate with. In written texts, the discursive choices of the writers include how the text and information are organized, what linguistic features are used, how these features are used, and what semantic information is shared (Fairclough, 2001; Gee, 2004; van Dijk, 1985). Although the organization of academic texts is usually genre-based (research article, review article, etc.) (Flowerdew, 2000) and predetermined by the medium of publishing (journal, handbook, book conference proceedings, etc.), writers make important discursive choices while organizing the text, especially regarding titles and subtitles. Also, writers’ discursive choices regarding titles, linguistic features, and semantic information significantly influence and are influenced by the norms, expectations, and discourses of the communities they affiliate. Therefore, any study that investigates discursive choices should pay attention to these aspects of the text. Recognizing this necessity, this research was designed with a linguistic orientation, and as the best fit for the research questions, Critical Discourse Analysis (CDA) was adopted as a methodology.

## **1.6. The Research Design**

The lack of prior research on discursive choices of epistemic communities in science and elementary science education literature created a challenge for this research and necessitated a well-thought-out research design. First, to investigate the discursive choices of epistemic communities, it was necessary to locate these communities in the science and elementary science education literature. However, due to the gap in the literature, these communities could not be located by simply reviewing the prior research on epistemic communities of science and elementary science education. Therefore, an investigation needed to be conducted to locate these epistemic communities in the literature to sample the representative texts and answer the research questions.

To locate the epistemic communities in the relevant literature, it was necessary to define them with their differentiating characteristics. Therefore, this research adopted Haas's (1992) definition of epistemic communities and looked for the networks of experts in science education and elementary science education literature with some social relationships and common discursive choices. VOSviewer program was used to reveal these networks in the literature by mapping the ways science education researchers cite each other's works since the ways researchers cite each other's work would indicate a certain relationship among them as well as common discursive tendencies. Based on Haas's (1992) definition, it was assumed that being cited by other researchers and co-citing each other's work consistently shows that these researchers (experts) share some normative beliefs, which are based on the frameworks (a set of agreed-upon principles) derived from previous research in the field and causal beliefs (the analysis of practices), and shared notions of validity. Therefore, in this research, to locate the epistemic communities, co-citations analysis was used.

Since co-citation analysis is useful to determine with what frequency two articles are cited by other articles in the literature and helps researchers observe the citation relationships within a field (Small, 1973), it was incorporated into the sampling procedure of the research design. Also, some limitations of co-citation analysis were addressed in the design. Considering that information gathered through co-citation analysis is time-dependent since the knowledge and relationships in any field change and evolve over time (Trujillo & Long, 2018), while investigating the literature, an extended period, around 43 years (between 1975-2018) of research, was taken into account. With the help of VOSviewer co-citation maps, the most influential articles (therefore, the authors of these articles; the most influential researchers/experts) in the literature were located. After locating some of the most influential articles in the literature, further investigations were conducted to address another limitation of this analysis. Co-citation analysis assumes two articles are semantically similar based on co-citation (Özçınar, 2015). However, the content of the articles could also provide much-needed information about semantic similarity (Boyack et al., 2013), which could indicate common discursive choices of the epistemic communities. Therefore, additional textual analyses were conducted to locate and differentiate epistemic

communities in the literature. Besides VOSviewer co-citation maps, VOSviewer co-occurrence maps were used to track semantic similarities of the most influential articles in the literature. Finally, with the help of VOSviewer co-occurrence maps, some of the epistemic communities of science and elementary science education literature were located and named.

After locating the epistemic communities sampling a representative text for each epistemic community was a straightforward process. Based on their citation frequency, co-citation cluster effect, and consistent citation history, the most influential articles located in the literature were purposefully selected as the sample to answer the research questions. The first research question was concerned primarily with the characteristics of the discourses promoted by the prominent epistemic communities, but the question itself was founded on two main assumptions. There are prominent epistemic communities in science education and elementary science education, and discourses promoted by these epistemic communities differ. The second research question was concerned with the reified power relations promoted and sustained by the epistemic communities in science education and elementary science education through discourse. The third research question focused on how the discursive choices of epistemic communities constructed common-sense assumptions; the ways discursive choices convince the reader that the promoted power differences make sense. Considering the embedded and layered nature of the research questions and their critical stance, Fairclough's (2001) triadic CDA approach was the perfect match for the research questions. Therefore, this approach was adopted for CDA.

Fairclough's (1995; 2001; 2013) triadic CDA approach consists of three interrelated processes of analysis that correspond to the three interrelated dimensions of discourse. These three dimensions are:

1. Text, the object of analysis: In this research, the objects of the analysis were the selected articles.

2. Interaction, the processes by which the object is produced and received: In this research, the language structures and the meaning-making processes were considered indicative of the interaction between text and context.

3. Context, the socio-historical conditions that govern the processes mentioned above: In this research, the socio-historical conditions were the conditions in which selected articles and the science education and elementary science education epistemic communities were formed and operated.

Since Fairclough (2001) suggests that each of these dimensions requires a different kind of analysis, the research was designed accordingly to accommodate these different analyses.

1. Text analysis (description); This analysis involves the study of the language structures produced in discursive practice. Therefore, the organization and linguistic features of the text were analyzed by using Fairclough's (2001) list of analysis questions. VOSviewer co-occurrence maps were also used for text analysis to see the consistency between visualized non-parametric analysis of the co-occurrences of the nouns and noun phrases within the text and the vocabulary and linguistic features analysis of the text based on Fairclough's (2001) guiding questions. Text analysis revealed valuable information to answer the first research question.

2. Processing analysis (interpretation): This analysis involves investigating the processes of production and interpretation of the text. Using Fairclough's guiding questions, these processes were investigated. Also, subject positions promoted in the text were analyzed by combining the guiding questions Gee (2004) provided with Fairclough's (2001) guiding questions, considering the structural effects of the values. Moreover, the information obtained from text analysis also supported this analysis. The findings of the processing analysis help this research to answer especially the second research question. However, due to the embedded nature of the second and third research questions (investigating the power structures and how they are created), information gathered from processing analysis also supported the social analysis of the sampled texts.

3. Social analysis (explanation); The third dimension, socio-cultural practice, is concerned with issues of power-power being a construct that is realized through interdiscursivity and hegemony. Analysis of this dimension includes exploration of the ways in which discourses operate. In this dimension of the CDA, social determinants of the discourses, ideologies hidden in the text, and the effects of the discursive choices of the epistemic communities were investigated. Analysis of the linguistic features and all the information gathered regarding epistemic communities' discursive choices were combined in order to support social analysis. Therefore, this analysis addressed the third research question.

### **1.7. Potential Significance of the Research**

This exploratory research aims to address a sizable gap in the education literature regarding the social groups and institutions influencing and being influenced by discourse. As explained before, current research on discourse in education mainly focuses on the classroom, curriculum, and policy discourses, yet overlooks the influence of social groups and institutions over these discourses. Especially, there is no substantial research providing information about the epistemic communities in the literature. Considering the fact that these communities, which consist of groups of influential researchers of the education literature, have a significant effect on what we observe regarding classroom, curriculum, and policy discourses, it is crucial to gather information about them to understand the role of discourse in education better. Therefore, this research has the potential to contribute to the literature by introducing a different, unexplored perspective to study discourse in educational contexts.

One of the significant endeavors undertaken by this research is to locate the epistemic communities in science education literature since it aims to investigate the discursive choices of these communities. For this reason, it has the potential to set an example of how to locate epistemic communities in science education literature. Consequently, this research can provide a much-needed reference point for further research on epistemic communities not only in science education literature but also in education literature in general.

This research can also be an alternative example of methodological use of CDA for educational research because it utilizes Fairclough's (2001) triadic approach and focuses on text-context interaction as a whole, unlike many research focusing only on the text in education literature. The critiques of CDA research have long been pointing out the danger of using CDA in the name instead of other analytical approaches due to its popularity (Martin, 2000; Verschueren, 2001; Widdowson, 2005), and there is numerous CDA research in the literature without meeting the fundamental requirements of this research framework (Rogers et al., 2005). Moreover, this research also utilizes a bibliographic and text analysis program, VOSviewer, to support CDA and locate epistemic communities, enabling the researcher to attain methodological, theory, and data source triangulation. Therefore, this research has the potential to show a unique way to utilize bibliographic and text analysis programs like VOSviewer along with CDA.

Given the influence epistemic communities have on knowledge production and dissemination, gaining awareness and understanding of these communities carries great importance. Potentially, the finding of this research can give us some information about the extent of these community influences. Also, considering the philosophical roots of the “epistemic community” concept and its rare use in science education literature, this research can re-introduce this terminology borrowed from political science literature and provide a ground for discussions about different social groups’ influences on science education.

Finally, the findings of this research can provide some valuable information regarding the epistemic communities’ discursive choices in science education and elementary science education and whether these choices promote power differences in the field. The awareness we could gain about the discursive choices and their effects can be used for emancipatory purposes in science education. Also, epistemic communities and all involved individuals and groups who are influenced and have influence over discourse could use this awareness to improve education in general.

## **1.8. The Outline of the Dissertation**

This chapter, CHAPTER 1, summarized the fundamental frameworks upon which this research was built and presented the purpose and rationale behind the research questions. It also provided some information on research design to make this unique design more accessible to the reader. As customary, the following chapter, Chapter 2, provided the reviews of the related literature. Chapter 3 explained the theoretical foundations of CDA, the purpose of this research, the research questions, why a specific CDA approach was chosen to answer these questions, and the research design. Also, the data collection and analysis procedures were presented, and measures of rigor, reflexivity, and the limitations were discussed. Chapter 4 was dedicated to epistemic communities. In the context of this research, the information gathered concerning epistemic communities and how these communities were located in the literature were presented in this chapter. The findings of the research were presented in two chapters. Chapter 5 presented findings regarding the Nature of Science Discourse in Science Education Literature, and Chapter 6 presented findings regarding the Nature of Science Discourse in Elementary Science Education Literature. Chapter 7 summarized the research and discussed the finding and how these findings relate to each other. Concluding remarks, contributions, implications, and recommendations were also shared in this chapter.

## **CHAPTER 2**

### **LITERATURE REVIEW**

This chapter introduced the relevant literature on the fundamental concept around which the research was designed, namely discourse. In the first section, the role of discourse in education and the popularization of discourse theory and research in education literature were explained. Then the progress of discourse studies in science education literature was reviewed to bring the gap this research addressed to light. Due to the substantial size of the gap in the literature and its pioneering role, this research focuses on the discursive choices of epistemic communities of science education and elementary science education in literature. Therefore, in separate sections, what constitutes discursive choices and how this research defines epistemic communities were explained with relevant research in the literature to provide a solid foundation for the research design and claims made by this research.

#### **2.1. Discourse in Education**

Language is complex and central to our lives. With language, we do not simply communicate referential messages with its linguistic and paralinguistic components; we also share relational information positioning the individuals and communities in specific power structures (Evans, 2006; Fairclough, 1995; Gee, 2004; Wetherell et al., 2001). Recognizing this vital role of language, discourse theory and research aim to explain the ways the referential and relational information are constructed and communicated through language. Prominent researchers of discourse theory define discourse as “language in use” (Fairclough, 1995; Gee, 2004; Wetherell et al., 2001) and explain what counts as “language in use” from different perspectives. According to Fairclough (2001), the way we use language is determined by social conditions. While being determined by the social conditions, it also affects and shapes these same conditions. This reciprocal relationship is actually what is being emphasized with this simple definition; “language in use.” From a critical perspective, Fairclough (2001)

also urges us to pay attention to the fact that “language rests upon common-sense assumptions and … these common-sense assumptions can be ideologically shaped by relations of power” (p.3). Similarly, Gee (2004) suggests that language in use can be seen as a dualistic tool used both for performance and affiliations. He states that “we fit our language to a situation that our language, in turn, helps to create in the first place” (p.10). By doing so, we actualize the two fundamental functions of human language, we “perform social activities and social roles” and “affiliate with cultures, social groups, and institutions” (p.1). Carrying the same definition into research, Wetherell et al. (2001) state that “the study of discourse is the study of language in use’ (p.3) and suggests that “the study of discourse is about the discovery and theorization of pattern and order” (p.5) within a social context. As it can be deducted from these definitions, discourse theory and research investigate language within its social context of use. Therefore, because of its discourse-oriented perspective, this research adopted the definition of discourse as “language in use” and refused to look at language as a decontextualized construct separate from the social context, especially in the context of education.

All materials and interactions in a learning environment involve language: curriculum, classroom dialog, etc. (van Dijk, 1980). Therefore, language and the ways we use language carry great importance in education. Various fields of studies and different theoretical approaches contributed greatly to the discourse studies in education. The field of sociolinguistics especially approaches like the ethnography of communication (Gumprez & Hymes, 1972) and linguistic anthropology (Silverstein & Urban, 1996), and cognitive linguistics (Halliday, 1973; Langacker, 1987), and particularly in education, social cognitive theories of language and thought (Chomsky, 1993, 2006; Piaget, 1959; Vygotsky, 1962), as well as poststructuralist approaches (Foucault, 1972, 1980), have significant influences that stand out among them. However, the ethnography of communication, linguistic anthropology, and social cognitive theories of language and thought paved the way for discourse studies, especially in science education.

Influenced by Noam Chomsky’s conceptualization of language as abstract and universal, studies on the ethnography of communication provided the much-needed

holistic theoretical and methodological perspective for educational researchers (Noy, 2017). These studies focused on language use in the social context and how these uses differ. One of the researchers who contributed to the development of this approach, Hymes (1974), argued that language use in real situations by actual people should be studied to understand how a person navigates through different patterns of language use and learns about what is being considered an appropriate way to communicate by their community. This approach made educational researchers pay attention to “language in use” in the context of classroom interactions, the actual teacher-student, student-student interactions, and how students navigate through discourse and gain membership in social groups. Also, the works of Gumperz and Hymes (Gumperz, 1982; Gumperz & Hymes, 1964; Hymes, 1972) revealed the central role of discourse in sociocultural contexts like educational contexts. They were further encouraging the educational researchers to pay attention to discourse. Also, the sociolinguistics researchers provided ways for conversation and semantic analysis (Gumperz, 1982; Labov, 1972), like a coding system for teacher and student talk to investigate classroom discourse (Sinclair & Coulthard, 1975).

Another approach that influenced discourse studies in education was linguistic anthropology. Linguistic anthropology investigates the ways language use assumes social relations and simultaneously creates these assumed relations in sociocultural contexts (Wortham & Perrino, 2017). Linguistics anthropology provides a sound theoretical and methodological base for educational researchers to study how language conveys referential and relational meanings, which is especially useful in science education. For example, one of the recent studies employing this framework and analyzing the language form to investigate the production of scientific knowledge in middle-school classrooms showed how referential and relational information could be manipulated in classroom discourse. In this research, Viechnicki and Kuipers (2006) revealed that by using different language forms like tense and aspect shifts and nominalizations, teachers and students were somewhat objectifying their subjective experience as scientific fact in the classroom interactions. Studies on linguistic anthropology of education also showed us the ways educational institutions use language in regulating ideologies and associating “educated” and “uneducated”

language use with varying social positions (Gonzalez & Arnot-Hopffer 2003; Wortham, 2008; Zentella 1997).

Utilizing social cognitive theories of language and thought (Chomsky, 1993, 2006; Piaget, 1959; Vygotsky, 1962), the researchers studying the cognitive processes had a lot to say about the role of discourse in education. Early educational researchers studying cognitive processes considered language a tool, a medium of thought, that aided cognitive processes (Johnson-Laird, 1983). This approach to language was considerably different from linguistic anthropologists' approach. Different explanations of the cognitive process like Piaget's (1959) stages of cognitive development, Carey (1985; 2000) and Vosniadou's (1994; 2007) conceptual change models, and other cognitive theories (Nelson, 1998) heavily relied on the assumption that language assists individuals as they form, organize and re-organize their thought structures. However, as the sociocultural theories gain more popularity in the field after Vygotsky's (1962) influence, the researchers paid more attention to the representational function of language than its communicative functions (Wells, 1999, 2006; Mercer, 2000). As a result, discourse theory and research gained more footing in education literature by providing a new perspective and needed tools to investigate language's social and communicative functions in educational contexts.

Discourse has a significant role as a mediator in most aspects of education (Wortham & Perrino, 2017). The communications taking place in a learning environment between teachers-students, student-student, etc., involve more than the referential information about the subject matter. These communications reveal teachers' and students' affiliations with social groups, regardless of whether these groups are inside or outside of the speech events (Wortham, 2008; Hsu & Roth, 2014). Being perceived as a member of a specific discursive community also regulates the way students learn a subject matter (Delpit, 2013; McVittie, 2004) and shapes their life trajectories (Wortham & Perrino, 2017). Research focusing on discourse in education particularly investigates language in use. However, these investigations cannot be limited to the educational language used in its immediate educational context. To make sense of what is being communicated, it is necessary to consider the knowledge and membership of various social contexts that contribute to the linguistic meaning. As

Wortham et al., (2017) state, “discourse in educational settings simultaneously accomplishes social processes that include ideologies, social identities, power relations, and enduring struggles, while also facilitating academic and informal learning that involves argument and evidence (p. XVIII).”

Recognizing the role of discourse in education, many researchers have been paying attention to discourse theory and research. The number of research focusing on discourse has grown remarkably since the late 20th century. Some of these researches focus on how discourse legitimizes different forms of segregation in classroom interactions and curriculums to join the discussions on gender, race, and cultural differences (Hughes, 2000, 2001; Millar, 1997; Yosso, 2002). At the same time, others paid attention to discourse to understand what was taking place in the classrooms discursively to meet the needs of reform efforts. Since the main goals of educational reform efforts in the last few decades were to support the development of communication skills and effective teaching. Also, to accomplish these goals, promoting higher-order thinking and reasoning and encouraging student interactions in a constructivist learning environment were necessary (Cazden & Beck, 2003; Walsh, 2006). The same concerns also led researchers to focus on the discursive properties of textbooks (van Dijk & Atienza, 2011). Moreover, discourse theory and research provided new tools for policy research to study the different contexts influencing policy (e.g., social, historical, and political contexts) and their implications for power hierarchies and emancipation (Anderson & Holloway, 2020; Fairclough, 2009). Thus, educational policies also became a topic of interest, expanding the scope of research on discourse in education.

For over two decades, discourse studies contributed significantly to the educational research literature and provided a deeper understanding of the reciprocal relationship between knowledge construction and discursive activity. These studies revealed that discourse plays a significant role in social practice, either supporting or constraining students' access to the promoted knowledge in educational settings (Christie, 2002; Colins & Blot, 2003; Murphy et al., 2018; Rogers, 2004). As they extensively investigated the complex and dynamic relationships among discourse, social practice, and learning. These studies showed us that within and across educational events, it was

the discourse that determined “what counts as knowing” and the acceptable ways of “doing things” and “being” (Anderson & Holloway, 2020; Gee & Green, 1998). The discourse of educational policies and standards regulates these benchmarks of educational activities. Therefore, it is not surprising that all forms of language use, interactions, and their participants (e.g., classroom, curriculum, policy discourses, and teacher-student, student-student interactions) attracted researchers’ attention (Flowerdew & Richardson, 2017; Lim, 2019; Wetherell et al., 2001), and ‘the study of language-in-use’ (Wetherell et al., 2001) became so prolific for educational researchers.

## 2.2. Discourse in Science Education

The use of scientific discourse, or as Lemke (1990) puts it, “talking science,” is an essential part of science teaching and learning. Yet, many studies show that talking science is a challenge for students (Bennett et al., 2010; Dou et al., 2019; Lemke, 1990). Science has its unique language and established norms for how to write, symbolize, communicate and talk about scientific knowledge. This particular language directly affects what is taking place in science classrooms and provides ample sources for discourse studies (do Nascimento, 2013; Hsu & Roth, 2014; Roth, 2004). Therefore, researchers in science education pay close attention to the classroom discourse as a crucial part of the meaning-making processes in science classrooms (Kelly, 2007). However, discourse theory and research encourage researchers to study knowledge construction, the dissemination of scientific knowledge, and how particular knowledge or information is shared and made available to others through ‘language in use’ (Pérez-Llantada, 2012). Therefore, they open even more doors for researchers to explore the role of discourse in science education.

In the late 20th century, Lemke’s (1990) influential work Talking Science introduced the classroom discourse as a topic in science education literature. It gave us a glimpse of how discourse can be used to maintain power by the teacher in science classrooms. In this groundbreaking set of studies of secondary science classrooms, Lemke used the social semiotic framework and revealed both thematic and organizational patterns in science discourse promoted in the classroom. These patterns showed us how the

teachers controlled acceptable ways to talk science (use scientific discourse) and how using the question-answer-response pattern (triadic dialogue) controlled the direction and content of the lesson. Teachers' strict use of scientific language portrayed science as ideological, and students had little opportunity to talk science. Lemke argued that students need to 'talk science' to learn science, "students have to learn to combine the meanings of different terms according to accepted ways of talking science" (p.12). Lemke's research on 'teachers' talk' and how they control the content of science lessons with strict use of scientific language led the researchers to question the relationship between teachers' content knowledge and the use of language.

Influenced by this research and recognizing the potential of discourse for learning and instruction, many researchers developed their own discursive approaches. Therefore, to assist science learning through discourse, different frameworks emerged like 'transformative communication' (Polman & Pea, 2001), 'Toulmin's argumentation pattern' (Erduran et al., 2004), 'improvisational science discourse' (Jurow & Creighton, 2005), 'heuristics for progressive disciplinary discourse' (Windschitl et al. 2008). Although the effectiveness and popularity of these frameworks in the field vary, they helped discourse theory and research to find their footing in science education literature.

On the other hand, progressively more studies in science education show that students struggle with scientific discourse because there are substantial differences between what is promoted in the classrooms and 'students' everyday discursive repertoire' (Hsu & Roth, 2014; Kelly, 2014; Roth, 2004). The broad spectrum and dissimilarity of semiotic communicative forms of scientific discourse are challenging to students since they have very little prior experience with these forms. The grammatical and semantic forms of science, including passive voice, abstraction, nominalizations, scientific symbols and notational systems, and scientific vocabulary (Halliday & Martin, 1993), are often alienating to students. This also leads students to think that science is complex, challenging, and reserved for cognitive elites, and who can access what science education offers is strictly controlled (Kelly, 2015). Findings of discourse studies in science education showed that to make the language of science their own; students need to 'talk science' (Lemke, 1990; Varelas et al., 2008). After investigating

the ways, second and third-grade students combine their own conceptions and the scientific conceptions about matter introduced to them by teachers through student-student and student-teacher interactions. Varelas et al. (2008) concluded that the ways teachers mediate classroom interactions make a difference and urged future researchers to pay attention to the social-organizational aspect of meaning-making as children construct meanings and reach understandings that are influenced and negotiated within the power structures in a classroom. Prior research in the field also had a similar perspective. They suggested that if teachers emphasize scientific discourse in its most strict form endorsed by the scientific communities, this may cause students to lose interest in science (Lemke, 1990; Moje, 1995, 1997).

Focusing on the role of discourse in high school chemistry classrooms, Moje (1995) utilized constant comparative analysis (Glaser & Strauss, 1967; Strauss, 1987) and a sociolinguistic framework. Moje's constant comparative analysis revealed that certain discursive choices like precision in language use and demarcating science from other disciplines positioned science and science teachers as expert authorities. Such discursive choices also established the power relationships in classroom conversations. Moje's research showed that scientific discourse promoted by the teacher could influence the students' role in the classroom and can be an instrument to provide access to scientific knowledge for students.

Such emphasis could also create hierarchical roles for students and teachers, giving more power to science teachers as authorities within the classrooms (Moje, 1997). The discourse of science promoted in the classroom influences the views of science made available to students (Moje, 1997). Teachers' questions and the way they use scientific discourse control the social context of the learning environment (Roth, 1996; 2004). Therefore, teachers can make complex concepts like the nature of science or socio-scientific issues accessible to students through certain discursive choices (Lemke, 1990; van Zee & Minstrell, 1997; Walker & Zeidler, 2007) or prevent students from gaining access to scientific knowledge (Varelas et al., 2008).

Discourse studies widen their perspective by focusing more on scientific knowledge and inquiry and how scientific discourse delivers this content. Questioning how proper

language use can give students access to scientific knowledge and practice, van Zee and Minstrell (1997) studied an exemplary physics teacher who used a specific questioning method called a reflective toss. Contrasting with Lemke's (1990) triadic dialogue, this three-part questioning method starts with an initiating student statement followed by a teacher question and finally student elaboration, which leads to classroom conversations and students' questions. The reflective toss method changed the structure of classic teacher-controlled scientific discourse and created discourse events enabling students to participate in the cognitive processes of the lesson. van Zee and Minstrell's (1997) study showed that teachers' questions could play a significant role in student learning and raised some questions about the role of students' questions and the use of language in classroom conversations.

Focusing on students' use of language as well as teachers, Kelly, Brown, and Crawford (2000) studied their ways of investigating and knowing science discursively by utilizing a sociolinguistic discourse analysis rooted in an ethnographic perspective. In this research, elementary students' language use was encouraged through teaching practices by positioning teachers as co-investigator and creating a community of learners. This established social environment valued listening and students' suggestions regarding the progression of the investigations. The research showed that the teacher's openness to students' opinions and interests outside the curricular objectives as a part of investigations enabled them to contribute to and alter the curriculum by sharing the outcomes of their informal science experiences. The findings of this research also showed that if teachers relinquish their role of authority and take the role of the facilitator who is "in authority" with the students, they could create a community of learners. Also, by enabling students to take the roles of scientists and spokespersons, the teachers can encourage them to express their ideas in a more eloquent way with clear reasoning, and in a respectful manner to their peers' ideas. To assure the quality of the investigations conducted by the community of learners, the teachers could use particular discourse strategies during science discussions and model the specific ways of talking science for students. Moreover, through modeling, the teachers could assist students' discursive preferences regarding articulating perspectives, providing evidence for claims, and utilizing other scientific

process skills. Therefore, Kelly, Brown, and Crawford's (2000) research findings raised questions about the relationship between the instruction of scientific language and students' scientific thinking in the literature.

Kelly and Bazerman (2003) investigated the ways students can be involved in practices that require scientific reasoning by creating written arguments. In this study, university students' scientific writing was analyzed using rhetorical semantic analysis combining genre analysis, epistemic generality, and lexical cohesion frameworks. The study used genre analysis to identify the rhetorical moves of these university students, epistemic generality to observe the relationship between the theoretical assertions and empirical data, and the analysis of lexical cohesion to map the recurrence and relationships of topics. Results showed that purposeful instruction enabling students to practice scientific language could help students to adopt scientific thinking and arguments can provide evidence that the students know how to think scientifically.

As discourse studies adopted new perspectives, different approaches to discourse emerged. Some studies divert from the mainstream and approach discourse as a "representational medium" (Roth & Duit, 2003) and a "means of doing science" (Yore et al., 2006). Recognizing the strong connection between argumentation and discourse in science, some researcher turned their attention to argumentation (Erduran et al., 2004; Jimenez-Aleixandre et al., 2000). Also, the role of student identity, the relationship between discourse and assessment, and the ways students adopt and appropriate scientific discourse became some of the noticeable research topics in the field.

Recognizing the need for research on the role of cultural identity and cultural practices in science education Brown (2006) explored the ethnic minority students' ways of managing their assimilation into the culture of the high school science classrooms and how using scientific discourse and assimilating into the culture of science classroom affected students' identities and their interpretation of science. The results suggested that students experienced very little difficulty in adopting cultural behaviors but struggled with the discursive practices of science. Part of the research entailed students' discussions about the ways these discourse practices influenced their

learning experience. These discussions revealed that discursive practices of science were perceived as a unique and intensive genre for communication by the students, especially, the nature of science discourse which has no commonality with their typical discursive behaviors. Students repeatedly described the nature of science discourse as containing double meanings. In addition, they described the distinctive differences they perceived between text writing and verbal discourse in science. Thus, the findings of this study provided some needed information regarding to the assimilation of students to scientific discourse and underlined the need for discourse studies to emphasize the relationship between students' identity and their scientific literacy development.

As the knowledge gained by discourse studies increased in science education, some studies began to focus on different aspects of student-student and teacher-student interactions and incorporate other frameworks and methodologies into these studies. Anderson et al.'s (2007) study of small group interactions in feedback activities and Barton and Tan's (2009) design experiment investigating the different types of funds of knowledge and discourse that students brought into science classes can be given as examples of such studies. On the other hand, some researchers chose to particularly focus on the teaching and learning of discourse of science. For example, Hsu and Roth's (2014) conducted a micro analysis of moment-to-moment interactions of high school students attending an internship program in a university laboratory. Framed with Bakhtin's (1981) dialogism, this research proposed that learning science is a process of appropriating authoritative discourse into internally persuasive discourse. In Bakhtin's (1981) dialogism, authoritative discourse refers to the discourse that permits no change in its structure or context, while internally persuasive discourse is the freely developed discourse that allows for the adoption of the new context. In general terms, the research suggested that learning science requires students to internalize authoritative scientific discourse while appropriating its content for their own. The findings suggested that science teaching and learning require both science and non-science language to create a constantly evolving heterogeneous process. Based on these findings, researchers used the framework of discursive evolution to explain the processes of teaching and learning the language of science. They identified

four stages of discursive evolution: “(a) using deictic references to connect scientific terminologies, (b) understanding science terminologies through its derivatives, (c) communicating science practices conventionally through science terminologies, and (d) communicating science practices innovatively through mutated science terminologies” (Hsu & Roth, 2014, p.729).

The studies in the special issue of Research in Science Education journal “The Methodology of Classroom Discourse Analysis in Science Education” (Convertini, 2021; Franco & Munford, 2021; Sandoval et al., 2021; Tang et al., 2021; Wilmes & Siry 2021) can be considered as evidence that classroom discourse is still emphasized by discourse studies in science education. The recent studies in this special issue also show that discourse plays a significant role in science classrooms in terms of reasoning (Convertini, 2021), meaning-making (Franco & Munfold, 2021; Wilmes & Siry, 2021), and how norms created by discourse affect agency (Sandoval et al., 2021). However, if we overlook this emphasis put on the classroom discourse, the contextual and theoretical, variance in discourse studies in science education is remarkable. Considering the significant role of discourse as a mediator in most aspects of education (Wortham & Perrino, 2017), the potential appears to be unlimited. However, there is almost no research studying the community or communities that influence the discourse of science education by establishing the norms of communication through their own discursive choice. Given that the discourse of science education literally controls students' access to scientific knowledge and has an effect on what we observe in the classrooms and every interaction that takes place in science education, there is a significant gap in the literature that needs to be addressed. Therefore, by claiming that the community or communities that influence the discourse of science education are epistemic in nature, this research aims to address this significant gap and investigate some fundamental exploratory questions that need to be asked to get a better understanding of the epistemic communities' discursive choices in science education and their role in the promoted power difference in the field. In the following sections of the literature review, what constitutes discursive choices and how this research defines epistemic communities are explained and relevant research in the literature is presented.

## **2.3. Discursive Choices**

As Gee (2004) suggests that discourse as a tool enables us to “fit our language to a situation that our language, in turn, helps to create in the first place” (p.10), which actualizes the two fundamental functions of human language; to “perform social activities and social roles” and “affiliate with cultures, social groups, and institutions” (p.1). If we apply this perspective to academic writing, writers of academic texts make various discursive choices to “perform social activities” (e.g., write an article) and “social roles” (e.g., researcher, reviewer) and “affiliate with social groups” (e.g., a field of research, scientific communities, discursive communities, epistemic communities). Therefore, through the discursive choices, they display their identities (Yang, 2013) and affiliate with not only social groups but also the discourses of these groups by “developing the capability to participate in discourse communities” (Duff, 2007, p.01.4). In written texts, the discursive choices of the writers include how the text and information are organized and what linguistic features are used, how these features are used, and what semantic information is shared (Fairclough, 2001; Gee, 2004; van Dijk, 1985). Although the organization of academic texts is usually genre-based (research article, review article, etc.) (Flowerdew, 2000) and predetermined by the medium of publishing (journal, handbook, book conference proceedings, etc.), writers make important discursive choices while organizing the text, especially regarding titles and subtitles. Also, writers’ discursive choices regarding titles, linguistic features, and semantic information significantly influence and are influenced by the norms, expectations, and discourses of the communities they affiliate. In the following sections, relevant information and prior research on titles and some linguistic features are given to clarify what is being investigated by this research as it explores the discursive choices of epistemic communities in science and elementary science literature.

### ***2.3.1 Research on Titles***

According to Soler (2011), “Titles are succinct descriptive labels of texts and are meant to fulfill different purposes, such as to individualize a publication, summarize its content and appeal to its audience, among others” (p.124). Titles of journal articles

are expected to convey the topic effectively and be clear, accurate, and precise (Hartley, 2008). Considering their roles, titles should draw readers' attention and provide enough information about the content to allow readers to decide whether to continue reading (Shahidipour, & Alibabae, 2017; Yitzhaki, 1994).

Titles can be categorized according to their functions. Eyrolle et al. (2008) present a model of title functions categorize titles into six functional groups. According to this model, titles can be thematic, functional, generic, relational, framing, and performative. Thematic titles explain what the textual unit deals with. Functional titles give information regarding the role of the textual unit. Generic titles indicate the sort of utterance the textual unit constitutes. Relational titles explain the relation of the textual unit with the others. Framing titles give information about how the textual unit is framed. Finally, performative titles indicate what sort of speech act the textual unit performs. Titles also vary according to the text level they are used in, main titles, and subtitles.

Research on titles reveals that titles vary especially across disciplines regarding their length, wording, and functions. Moreover, in similar studies, it has been observed that the aforementioned variables differ within disciplines and subdisciplines. Yet, in terms of syntactic structures and informativity, these studies have reported some significant similarities. Research focusing on the length of titles showed that the length of titles differs considerably within and across disciplines. For example, after investigating the titles of the 600 research articles, Anthony (2001) concluded that titles of subdisciplines of computer science vary significantly in terms of their length, wording, and functions. Also, both Busch-Lauer (2000) and Haggan (2004) found that science titles were verbose and lengthy compared to the literature and linguistics titles. Studies focusing on different text formats like research articles, dissertations, books, etc., found that dissertation titles have the highest number of words, while book titles have the least number (Gesuato, 2008). On the other hand, the studies also showed that individual preferences of the authors of the articles could have an effect on these factors, especially the title length (Afful & Mwinlaaru, 2010).

Research investigating the syntactic structure of the titles revealed that noun phrases were the most frequently used syntactic structure in the titles (Fortanet et al., 1998). Haggan (2004) also found that nominal constructions were favored by science and linguistics titles. Frequent use of nominal constructions in titles was also supported by other studies (Afful & Mwinlaaru, 2010; Cianflone, 2010; Siso, 2009). Also, Gesuato (2008) observed that in books, dissertations, journal articles, and proceeding papers, noun phrases were used, frequently exceeding %80 in each genre. The findings of recent studies also suggest that there are some discipline-specific differences among titles in terms of syntactic structures (Moattarian & Alibabaeen, 2015).

Recent studies on article titles suggest a relationship between the length of article titles and citation rates (Habibzadeh & Yadollahie, 2010; Jacques & Sebire, 2010; Rossie & Brand, 2020). These studies showed that articles with long titles are cited more. Especially those referring to the methodology or their results, hence providing more information for the readers and attracting their attention. Also, this relationship appears to be moderated by the impact factor of the journal; higher impact factor means a stronger relationship between title length and citation rate (Habibzadeh & Yadollahie, 2010). Researchers also claim that high citation rates might be related to specific title characteristics particular to a field and as judged by certain title words, some topics would appear more common in highly-cited papers than in poorly-cited papers (Jacques & Sebire, 2010)

### **2.3.2 *Linguistic Features***

First chapter of the thesis There are many linguistic features that linguistic researchers use to analyze texts and these features are often categorized and examined under three constructs: lexical, syntactic, and cohesion (McNamara et al., 2010) in this field. However, within the scope of this research, only the linguistic features that the CDA pays particular attention to were relevant. Therefore, since this research utilized Fairclough's (2001) triadic CDA, the linguistic features particularly addressed within this approach are explained below.

*Genre:* A genre refers to a categorization of any form or type of communication which could be written, spoken, or an artistic expression like music, art, film, etc. In discourse analysis, it signifies the category of a particular type of text. Generally, these categorizations are subjective and based on some socially agreed-upon conventions over time. Genres often have sub-genres. For example, the genre of research articles could be subdivided into the fields of research like education, politics, history, etc., and each of these sub-genres could be divided even more (science education, math education, so on...). One important point is that these categorizations and divisions should serve a purpose and have agreed-upon conventions. Fairclough (1995) defines a genre as “a socially ratified way of using language in connection with a particular type of social activity” (p.14) or “different ways of (inter)acting discoursally” (Fairclough, 2003, p. 26).

*Readers' Attention:* Readers' attention can be manipulated by choosing and placing certain components of the texts in a purposeful manner. The arrangements of the paragraphs, titles, use of diagrams and sketches, quotations, italics, and other embellishments can be used to direct readers' attention either to or away from certain components of the text (McGregor, 2003). The writer's choices for directing readers' attention provide information for CDA by giving clues about the roles of other communicative tools and how they are being used besides words.

*Foregrounding /Backgrounding:* Either by using physical placement or other means of language use like emphasizing through word choices or syntactic structure, some parts of the text can be portrayed as important. When a writer gives prominence to parts of a text, this is called foregrounding. The opposite of foregrounding is backgrounding, making parts of a text appear unimportant. CDA pays attention to foregrounding and backgrounding because, depending on the writers' choices, certain pieces of information can be emphasized or de-emphasized (Baker & Ellece, 2011). Some other linguistics features could complement backgrounding, like absence, nominalization, the use of passive voice, etc. In CDA, foregrounding and backgrounding are frequently used to analyze the ideological stance of the writer (Fairclough, 2001).

*Absence:* According to van Leeuwen (2015), absence refers to ‘something missing’ that could be in language use or discourse. To detect something that is missing in the text is a difficult task since any given text is expected to have a logical consistency and inclusiveness to serve its purpose. Therefore, to detect what is absent, researchers are required to refer to additional sources. Different methods can be used to identify absence. For example, corpus linguistic techniques can be used by comparing a single text with a set of reference texts or comparing two similar texts or sections of a text against each other. Also, in some cases, researchers with different backgrounds can be involved in the analysis to detect what is missing in the text. Including absence in the analysis and acknowledging that what is missing in the text also contributes to the constructed meaning of what is present, helps researchers investigate the intentionality of the writer’s choices in CDA.

*Presupposition:* While we read a written text and process its meaning, we deduct various information which is not clearly stated in the text. The writer of the text presupposes that the readers would understand this information. Baker and Ellece (2011) define presupposition as ‘an unwritten proposition’ which is accepted to make sense of the written statement. There are various lexical classes and construction that are considered to be the basis for presuppositions: factives, aspectual verbs, temporal clauses headed by “before,” “after,” “since,” etc., manner adverbs, sortally restricted predicates of various categories, cleft sentences, quantifiers, definite descriptions, names, intonation (Stanford Encyclopedia of Philosophy, n.d.). One example of presupposition could be the previous sentence; the sentence presupposes that ‘presuppositions’ can have a different basis. Yet another simple example could be ‘I am the writer of this theses. The sentence presupposes that I exist. Fairclough (2001) suggests that presuppositions can be used to analyze writers’ commonsense assumptions, beliefs, and attitudes that are taken as given. Since presuppositions help us identify the implicit meanings in the text and what is taken for granted by the writer, which might have some connections to ‘intertextual relations’ (Fairclough, 2001), they are quite useful tools for CDA.

*Agency:* From a grammatical perspective, an agent can be described as the participant who carries out an action. Even though it appears similar to the term ‘subject,’ this

similarity is all relative to the word order and importance in the sentence. For example, in the sentence ‘The researcher evaluated the results,’ the researcher is both the subject of the sentence and the agent who carried out the action -evaluation-. However, if we would like to emphasize that the results were evaluated, we can rearrange the words in the sentence, ‘The results were evaluated by the researcher.’ In this sentence, ‘the researcher’ is still the agent, but the subject of the sentence is now ‘the results.’ Depending on the writers’ discursive choices, an agent can be represented in various ways. So linguistically, agency refers to how characters or objects are represented in relation to each other (Baker & Ellece, 2011). Therefore, agency helps us figure out how social actors are represented in the text.

*Nominalization:* According to Halliday (1994, p. 41), nominalization is a grammatical expression “whereby any element or group of elements is made to function as a nominal group in the clause.” If simply put, it refers to the conversion of processes into nominals (relating to or constituting a name) (Fairclough, 2001, p.103). For example, a verb – understand- can be converted into a noun -understanding- or an adjective -difficult- can be converted into a noun -difficulty-. For example, without nominalization, it is clear from the sentence ‘I understand this concept’ that I am the one who understands the concept. However, with the nominalization ‘Understanding this concept...’ I disappear from the sentence. Nominalization can be used to hide who is carrying out the process. It can even be used to obscure blame or dehumanize certain groups. Scientific texts especially favor nominalization in order to appear ‘objective’ (Fairclough, 2001). Therefore, nominalization provides useful information for CDA to determine the effects of the writer’s choices in the text.

*Active and Passive Sentence Use:* In the text, depending on the writers’ choices, ‘action processes can appear as active sentences or as passive sentences (Fairclough, 2001; p. 104). In the formation of the active sentence, the subject of the sentence performs the action. Whereas, in the formation of the passive sentence, the subject of the sentence has an action done to it by someone or something else. By simply changing the formation of the sentence, the writer could represent the subject differently. In an active sentence, it is presupposed that the subject has the capability/position/ power to perform the action. On the other hand, when the sentence is constructed as passive, it

is presupposed that the subject either allows or has no power to prevent the action done to it by someone or something else, or the subject is irrelevant. A writer can also use a passive sentence to remove the agent from the sentence. In such cases, as readers, we may not have background knowledge or access to determine who is performing the action that affects the subject. For example, a sentence with no agent, like ‘The students were evaluated,’ does not give enough information with regards to the performer of the action -evaluation-. We could only make assumptions based on our experiences or what is insinuated by the text. Therefore, as readers, if the writer chooses to omit that information in the text, our perception can be manipulated. CDA pays attention to the ways that sentences are constructed to investigate the representation of power and manipulation of readers’ perceptions by the writer (Fairclough, 2001).

*Insinuations:* Insinuations are one of the manipulative tools that a writer could use to indirectly express derogatory, critical, or unfavorable meaning or the opposite. It is usually a sentence-level device that requires some background knowledge so the reader can understand it. Therefore, not all insinuations in the text can be understood by all the readers. However, writers often use insinuations when they try to make the reader believe or assume something but do not want to be held accountable for expressing it (Camp, 2018). Since CDA investigates the ways discourse produces and reproduces domination, insinuations play an important role in the analysis. Why the writer chose to use insinuations and the reasons that s/he is trying to avoid accountability reveal more information about the power relations represented in the text than what is explicitly written.

*Connotations:* A word can be used to imply a meaning which is different than its literal or explicit meaning (its denotation). This different meaning usually suggests cultural or emotional associations. The implied meanings of the words are called connotations. According to sign theory (Saussure, 1966), a sign consists of a signifier (the representation of something) and what is signified (the mental construct of what is being represented). Words, either in written forms or in utterance, are signifiers. For example, the word ‘cold’ signifies having a relatively low temperature (denotation), which is represented in our mental construct as we read or hear the word. Yet, in a

sentence like ‘S/he is cold,’ what the word cold signifies may differ depending on the context of the conversation. S/he might be affected by the low temperature, or s/he might be acting distant in social interaction. The relationship between signifier and signified is not fixed. It depends on the language users’ discretion. Words may have the same denotative but different connotative meanings. Therefore, by simply choosing to use one word instead of another, connotations can be used to express positive or negative attitudes. For instance, instead of saying ‘S/he is childish,’ suggesting her behaviors are immature, we could say ‘S/he is youthful,’ implying that her behaviors are lively and energetic. In CDA, connotations are the indicatives of the writer’s position and provide invaluable information about the promoted power relationships represented in the analyzed text.

*Modality:* In the text, modality can be detected by the set of words called modal verbs, including should, would, will, could, can, may, must, and shall. Also, there are some words called ‘semi modals’ to express modality (Leech, 2004), like have to, need to, and want to. Moreover, adverbs such as perhaps, probably, necessarily, and inevitably are also called modal adverbs. The identifying characteristic of the modal words is that they express either possibility (epistemic modality) or necessity (deontic modality). When close attention is paid to these words, they reveal the power inequalities in the text. Epistemic modalities, which are used to express possibility, allow a writer to portray different representations of the world shaped by her choice of words. In contrast, deontic modalities expressing necessity can be used to appoint a position of authority.

*Subject Positions:* Davies and Harré (1990, p.48) define positioning as ‘the discursive process whereby selves are located in conversations as observably and subjectively coherent participants in meaning-making. Both conversations and written texts include various positionings. If what a person says positions the other person it is called interactive positioning. Also, in a conversation or a text a person can position oneself, in this case, this positioning is called a reflexive positioning. Thus, social actors or individuals are given certain roles and identities by the discourse which are referred to as subject positions. As Angermuller (2018) states, “discourse not only represents value and the social order but, through representation, it also contributes to constituting

the social as a hierarchical world of more or less valued subject positions” (p.414). Therefore, subject positions promoted by the discursive choices of the text provide valuable information regarding their power difference and hierarchical roles. Since one of the questions this research aims to answer was “Do the discursive choices of the epistemic community of science/elementary science education create power differences?” particular attention was given to this linguistic feature in the research design.

Like subject positions, nominalizations carried great importance for this research. Nominalizations are heavily used in scientific texts and speculated to be developed in the scientific register (Halliday, 1993). Moreover, they turn processes into entities, which is often how scientists create new terminology (Halliday & Martin, 1993). Given that this research focuses on science/elementary science literature and the discursive choices of the epistemic communities located in this literature, it is clear that nominalizations also carried great importance. Therefore, in the following sections, relevant research on subject positions and nominalizations is presented.

### ***2.3.3 Research on Subject Positions***

In education literature, current research on subject positions often utilizes Davies and Harre’s (1990) positioning theory, often used to explore classroom discourse. Studies focus on constructed identities (Duff, 2002; Wood, 2013), gender and gender identities (Clarke, 2006; Nguyen & Yang, 2015), and the self-positioning of teachers and students (Maloch, 2005; Trent, 2012) often utilize positioning as an analysis tool. Also, positioning analysis can easily be combined with CDA since both approaches claim that power, control, and agency influence and be influenced by discourse practice and aim to explore these influences (Kayı-Aydar, 2019). Positioning analysis can also be used as a tool in CDA. For example, while studying the discursive positioning of native English teachers in Hong Kong schools, focusing on self-positioning, Trent (2012) utilized referential identity categories (Bucholt & Hall, 2005) with Fairclough’s CDA approach (2001). However, in education literature, subject positions as linguistic features are rarely investigated in texts. Linguistics studies pay attention to subject positions and investigate “the identities and roles, the sets of labels and categories that

allow people to be recognized as members of a discourse community” (Angermuller, 2018, p.416). These studies also investigate how discursive practices create dominant and dominated subject positions within a population and how these positions could have material consequences (Beetz & Schwab, 2017). Moreover, considering academic discourse, linguistic studies show that “whatever the ideas and intentions academics want to convey through academic discourse, they are always engaged in social practices of constructing subject positions” (Angermuller, 2018, p.420). In the discourse and critical discourse analysis approaches, subject positions are particularly investigated, as they provide information regarding the social actors or individuals and their ascribed roles and identities (Gee, 2004). Since discourse analysis is not only concerned with how the text is produced but also how discourses become commonsensical accounts of how the world works. Subject positions help explain how text produces accounts of the world (Sabaratnam, 2020). Therefore, investigating this linguistic feature of the texts provide particular information regarding the power structures promoted by the discourses.

#### ***2.3.4 Research on Nominalizations***

According to Halliday (1994, p. 41), nominalization is a grammatical expression “whereby any element or group of elements is made to function as a nominal group in the clause.” Simply put, it refers to “the conversion of processes into nominals (relating to or constituting a name)” (Fairclough, 2001, p.103). For example, a verb – understand- can be converted into a noun -understanding- or an adjective -difficult- can be converted into a noun -difficulty-. Nominalizations are considered an aspect of complexity in written language (Halliday & Matthiessen, 2004). In academic writing and scientific texts, nominalizations are frequently used (Baratta, 2010; Halliday & Matthiessen, 2004) to maintain an authoritative, impersonal tone by removing agency and to provide textual cohesion by connecting the elements of the text with structured sequences of words.

Previous research findings show that nominalizations are a distinctive linguistic feature of scientific texts (Ravelli, 1996). Compared to other texts where nominalizations are used, like written speeches and non-academic writings, the

frequency of nominalizations within academic texts is considerably high (Biber et al., 1999), accounting for around 15% of the nouns (Biber & Gray, 2016). These findings can be attributed to scientific texts' noun-heavy register (Hyland & Jiang, 2021). As Halliday & Martin (1993) suggests, the frequent use of nouns and nominalizations is expected in scientific texts since science is interested in exploring and explaining the 'things' observed in the natural world. Also, using a noun-heavy register enables these texts to adopt an abstract, impersonal, and information-oriented tone (Taavitsainen & Pahta 2000), but more than that, the use of nominalizations allows academics to create their own nouns or terminologies (Halliday 2004; Banks 2008).

Nominalizations are helpful for academic writers in many aspects. They convey a large amount of knowledge with few words and help meet the word limits of journals (Biber & Gray 2013). Also, by compacting certain information into nominalizations, writers can organize them and connect and compare them with other information in a few words without needing to restate their previous explanations (Halliday, 2004; Hyland & Jiang, 2021). Using nominalizations as subjects or objects of a sentence saves time and space for the writers and enables them to avoid redundancy. Instead of repeating the previously given information in its entirety, nominalizations help writers keep the flow in the text by bringing the elements of the text together with structured sequences of words to assure cohesion (Eggins, 2004). Compacting information with nominalizations and using them as objects or subjects of a sentence creates 'discursive flow' (Derewianka, 1990; Fang et al., 2006), in which sentences follow each other while word sequences and meanings are preserved to make the transitions seamless.

The use of nominalizations affects other linguistic features of the text, like agency and grammar. Nominalizations usually remove the agency (actor) from the text, and along with the agency, significant information and sometimes true meaning can be lost (Billig, 2008; Fang, 2004). For example, without nominalization, it is clear from the sentence 'I understand this concept' that I am the one who understands the concept. However, with the nominalization, 'Understanding this concept...' the agency, the actor of the action, disappears from the sentence. Since semantic information is hidden from the reader with nominalization, it can be used intentionally to hide who is carrying out the process, obscure blame, or dehumanize certain groups. Scientific texts

especially favor nominalization to appear ‘objective’ (Fairclough, 2001). However, when they are not appropriately used, subjective experiences can also be represented as objective scientific truths with nominalizations (Viechnicki & Kuipers 2006). Also, if nominalizations are frequently used within a text, semantic information hidden from the reader makes it difficult to decipher the information compacted in nominalizations (Kazemian et al., 2013) since the text becomes dense with information yet presented ambiguously with abstraction. Moreover, the use of nominalizations changes the semantics of the text and the grammatical structure by adopting more passive sentence structures. Hence, adding another layer of complexity for the reader (Halliday & Matthiessen, 2014). Therefore, nominalizations combined with the information gathered from other linguistic features of the text, like agency and grammar, provide useful information for CDA to determine the effects of the writer’s discursive choices in the text.

The use of nominalization has been a subject of various research. Most of the studies particularly investigating nominalizations focus on the frequency of its use in texts (Biber et al., 1999; Biber & Gray, 2016; Charles, 2003; Degaetano Ortlieb & Teich, 2019), and the results of these studies show a constant increase in the use of nominalizations in academic writing over time. While other studies in the literature focus on its historical origins (Banks, 2005), its contribution to cohesion (Susinskiene, 2009), and its role in the students’ scientific writing and acquisition of academic writing skills (Baratta, 2010; Hoadley-Maidment, 1997; Jodairi Pineh, 2022) and the nominal styles used by texts (Jalilifar et al., 2014; 2017). The findings of all these studies repeatedly emphasize the role of nominalizations in the formation of discourse. Even though linguistic studies provided ample sources of information regarding the various use of nominalizations, subject positions, other linguistic features, and organization of the academic texts, very little is known about the discursive choices of epistemic communities of science and elementary science education literature. Therefore, there is a significant gap in not only education literature but also in linguistics literature.

## **2.4. Epistemic Communities**

Although it is not a widely used term in education literature, the term ‘epistemic community’ is gaining some recognition in education and science education literature (Glazer & Peurach, 2015; Kelly, 2014). However, this recognition is still limited. Moreover, the definition and philosophical roots of the term epistemic community (communities) are rarely discussed in education literature since the versatile nature of the term ‘epistemic’ and the variance of ‘epistemology’ as a philosophical approach creates a challenge. To meet this challenge and define epistemic communities, a particular philosophical perspective needs to be adopted. Therefore, in this section, (a) first linguistic and philosophical roots of the term “epistemic communities” will be discussed, (b) second, the historical development of this term will be summarized, and (c) finally, the reasoning behind adopting Haas’s (1992) definition and epistemic community definition utilized by this research will be explained.

The words ‘epistemic’ and ‘epistemology’ are closely related to the Greek word ‘episteme,’ which is derived from the verb ‘epistenai’; the prefix epi- (to know) is combined with the verb ‘histenai’ (to cause to stand) (Miriam Webster, n.d.; Online Etymology Dictionary, n.d.). There is not a single all-inclusive definition of ‘Episteme’; it can mean knowledge, understanding, or acquaintance based on the philosophical ground of the translation (Stanford Encyclopedia of Philosophy, n.d.). Therefore, in relation, the definition of ‘epistemic’ has the exact versatile nature; ‘epistemic’ could mean ‘relating to knowledge,’ ‘relating to understanding’ and ‘relating to an acquaintance,’ as well as ‘relating to the degree of knowledge’s validation’ (Stanford Encyclopedia of Philosophy, n.d.), a principled system of understanding’ (Foucault, 2019). Thus, these different definitions are associated with different philosophical accounts like Aristotle’s episteme, neo-Aristotle episteme, Foucault’s episteme, etc. (Greco, 2014; Stemple, 1981). As such versatility allows this term to be adapted for numerous contexts, contingent on the researchers’/authors philosophical perspective, the term epistemic could be used in various ways.

A whole branch of philosophy is dedicated to studying this versatility, namely ‘epistemology,’ which also mimics the challenge the term epistemic creates for the

researchers and philosophers. Throughout history, philosophers have supported many different approaches to epistemology. These different approaches are summarized in the Stanford Encyclopedia of Philosophy (n.d.) entry as follows;

In different parts of its extensive history, different facets of epistemology have attracted attention. Plato's epistemology was an attempt to understand what it was to know and how knowledge (unlike mere true opinion) is good for the knower. Locke's epistemology was an attempt to understand the operations of human understanding, Kant's epistemology was an attempt to understand the conditions of the possibility of human understanding, and Russell's epistemology was an attempt to understand how modern science could be justified by appeal to sensory experience. Much recent work in formal epistemology is an attempt to understand how our degrees of confidence are rationally constrained by our evidence, and much recent work in feminist epistemology is an attempt to understand the ways in which interests affect our evidence and affect our rational constraints more generally. (p.1)

Considering all these variances and different approaches, it is clear that defining 'epistemic community' is not an easy task. Different definitions could be used to explain epistemic community based on the various meanings of 'episteme' and the different philosophical approaches to epistemology. For example, epistemic communities can be defined as; 'a community that influences and shapes our knowledge/understanding/acquaintance of how we know what we know' or 'a community that decides what is necessary for our understanding,' or 'a community that determines how science could be justified/ what counts as scientific,' or 'a community that investigates how our degrees of confidence are rationally constrained by our evidence' or 'a community that assesses how interest/beliefs affect our evidence.' Therefore, definitions of epistemic community contain a particular understanding of episteme and an approach to epistemology. Early definitions of the epistemic community have this characteristic. The researchers who introduced this term to the literature, Holzner (1972) and Ruggie, (1975), notably avoided addressing the multi-faced nature of the term. They focused only on the 'epistemic criteria' and 'members faith in common scientific method' as they defined it (Meyer & Molyneux-Hodgson, 2010).

In 'Reality Construction in Society', the book that proposes a sociology of knowledge to analyze the process of knowledge formation, its organization, and diffusion in

society, Burkhard Holzner introduced the term epistemic communities for the first time. Holzner (1972) defined epistemic communities as communities “unified by a common epistemology and frame of reference, such as the scientific community, religious communities, work communities, some ideological movements and the like” (p. 69). According to Hozner (1972), this unison was based on an agreed-upon “perspective for the construction of reality” (p.69), which assures a common frame of references, symbolic systems, and power arrangements for the epistemic community. To be a member of these communities, one must have certain qualifications. Members should adopt the same frame of reference and be able to use the same symbolic system. Holzner also indicated that these qualifications could be learned with proper education, but the epistemic community controls who can receive an education and what information is to be distributed. Therefore, through the distribution of information, the power arrangements of the epistemic community are established.

John Ruggie (1975) expands Holzner’s (1972) ‘epistemic community’ framework by employing Foucault’s episteme. In the Order of Things: An Archaeology of the Human Sciences, Foucault (1973) examines the embedded nature of epistemic assumptions in historical context and proposes that different historical periods have different epistemic assumptions and these assumptions determine what is considered truth and acceptable discourse; as the epistemic assumptions change in time, so do the truth claims and discourse. Based on this reasoning, Ruggie (1975) defines epistemic communities as “interrelated roles which grow up around an episteme” (Ruggie 1975, p. 570). Like Holzner, Ruggie suggests that these epistemic communities have shared “intentions, expectations, symbols, behavior rules, and positions of reference” (Cross, 2013). Moreover, he claims that the interrelated roles which formed around an episteme also “delimits, for their members, the proper construction of social reality” (Ruggie 1975, p. 570). Simply, Ruggie suggests that epistemic communities form their own discourse and truth claims. This discourse creates normative expectations and values for its members based on an episteme, “a dominant way of looking at a social reality” (p.569) which is era-specific and can be biased and limited.

These aforementioned definitions and frameworks’ influence were not substantial in the literature. However, together with his father Ernst B. Haas’s work ‘When

Knowledge Is Power,’ they paved the way for Peter Haas’s (1992) epistemic community framework, which has a prominent effect on the corresponding international policy literature and other fields. Peter Haas’s definition of epistemic community was informed by different science and social science theorists. Therefore, the historical development of the term carries importance to understanding this framework.

The genealogy of the term ‘epistemic community’ can be traced back to both natural and social sciences. The influence between these two fields and the resemblance between the theories of the scientific community and epistemic community clearly shows this connection. Also, through this connection, the reasoning behind the terminological choice of this research favoring the term epistemic community over the scientific community can be explained. Simply put, the notion of the epistemic community derives from the notion of the scientific community but expands this notion by emphasizing the social dimensions in the formation of these communities, like beliefs and discourse. Therefore, to comprehend what the notion of the epistemic community entails, we first need to understand how the notion of the scientific community was developed.

The notion of the scientific community is commonly used in many fields, and science education is not an exception. The early science philosophers’ works on the formation of communities in science are still in use today in science education literature (Loving & Coborn, 2000; Matthews, 2004; 2017). Among the early science philosophers, two names especially stand out Ludwick Fleck and Thomas Kuhn, since Fleck characterized the scientists as communities and Khun defined the role of scientists as communities in their works. Ludwick Fleck (Fleck,1979) was one of the first science philosophers to refer to scientists as a social group and gave them the name ‘thought collectives.’ Fleck (1979) claimed that when a community of scientists adopts ‘a thought style’, a certain way of thinking and perceiving based on a set of rules determining the acceptable ways to communicate and cooperate, which is characteristic to that specific community, this adopted ‘thought style’ forms ‘a thought collective.’ While, Kuhn (1996) tied Fleck’s definition of community of scientist and paradigm together; “Paradigm is what the members of a scientific community share,

and, conversely, a scientific community consists of men who share a paradigm” (Kuhn, 1996, p.176). Both Ludwick Fleck’s notion of ‘thought collectives’ and Thomas Kuhn’s ‘paradigm shift’ referred to how shared norms of communication support the formations of scientific communities and vice versa. Therefore, the relationship between discourse and formation of scientific communities has been recognized in science education literature but not studies. Moreover, not many researchers have paid attention to the influence of these communities over discourse. In recent years, social epistemologists started to pay attention to the formation of scientific communities and developed various models (Goldman, 2018; Kitcher, 1990; Zollman; 2007). However, they did not gain much attention from the science education field and these models constantly criticized for not being supported by empirical data (Martini & Pinto, 2017; Thicke, 2020). Therefore, there is a sizable gap in science education literature regarding the formation of communities and the relationship between discourse and formation of communities.

Taking into account its historical development and this research’s emphasis on discourse as the social dimension of the formation of the communities in science education, Haas’s (1992) epistemic community definition and framework were used in this research. Like Holzner (1972) and Ruggie (1975), influenced by Fleck’s (1979) ‘thought collective’ notion, Khun’s (1962) prior definitions of scientific communities, and Foucault’s (1973) work on ‘episteme,’ Haas (1992) defines an epistemic community as “a network of professionals with recognized expertise and competence in a particular domain and authoritative claim to policy-relevant knowledge within that domain or issue-area” (p.3) and points out that epistemic community not only refers to scientific communities or scientist, and professionals from different disciplines could be part of an epistemic community. Haas (1992) also gives us a list of criteria that an epistemic community has. This list mainly consists of four criteria. However, some additional characteristics of the epistemic communities are also mentioned within the framework. According to Haas (1992), epistemic communities have

1. a shared set of normative and principled beliefs, which provide a value-based rationale for the social action of community members;

2. shared causal beliefs, which are derived from their analysis of practices leading or contributing to a central set of problems in their domain and which then serve as the basis for elucidating the multiple linkages between possible policy actions and desired outcomes;
3. shared notions of validity- that is, intersubjective, internally defined criteria for weighing and validating knowledge in the domain of their expertise; and
4. a common policy enterprise- that is, a set of common practices associated with the set of problems to which their professional competence is directed, presumably out of the conviction that human welfare will be enhanced as a consequence. (p.3)

In addition to these characteristics, members of an epistemic community are expected to have “a shared intersubjective understanding,” “a shared way of knowing,” “shared patterns of reasoning,” and “shared discursive practices” (p.3).

Haas's (1992) comprehensive and detailed epistemic community framework was complementary to both critical and discourse theories utilized by this research. Since its emphasis on social and policy actions of the members of the epistemic communities resonates with the critical theories' emphasis on social behavior within the political and ideological context and its acknowledgment of the shared discursive practices as one of the defining characteristics of epistemic communities' echoes discourse theories' claim that discourse affects our beliefs, thoughts, and identities (see Chapter 3, 3.1.2 Critical Theory and Discourse Theory). Therefore, the term epistemic community was adopted by this research, and Haas's (1992) framework was used to locate and identify the epistemic communities in science education and elementary science education literature for sampling purposes.

#### ***2.4.1 Research on Epistemic Communities***

Even though this research employs discourse theory and critical theory as its fundamental frameworks, due to the unique character of the sampling procedure it also utilizes Haas's (1992) epistemic community framework to locate epistemic communities in science education and elementary science education literature. Therefore, this section attempts to summarize what has been learned from the studies which utilized this framework over the last few decades.

Peter Haas's (1992) epistemic community framework is mostly used in international relations and policy literature to investigate the influence of certain groups that could be considered experts on decision-making and policy development processes regarding complex and uncertain issues. Complementary to the existing policymaking theories, Haas's (1992) framework is intended to be used to study group interest and decision-making processes, socialization and identities, policy legacies, and the use of rhetoric and discourse (Dunlop, 2011). One of the advantages of this framework is that it offers a list of characteristics of epistemic communities that could be used to identify or locate these communities. As a result, in the literature, this framework has been mostly used either to study the influence of an epistemic community on certain issues or a field or to identify an epistemic community among the people involved with an issue or a field.

There are numerous researches on the role and influence of epistemic communities over certain policy development or decision-making processes utilizing Haas's epistemic community framework. Hopkins's (1992) study of food aid reform, Adler's (1992) study of the conception and practice of nuclear arms control, Gough and Shackley's (2001) study of climate change epistemic community, van Daele's (2005) study of the International Labour Organization (ILO), Barth's (2006) study of scientist influence on the international arms control agenda, Hardy and Melville's (2018) study of district educators professional learning as policy enactment, Kourtelis' s (2021) study on European neighborhood policy are few that could be named. In addition to the findings regarding the studied issues, the findings of these studies support Haas's (1992) framework suggesting that "members of epistemic communities have shared normative and causal beliefs as well as common validating criteria and policy preferences" (p.3). Moreover, these studies show that there could be various epistemic communities, which can consist of sub-epistemic communities.

On the other hand, the number of researches utilizing this framework for the identification and characteristics of epistemic communities is considerably few. The difficulty in accessing all involved people or experts regarding an issue or a field to identify members of the epistemic communities is assumed to be the most probable cause of the difference in the number of research (Dunlop, 2011). Studies utilizing

Haas's (1992) framework for identifying epistemic communities usually analyze scientific documents like articles, conference proceedings, and other texts and employ qualitative approaches promoted by Haas (1992) and focus on the belief systems. In recent years, surveys (Radaelli & Connor, 2009) and other quantitative approaches like newly developed bibliographic and text analysis methods (Roth & Bourgine, 2003) have been gaining popularity in identifying epistemic communities. For its practicality and extensive coverage of the field to locate the epistemic communities in science and elementary science literature, this research also utilized a bibliographic and text analysis program, VOSviewer.

Within the scope of this research two epistemic communities were located and studied in the literature. Since the located epistemic communities both form around the same theoretical framework, nature of science, providing some information about the position of this framework in the literature and some descriptive characteristics of the research on nature of science could help the reader to make sense of the contextual connections in this research. Therefore, in the following section some information regarding the nature of science research is provided.

## **2.5. Nature of Science**

Nature of science has a significant place as a theoretical framework in science education literature and has been extensively researched since the second half of the 20th century. The literature reviews conducted on nature of science research (Abd-El-Khalick, 2014; Abd-El-Khalick & Lederman, 2000; Lederman, 1992) show us the intensity and effectiveness of these research endeavors and the role of nature of science as one of the objectives of science education. The crucial role of "the adequate conception of nature of science" in science education and scientific literacy is constantly emphasized in the literature (Deng et al., 2011; Cofre et al., 2019; Lederman, 1992, 2007). Moreover, it is presented as "the agreed-upon objective by most scientists and science educators for the past 85 years" (Abd-El-Khalick & Lederman, 2000, p.665). On the other hand, the reviews also show us that the nature of science understanding of students and teachers has yet to be brought to an adequate level (Cofre et al., 2019; Deng et al., 2011; Lederman, 1992; Lederman et al., 2014).

Therefore, there are still some fundamental questions to be answered regarding how to teach nature of science, what are the effective ways to improve teachers' and students' nature of science understanding, and what are the factors affecting nature of science learning (Abd-El-Khalick & Lederman, 2000; Cofre et al., 2014; Lederman & Lederman 2014; Mesci & Schwartz, 2017; Pavez et al., 2016). The discussions on how to answer these questions have long been taking place in the literature. However, the most significant discussion in the literature on nature of science is the discussion regarding the definition of nature of science.

Considering the various philosophical approaches to science and the discussions of what science is; science as a knowledge derived from the facts of experience, falsificationism, Khun's paradigms, Feyerabend's anarchistic theory of science, Bayesian approaches, the new experimentalism, realism, and anti-realism (Chalmers, 1999), it is not surprising that there is not a consensus regarding "the definition of nature of science" in science education literature (Abd-El-Khalick & Lederman, 2000; Lederman, 1992). From the early attempts to define the nature of scientific knowledge (Conant, 1947; Kimball, 1967; Klopfer, 1969; Rubba & Anderson, 1978; Showalter, 1974), nature of scientific theories (Cotham & Smith, 1981), nature of scientific enterprise (Cooley & Klopfer, 1963) defining nature of science remained as a challenge for researchers. Therefore, instead of a definition, some general characterizations are often used, especially emphasizing the epistemic foundation of the phrase "nature of science." In the literature, nature of science is consistently referred to as "the epistemology of science," or "science as a way of knowing" (Lederman, 1992), which is to a degree indicative of the way how this phrase came to be as a result of the discursive choices of an epistemic community (see Chapter 2, 2.4 Epistemic Communities).

Researchers studying nature of science generally respond to the lack of definition in two different ways. Since there is some agreement on the general aspects of nature of science, some researchers claim that these agreed-upon aspects can be studied without a definition (Akerson, et al., 2000; Çetinkaya- Aydin & Çakiroğlu, 2017; Lederman et al. 2014). On the other hand, assuming that it is not possible to reach an agreed-upon definition of nature of science due to its ambiguous philosophical underpinnings, some

researchers promote alternatives to this notion like “features of science,” which emphasizes the epistemological, historical, psychological, social, technological, and economic elements of science (Matthews 2012) or the “cognitive aspects of science” which emphasizes the activities, aims and values, methodologies and methodological rules and products of science (Irzik & Nola, 2011) This perspective later evolved and popularized as the Family Resemblance Approach (Irzik & Nola, 2014; Erduran & Dagher, 2014). Nevertheless, neither the lack of an agreed-upon definition nor the suggested alternatives had much effect on the popularity of “nature of science” in science education. For over a century, studies of nature of science have had substantial influence over science education and reform. The way the aspects of nature of science have shaped school science programs for many years clearly shows this effect (Central Association of Science and Mathematics Teachers, 1907; McComas, 2017).

As mentioned before, there is an agreement on some of the general aspects of nature of science, and these aspects, especially the ones that are assumed to be accessible to K-12 students, are consistently emphasized in science education literature (Abd-El-Khalick, 2012; Abd-El-Khalick & Lederman: 2000; Abd-El-Khalick et al., 1998; Lederman, 1992; Lederman et al., 2014; Lederman & O’Malley, 1990). This “consensus view” of nature of science, provided the much-needed foundation for empirical research (Abd-El-Khalick & Lederman: 2000; Erduran & Dagher, 2014). These aspects form the basis of the most frequently used research tool developed by Lederman et al., (2002) the Views of Nature of Science Questionnaire, VNOS, and this work summarized the aspects of nature of science as follows:

scientific knowledge is tentative; empirical; theory-laden; partly the product of human inference, imagination, and creativity; and socially and culturally embedded. Three additional important aspects are the distinction between observation and inference, the lack of a universal recipe like method for doing science, and the functions of and relationships between scientific theories and laws (p.499)

Supporting these K-12 appropriate aspects of nature of science in the literature has led to the separation of the notion of nature of science from scientific inquiry and methodology. Lederman’s (Lederman, 2007; Lederman & Lederman, 2019) support for the differentiation of nature of science from scientific inquiry also contributed to

this separation (Deng et al., 2011). However, this approach raised many questions and criticism regarding the aspects of nature of science in the literature (Alsop & Gardner, 2017, Hodson & Wong, 2017; Matthews, 2012). Especially some researchers consider the emphasis put on the characteristics of scientific knowledge by the aspects mentioned earlier compared to the scientific inquiry (Alsop & Gardner, 2017; Hodson & Wong, 2017) or the methodological rules in science (Irzik & Nola, 2011; 2014) as problematic. Also, the way the agreed-upon aspects of nature of science are labeled as K-12 appropriate or accessible by their relevance to K-12 science education is criticized (Hodson & Wong, 2017). Moreover, there are various lists of the agreed-upon aspects of the nature of science in the literature (Abd-El-Khalick, 2012; Abd-El-Khalick et al., 1998; Lederman et al., 2002; Lederman et al., 2014; Niaz & Maza 2011) however, these lists have some inconsistencies. Therefore, in the literature even the consensus view of the aspects of nature of science is not fully established, or agreed upon. Also, there are still some substantial debates and criticism over these aspects (Duschl & Grandy, 2013; Matthews, 2012; Rudolph, 2000; van Dijk, 2014; Van Eijck et al., 2009). Critiques often state that these aspects “greatly oversimplify the nature of observation and theory and almost entirely ignore the role of models in the conceptual structure of science” (Grandy & Duschl, 2007, p. 144). Moreover, even the way these aspects were presented in the literature is criticized by some researchers (Clough, 2007). Howbeit, the aspects of nature of science are constantly included in science curriculums (McComas & Olson, 1998) and the rising popularity of the nature of science aspects in science curriculums around the world has been constant for decades (Olson, 2018).

Bazzul (2017) states that

The NOS debates bear resemblance to a common, and productive, problem that all disciplines share—the problem of orthodoxy... How does a social group—science education researchers and educators, for example—develop and adhere to a set of practices or knowledges that help comprise its social fabric? (p.68)

What Bazzul (20017) points out is the gap this research is addressing and corresponds to what it aims to do by focusing on discourse and adopting a critical perspective. In the scope of this research, besides their theoretical position in the literature, the

descriptive observations regarding the nature of science research in science education literature carry importance in understanding how the epistemic communities formed around this theoretical framework. Therefore, to deliver a much more comprehensive vantage point, when the reviews of nature of science research are reviewed following observations were made regarding the research. First, the reviews of nature of science research show us that students and teachers constitute the sample of most studies (Abd-El-Khalick & Lederman, 2000; Deng et al., 2011; Cofre et al., 2019; Lederman, 1992; Lederman & Lederman, 2014). Teaching and learning of nature of science involve teachers and students unsurprisingly. However, there are also studies investigating scientists' views of nature of science (e.g., Aydeniz & Bilican, 2014; Schwartz & Lederman, 2008) in the literature, suggesting that other stakeholders' views of nature of science can be studied in science education, like scientist. Second, the reviews revealed that students' views of nature of science are mostly investigated at the middle school, high school, and university level, and in comparison, research on elementary students' views of nature of science is fewer in number (Deng et al., 2011; Cofre et al., 2019). While teachers' views of nature of science are investigated at different levels and contexts; in-service and pre-service. The number of research investigating the views of pre-service teachers, especially pre-service elementary teachers, appears to be more in comparison to in-service teachers (Cofre et al., 2019; Abd-El-Khalick & Lederman, 2000). Finally, the reviews also showed that while forced-choice instruments were popular in the 1900's after 1990 open-ended instruments gained popularity (Abd-El-Khalick, 2014). Consequently, in recent years Views of Nature of Science Questionnaire (VNOS) with all its versions (VNOS-A, VNOS-B, VNOS-C, suitable for science teachers and high school students, and VNOS-D, VNOS-E for elementary school students) is the most used instrument followed by TOUS and VOSTS (Abd-El-Khalick, 2014; Cofre et al., 2019). Thus, in terms of their research subjects, grade orientation, and choices of instruments there have been some observable preferences in the nature of science literature.

Abd-El-Khalick & Lederman (2000) states that they often prefer to use the phrase NOS instead of the more stylistically appropriate the NOS. By doing so they claim that they reflect their lack of belief in the existence of a singular NOS or agreement on

what the phrase specifically means. In this research, the abbreviation NOS was intentionally not used, since its symbolic representation could carry a different meaning than ‘nature of science’. Also, the stylistic phrase the nature of science and the phrase nature of science were both used to differentiate what is being promoted as the nature of science by the epistemic communities in the body of the text.

## **CHAPTER 3**

### **METHODOLOGY**

In this chapter, (a) the theoretical foundations of CDA, (b) the purpose of this research and the research questions, and why a specific CDA approach was chosen to answer these questions were explained. Due to the overlapping characteristics of the design structures (c), the research design was explained in detail, and (d) a schema summarizing the research design was provided. As the format dictated, (e) the data collection procedures, (f) the data analysis procedures, and (g) the step-by-step explanation of data analysis were presented. Also, (h) measures of rigor, (i) reflexivity, and (j) the limitations of the study were discussed.

#### **3.1. Theoretical Foundations of Critical Discourse Analysis**

Critical discourse analysis (CDA) is one of the distinctive tools of critical research. CDA has a unique methodological perspective utilizing different theories and methods (van Dijk, 1993; 2007). It is often used with corpus linguistic approaches, analyzing words, linguistic features, patterns, etc. (Baker et al., 2008; Cheng, 2012). Therefore, depending on the theoretical underpinnings, the design of a CDA research can utilize qualitative, quantitative, or mixed methods. Being considered as both theory and method, CDA differs from discourse analysis methods (Fairclough, 2004; Rogers, 2004). It focuses on the relationship between language and power by investigating how discourses shape and are shaped by context. There are various approaches to CDA research. The most recognized approaches in the literature are Fairclough's (1989; 2001) critical approach (socio-cultural approach), van Dijk's (1993; 2001) socio-cognitive approach, and Wodak's (2009; 2015) discourse-historical approach.

Since this research focuses on the specific communities of education literature, Fairclough's socio-cultural approach to CDA was utilized. Researchers like Fairclough (2001) and van Dijk (1993; 2007), the most recognized exponents of the

CDA, support a flexible methodological approach and align themselves with a more classical view of critical research and theory, namely Jürgen Habermas's "theory of communicative action" (1984). According to Habermas (1984), normative expectations and values are the basis for critical theory. Critical research grounds itself on normative expectations and values governed by human conduct, and it methodologically seeks to critique ideologies that shape and be shaped by human conduct. Simply put, ideologies can be defined as assumptions that are not readily detected in conventions mediating how people interact linguistically (Fairclough, 2001); they constitute normative expectations and values. From this pure critical point of view, critical research differs from qualitative research. Qualitative research investigates the subjective constructed meaning behind human conduct, which is intimately connected to ideologies; however, methodologically, the reciprocal relationship between human conduct and ideologies is not so much in focus. To a critical researcher understanding the role of ideologies and the reciprocal relationship between human conduct and ideologies are paramount. For this reason, Fairclough explains the role of ideologies in critical discourse analysis extensively in his work "Language and Power" (2001). To Fairclough,

"Ideologies are closely linked to power, because the nature of the ideological assumptions embedded in particular conventions, and so the nature of conventions themselves, depends on the power relations which underlie the conventions; and because they are a means to legitimizing existing social relations and differences of power, simply though the recurrence of ordinary, familiar ways of behaving which take these relations and power differences for granted." (2001, p. 2)

Without denying its multifaceted nature, some contemporary researchers consider CDA to be more associated with qualitative research designs (Hussain et al., 2013). Some researchers present CDA as a qualitative analytical approach (Mullet, 2018). While these considerations are practical since associating CDA with a specific approach provides an easy solution to methodological challenges. They also open a door for the unsystematic use of CDA. The critiques of CDA research have long been pointing out the danger of using CDA in the name instead of other analytical approaches due to its popularity (Martin, 2000; Verschueren, 2001; Widdowson, 2005), and there is numerous CDA research in the literature without meeting the

fundamental requirements of this research framework (Rogers et al., 2005). Associating CDA with specific research design and supporting methodological rigidity carries a threat to the critical nature of CDA since methodological constraints could also be subject to the same power relations that CDA tries to untangle. Contextual contingency and theoretical versatility are characteristic of CDA research. Therefore, CDA cannot be reduced to a single approach (Fairclough, 2009). Moreover, the complex nature of examining something critically should create a challenge for the researchers methodologically. If this challenge is met correctly, it becomes the most vital aspect of CDA research. As Bucholtz (2001) points out, the diversity of the CDA approaches strengthens the framework. The research questions and the paradigms these research questions dictate determine the design of CDA research. Therefore, researchers tackle this problem differently depending on their research questions and the CDA approaches they adopted.

The relationship between discourse and power is substantial. Therefore, CDA investigates this relationship to reveal how power is exercised in language use and how sociolinguistic conventions distribute power. To support these claims stated above and provide a clear explanation of the theoretical and structural design of this research, in the following section, a summary of critical paradigm, critical theory, discourse theory, and critical discourse analysis will be provided.

### ***3.1.1. Critical Paradigm***

Characteristically, CDA research is grounded in a critical paradigm. The critical paradigm strives for emancipation and freedom. It aims to contribute to our understanding of social behavior by focusing on the political and ideological context presumably neglected by positivistic and interpretive paradigms (Cohen, Manion & Morrison, 2000). According to Gage (1989, as cited in Cohen, Manion & Morrison, 2000), while the positivistic paradigm is preoccupied with technical knowledge, the interpretive paradigm is more concerned with hermeneutic knowledge. By parallel thinking, we can postulate that the critical paradigm is concerned with contextual knowledge, which involves ideological aspects of hermeneutic knowledge. If the hermeneutic knowledge is to interpret the way the world is interpreted

(Habermas, 1971; Terry, 1997), contextual knowledge is to interpret the reciprocal relationship between context and the way the world is interpreted (how context affects the way the world is interpreted and how the way the world is interpreted affects the context). The critical paradigm's this reciprocal perspective has been explained in the literature in many different ways. Cohen et al. (2000) explain it through the knowledge-power relationship by stating that "what counts as knowledge is determined by the social and positional power of the advocates of that knowledge" (p. 27). Whereas, Frowe (2001) approaches this reciprocity by emphasizing the role of language and suggests that language shapes reality and the reality is constructed through the reciprocal relationship between language that contains power relations and the world in which these power relations exist. It is challenging to define a paradigm that looks at the knowledge and reality (as in the postulated definition, the way the world is interpreted, and the context of that interpretation) from an unconventional perspective. The critical paradigm's emancipatory nature consistently challenges the way we see knowledge because knowledge is not value-free. It is influenced by ideologies that create hierarchical roles with varying power and privilege. In the critical paradigm, as constructed entities, knowledge and reality will always be influenced by societal power relations, which include cultural, historical, political, and economic factors (Guba & Lincoln, 1994), and will be used to sustain these power relations.

Due to its unique perspective, the critical paradigm accommodates the ontological and epistemological assumptions of both positivist and interpretive paradigms to expose the dichotomous nature of reality. Its emancipatory orientation allows this reconciliation and causes critical theory and research to diversify significantly. From West European Marxist theory to contemporary feminist theory, critical paradigm provides a versatile foundation for critical theory and discourse theory and various other theoretical traditions and paradigms addressing social justice and marginalization issues (Lather, 1992; Popkewitz, & Fendler, 1999; Showalter, 1984).

In education literature emancipatory orientation of the critical paradigm can easily be observed in Paulo Freire's critical pedagogy perspective, especially in his classical

work “Pedagogy of the Oppressed” (2018). As Giroux (2010) explains it in his article discussing Freire’s critical pedagogy

Critical pedagogy attempts to understand how power works through the production, distribution, and consumption of knowledge within particular institutional contexts and seeks to constitute students as informed subjects and social agents. In this instance, the issues of how identities, values, and desires are shaped in the classroom are the grounds of politics. Critical pedagogy is thus invested in both the practice of self-criticism about the values that inform teaching and a critical self-consciousness regarding what it means to equip students with analytical skills to be self-reflective about the knowledge and values they confront in classrooms. (p.717)

Freire’s critical pedagogy perspectives raised many discussions and informed numerous discourse studies in education literature since it examines ‘how social injustice work through the discourse and experience’ (Giroux & Simon, 1989). Still, immediate contexts such as teacher- student interactions and curriculum were more in focus than macro-level interactions in these studies (e.g. Hoffman, 1996; Hughes, 2000, 2001; Solorzano & Yosso, 2001), even though the need for research on academic discourse was mentioned. To clarify the theoretical foundation of this research further, a brief explanation regarding critical theory and discourse theory will be provided in the following section.

### ***3.1.2. Critical Theory and Discourse Theory***

There are numerous approaches and multiple theories referred to as critical theory (Agger, 2006; Tyson, 2014). As mentioned before, this research utilized Fairclough’s (2001) critical approach to CDA. Therefore, it was aligned with Frankfurt School’s tradition, more specifically Habermas’s Critical Theory (1984). According to Habermas (1984), our consciousness can be transformed by paying attention to how ideology reflects and distorts reality and reified power relations. Therefore, to unmask hegemony and power relations, the values and assumptions of the conventional social structures should be challenged. From this perspective, the critical theory differs from descriptive and explanatory theories significantly because it aims to emancipate the suppressed and understand how the social structures come to be so that they can be transformed instead of accepted as they are. Since Habermas saw everyday speech as

the best ground for ‘critical rationality’ (Popper, 1959) and ‘critical methodology’ (Ingram, 1990), many CDA approaches adopted his critical theory because it was complimentary to discourse theory.

The disciplinary root of discourse theory is rather complicated. The works of both linguistic theorists such as *Language and Control* by Fowler, Hodge, Kress, and Trew (1979), *Language and Power* by Fairclough (1989), and social theorists’ like *The dialogic imagination; Four essays* by Bakhtin (1981) and *Marxism and the Philosophy of Language* by Volosniov (1973) have contributed to the emergence of discourse theory. Therefore, discourse theory’s critical orientation can be attributed to the influences of both linguistic and social theorists’ critical approaches.

The simplest definition of discourse is ‘language in use’ (Wetherell et al., 2001). Discourse can also be defined as a social meaning-making process that involves communication, knowledge construction, and interaction with ideologies. Discourse affects our beliefs, thoughts, and identities (Wolfe & Griffin, 2017; Grad & Martin-Rojo, 2008). Discursive practices organize human conduct; there are always certain ways to communicate and take turns in a conversation that are acceptable, and certain contextualized cues shape our discursive choices (Tannen, 2012). Discursive practices produce/reproduce unequal power relations through their ideological effects; they arrange/rearrange social conventions, signify objects and subjects in certain ways, and position people (Fairclough & Wodak 1997, Wetherell et al., 2001). Discourse mediates the way meaning is produced or what is considered meaningful when a topic is talked about and reasoned about and influences how ideas are put into practice (Foucault, 1980; Bucholtz & Hall, 2005). There is an innate relationship between discourse and ideology (van Dijk, 2011). As ideology produces an accommodating discourse, that discourse shapes social reality, which influences the propagation of the ideology. Thus, discourse theory and critical theory complement each other since both theories look at reality from the same perspective. Moreover, discourse analysis provides practical tools for critical approaches to research human conduct and the social underpinnings of the meaning-making processes.

There are various discourse traditions such as conversation analysis, sociolinguistic, Bakhtinian, and Foucauldian approaches, and many more besides critical discourse analysis (Wetherell et al., 2001) that could be utilized by themselves or in combination with a critical framework. In this research, Gee's (2004) discourse theory was also utilized to support some aspects of Fairclough's CDA approach. Gee (2004) emphasizes the multifaced structure of discourse. He seeks to balance cognitive and social aspects of discourse in his approach and believes "minds, bodies, social interactions, social groups, and institutions" should all be a part of the discourse analysis (Gee, 2004, p.6). To raise our awareness of the distinction between the cognitive and social aspects, Gee (2004) refers to his approach as "D/discourse analysis." Discourse with a "d" refers to how language is used in real interactions in accordance with identities. Discourse with a "D" refers to all the activities and identities that are embedded in the social and cultural models besides language. For example, there are particular terminology and linguistic ways to communicate that one should adopt in academic interactions but simply being able to use these, the discourse, is not sufficient to be considered as an academician. To be considered an academician, one should also know the academic ways of thinking, believing, and valuing which are expressed and perceived through language in use and part of the Discourse of academia. According to Gee (2004),

We are all members of many, a great many different Discourses, Discourses which sometimes breed with each other to create new hybrids. ...you use language and "other stuff"-ways of acting, interacting, feeling, believing, valuing, and using various sorts of objects, symbols, tools, and technologies-to recognize yourself and others as meaning and meaningful in certain ways. In turn, you produce, reproduce, sustain and transform a given "form of life" or Discourse. All life for all of us is just a patchwork of thought, words, objects, events, actions, and interactions in Discourse. (p.7)

From this perspective, Gee's (2004) theory of discourse focuses on the ideal subject positions, situated meanings, and intertextual references in the text as crucial parts of the D/discourse analysis, which are natural indicators of power differences in language. Since this perspective fits well with the critical perspective of Fairclough's (2001;2013) triadic CDA framework, these discursive structures were also utilized in

this research to reveal the power relations in the text. Further explanations will be given in the data analysis section (see Chapter 3, 3.6. Data Analysis).

### ***3.1.3. Critical Discourse Analysis***

CDA aims to understand the role of language in social interactions, especially how it governs “the relationships of power and privilege” and it endeavors to make the power structures within “institutions and bodies of knowledge” more transparent (Foucault, 1972; Gee, 2004; Locke, 2005; Luke, 1996). The roots of CDA can be traced back to numerous theories and approaches that directed the attention of social sciences to language. The discourse studies (e.g., Foucault, 1972), post-structuralism (e.g., Derrida, 1974), critical theory (e.g., Habermas, 1971), and critical linguistics (e.g., Fowler et al., 1979), are only a few to be named that greatly contributed to the development of CDA. As a result, CDA is considered not only a methodology to analyze text but also a theory of language (van Dijk, 2001), a framework that aims to reveal the information hidden in the text. Due to its critical and interdisciplinary approach, CDA is frequently utilized by emancipatory research with varying theoretical and methodological foundations (Lin, 2014; Mullet, 2018; Rogers et al., 2016). Analyzing discourse from a critical perspective reveals the power structures in which meaning-making is embedded (Rogers, 2011). Therefore, CDA investigates the semiotic dimensions of power and challenges the social conditions produced/reproduced by discourses (Wodak, 2015). As mentioned before, CDA adopts critical paradigms reciprocal perspective. It investigates how ideologies control discourse and in return how discourse produces/reproduces ideologies to understand the power relations created by this reciprocal interaction. Employing both critical and discourse theories, CDA research aims to reveal how language contributes to domination and raise our consciousness of hidden power in the language in use. Since, through the increased awareness of the role of language in production, maintenance, and change of social relations of power, its emancipatory purpose can be realized (Fairclough, 2001).

There are three significant approaches to CDA in the literature: Fairclough's (2001; 2013) critical approach (socio-cultural approach), van Dijk's (1993; 2001) socio-

cognitive approach, and Wodak's (2009) discourse-historical approach. Fairclough's (2001; 2013) CDA approach consists of three interrelated processes of analysis (description, interpretation, explanation) corresponding to the three elements of discourse (text, interaction, context). According to this critical approach, 'text,' the object of analysis (like verbal communication), is embedded in context, the socio-historical conditions that govern the text production and interpretation processes (like reading or writing). The interaction between text and context constitutes these production and interpretation processes. Therefore, to investigate discourse critically, all these three elements of discourse (text, interaction, and context) are needed to be addressed in the analysis. Fairclough (2001;2013) offers three overlapping levels of analysis complementary to his multi-functional perspective of text:

1. Text analysis (description); investigating the language structures
2. Processing analysis (interpretation); investigating the process of production, interpretation, distribution, and consumption.
3. Social analysis (explanation); investigating the ways in which discourses function in different social contexts.

van Dijk's (2005) approach to CDA does not differ fundamentally from Fairclough's critical approach. van Dijk's (2005) socio-cognitive approach also considers discourse as a form of social practice like Fairclough's (2001). However, instead of focusing on discursive practices, van Dijk's (2005) socio-cognitive CDA approach investigates social cognition, because, it mediates the interaction between text and society. According to van Dijk (2001), there are different forms of social cognition and these different forms are used by certain groups, organizations, and institutions that are referred to as social collectivities in his works. These social cognitions are "socially shared representations of societal arrangements, groups, and relations, as well as mental operations such as interpretation, thinking and arguing, inferencing and learning" (van Dijk, 1993, p.257). Therefore, to investigate how social cognitions mediates the interaction between text and society, CDA should analyze discourse at two levels: macro vs. micro. In this approach, while 'verbal interaction, and

communication' were investigated at the micro-level, 'power, dominance, and inequality between social groups determining the social order are the focus of the investigation at the macro-level (van Dijk, 2005). van Dijk's and Fairclough's CDA approaches differ in terms of analysis because van Dijk's approach focuses on micro vs. macro levels while analyzing discourse. In contrast, Fairclough's approach focuses on the interaction between the two.

Wodak's CDA (2009; 2015) approach is called the discourse-historical approach. Wodak's (2015) approach is based on three assumptions regarding discourse. First, "discourse involves power and ideologies," because social values and norms always have a role in our interactions, and power relations are preserved through them. Second, the interpretation of discourse involves power and ideologies because our interpretations are also discourse-bound. Third, "discourse is historical," because any communicative event taking place at a moment is connected to other communicative events that are happening or have happened. Similar to van Dijk's approach, Wodak's approach also has some common assumptions with Fairclough's approach. The first two of the aforementioned assumptions are shared by Fairclough and the third assumption is comparable to his notion of intertextuality. However, Wodak's CDA approach differs from Fairclough's approach because of its inductive nature; the analysis focuses on the text, then context, whereas, in Fairclough's CDA approach, the focus of analysis oscillates between context and text (Fairclough, 2001).

Overall, despite their differences, all the CDA approaches make the following assumptions regarding discourse (Fairclough & Wodak, 1997; Rogers et al., 2005; van Dijk, 2001; Wodak, 2015).

- Discourse does ideological work.
- Discourse constitutes society and culture.
- Discourse is situated and historical.
- Power relations are partially discursive.
- Mediation of power relations necessitates a socio-cognitive approach
- CDA is a socially committed paradigm that addresses social problems.

- Discourse analysis is interpretive, descriptive, and explanatory and uses a “systematic methodology.”
- The role of the analysis is to study the relationship between text and social practices. (Fairclough & Wodak, 1997, p.271-280)

The following section explains why Fairclough’s approach to CDA (2001) was chosen as a methodology for this research and how its theoretical foundation complements the purpose of this research and the research questions.

### **3.2. Restatement of Purpose and Research Questions**

Discourse studies in science education mainly focus on classroom dialog (Hanrahan, 2005, Kelly, 2007; Moje, 1997), policy documents (Hufnagel et al., 2018, Thomas. 2011), or curriculum materials (Bazull, 2014; Sharma & Buxton, 2015), yet neglect to investigate the discourses promoted by the epistemic communities of science education at its source. Researchers of science education have an ultimate say in what discourses should look like since they constitute the epistemic communities that determine the characteristics of the promoted discourses in science education through their discursive choices. However, there is almost no research investigating the epistemic communities’ discursive choices or whether these choices create power difference and reinforce a culture of power in science education. Any effort to address this significant gap needed some contextual knowledge contributing to our understanding of the social behaviors of epistemic communities in science education. More specifically, to understand the ways epistemic communities’ discursive choices create a relationship of power and privilege, it was necessary to investigate the reciprocal interaction between the discursive choices and social contexts in science education. Therefore, adopting a critical research perspective was useful to investigate this reciprocal interaction since context both affects the discourse and is affected by it. Therefore, CDA, especially Fairclough’s (1989; 2001) critical approach (socio-cultural approach) to CDA, was the best methodological fit for addressing this gap in the literature.

This research aims to understand how science education and elementary science education discourses mediate the relationship of power and privilege through the

prominent epistemic communities' discursive choices. To achieve this goal, it was necessary to understand the characteristics of these discourses and investigate whether these discourses create power differences as assumed. Only after establishing this basis the ways these epistemic communities' discursive choices create power differences could be investigated. Based on this reasoning, the research focused on the three questions in two interconnected contexts, science education and elementary science education.

1. What are the characteristics of discourses promoted by the epistemic communities of science education?
2. Do the discursive choices of the epistemic communities of science education create power differences?
3. If so... How do the discursive choices of the epistemic communities of science education create power differences?
4. What are the characteristics of discourses promoted by the epistemic communities of elementary science education?
5. Do the discursive choices of the epistemic communities of elementary science education create power differences?
6. If so... How do the discursive choices of the epistemic communities of elementary science education create power differences?

Ostensibly, the first research question may not appear to be having any critical aspects. At first glance, it appears to target essential descriptive information that supports the remaining research questions. However, if we look at it closely, we could realize that this might not be the case. Characteristics of discourses are context-bound, and even a simple list of these characteristics themselves could create a context that affects discourse. Thus, the reciprocal relationships between context and discourse still play a role, and investigating the characteristics of discourses require a critical perspective to answer this question. As for the remaining two research questions, they are self-evidently critical since they are focused on power differences. Therefore, not only the

nature of the gap in the literature but also the nature of the research questions dictated the research design to be critical.

The critical nature of the research questions combined with the limited prior research and theoretical background on epistemic communities and their discursive choices in science education literature created a challenge methodologically. As a result, measures of rigor and reflexivity become a focal point in the research design procedure, which required investigating the research questions in two overlapping contexts: science education and elementary science education. The reason behind investigating both science education and elementary science education contexts together is briefly discussed in the introduction. In the following section, how the research benefited from this choice and how each research question influenced the research design, data collection, and analysis will be explained in detail.

### **3.2. Research Design**

Despite its methodological flexibility, the theoretical framework and analytical method of CDA are well developed and agreed upon. However, even though there is a clear consensus about what is expected of CDA research, both the critics and the proponents of the CDA research agree that there is numerous CDA research with profound methodological flaws. Particularly, lack of awareness of the need for rigor, reflexivity, theoretical underpinnings, and unsystematic or misrepresented methodological approaches and methods are the most frequently observed flaws in CDA research (Fairclough, 1992; Rogers, 2005; Verschueren, 2001; Widdowson, 2005). To avoid these pitfalls, this research paid particular attention to the close relationship between research questions and research design to assure methodological consistency, rigor, and reflexivity while utilizing Fairclough's (2001) CDA framework. Since the purpose of the research and the way this purpose is operationalized into specific research questions have a direct effect on the research design and the methodology (Cohen et al., 2000), each research question and its effect on the research design were explained exclusively to make the decision-making process accessible for the reader.

This research investigates the discursive choices of the prominent epistemic communities of science education and elementary science education literature and whether these communities' discursive choices create power differences, in other words, hierarchical roles with varying power and privilege. As mentioned before, the research focused on three questions in two interconnected contexts, science education and elementary science education.

The first research question was:

*What are the characteristics of the discourses promoted by the epistemic communities of science education /elementary science education?*

This research question was concerned primarily with the characteristics of the discourses promoted by the prominent epistemic communities, but the question itself was founded on two main assumptions. First, there are prominent epistemic communities in science education and elementary science education literature, and discourses promoted by these epistemic communities differ. Even though these assumptions were self-evident, there was no prior research readily available in the literature to locate the prominent epistemic communities in science education or elementary science education literature. The difficulty in locating the epistemic communities in the literature was one of the reasons to investigate the science education and elementary science education contexts together. Because without enough information about the epistemic communities of science education and their discursive choices, locating the epistemic communities of elementary science education and claiming that they have their own distinctive discursive choices would not be feasible. Reversely, even though locating the epistemic communities of science education is possible, investigating the discursive choices of these communities without any comparative reference point would carry the risk of misrepresentation. This stage of the design was important not only because it supported the two primary assumptions stated above, but it also enabled the research to show that even though elementary science education discourse is strongly connected to and can even be considered as a sub-discourse of science education in character (Gee, 2004), it somehow differs due to the particular discursive choices of the epistemic communities.

Consequently, investigating the discursive choices of these two epistemic communities together yielded more specific information by contrast. Moreover, investigating science education and elementary science education contexts together enabled this research to address all levels of context to attain theoretical or perspective triangulation (see Chapter 3, 3.8 Research Rigor).

To investigate the characteristics of the discourses promoted by prominent epistemic communities, the first step in the research design was to find a way to locate these communities. Therefore, a mapping program, VOSviewer, was used to locate the prominent epistemic communities of science education and elementary science education in the literature. VOSviewer's bibliometric network map generator allows users to construct visualizations of citations, co-citations, or co-authorship relations based on the data obtained from a body of scientific literature. The capabilities of this program allow the research design to have an extensive perspective by enabling an investigation of all the published science education and elementary science education articles in the entire Web of Science database. Since this program can also be used to map co-occurrences of nouns and noun clauses within the text it was used to further distinguish the epistemic communities in the literature. This feature of the program was further used as a member checking tool for CDA that investigates the characteristics of the discourses promoted by the located epistemic communities. The VOSviewer mapping and purposeful sampling procedures will be discussed in the Data Collection and Analysis sections in dept. (See, Chapter 3, 3.5 Data Collection, 3.6 Data Analysis)

In the research design, the first step of Fairclough's (2001) triadic CDA approach, text analysis (description), investigating the linguistic features of the text, was corresponding to the first research question. Since it was aiming to reveal characteristics of the discourses promoted by the located epistemic communities and it was gathering descriptive information. Yet, considering the critiques of CDA research call for attention to rigor, reflexivity, and trustworthiness (Fairclough, 1992; Rogers, 2005; Verschueren, 2001; Widdowson, 2005) an additional analysis was incorporated into the research design with the help of the VOSviewer program to

assure the methodological and data source triangulation in the research design. (see Chapter 3, 3.6 Data Analysis, 3.8 Research Rigor)

The second research question was:

*Do the discursive choices of the epistemic communities of science education/elementary science education create power differences?*

This research question was concerned with the reified power relations promoted and sustained by the epistemic communities. Therefore, in the design, the second step of Fairclough's (2001) triadic CDA approach, processing analysis (interpretation) investigating the process of production, interpretation, distribution, and consumption which involves situated meanings and subject positions, was corresponding to the second research question. Since exploring whether the epistemic communities' discursive choices create hierarchical roles with varying power and privilege could only be possible through understanding the meanings and identities (subject positions) that were used and constructed by the discourse. Once more, to address the rigor, reflexivity, and trustworthiness issues, an additional analysis was incorporated into the research design by utilizing Gee's (2004) D/discourse analysis approach specifically focusing on the subject positions promoted by the discursive choices of the epistemic communities. (See. Chapter 3, 3.6 Data Analysis, 3.8 Research Rigor)

The third research question was:

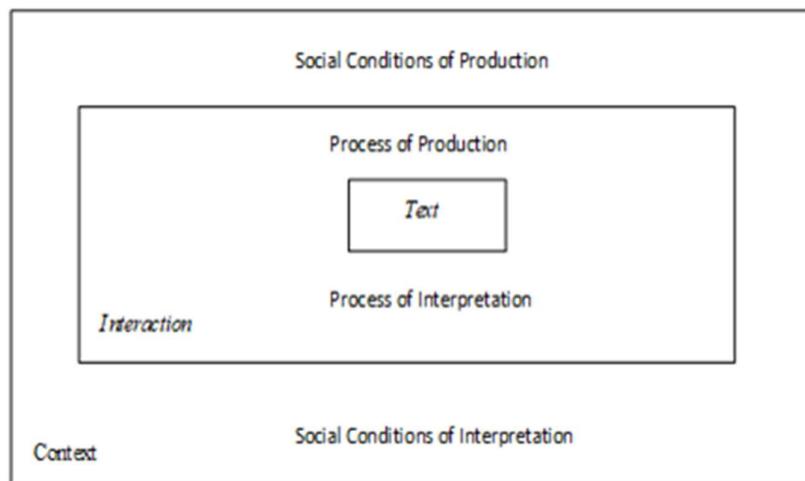
*If so... How do the discursive choices of the epistemic communities of science education/elementary science education create power differences?*

This research question was focused on the ways the discursive choices of epistemic communities constructed common-sense assumptions; the ways discursive choices convince the reader that the promoted power differences make sense. Considering the overlapping nature of the research design which was mimicking the adopted CDA approach, to answer this question all the information grater from the previous investigation steps had to be put together. Therefore, this question effortlessly matched the third step of Fairclough's (2001) triadic CDA approach, social analysis

(explanation), which considers all the constituent parts of the discourse to understand how these parts link to each other and fit into the larger contexts. The following figures explain how the research design addressed each element of discourse and utilized Fairclough's (2001) CDA approach.

**Figure 3.1**

*Fairclough's Representation of Discourse as Text, Interaction, and Context*



Note: Fairclough's representation of discourse as text, interaction, and context adapted from *Language and Power* (p. 21), N. Fairclough, 2001. Routledge.

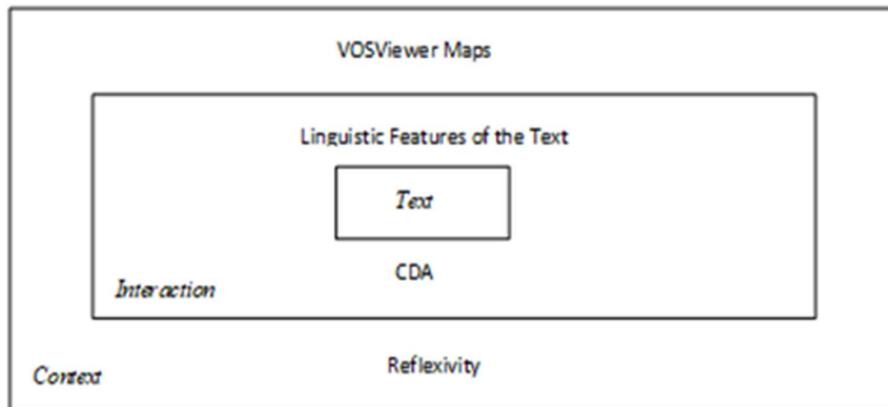
According to Fairclough (2001), the text is a product of discourse. It is a part of the meaning-making process that also includes the production (production of the text) and interpretation (interpretation of the text) processes. Therefore, CDA does not only focus on the text but on productive and interpretive processes as well. The characteristics of the discourse give us information about the text and provide traces of the productive process and cues for the interpretive process. Moreover, these processes are socially determined. Therefore, social conditions of production and interpretation are also part of the discourse. Simply put, the text is embedded in context, and there is an interaction between text and context, and even this interaction is socially determined and context-bound. Thus, all these three elements (text,

interaction, context) together constitute discourse. See Figure 3.1 Fairclough's representation of discourse as text, interaction, and context (2001, p21)

It can be seen in the Figure 3.2, showing the primary methods used according to Fairclough's CDA framework in the research design, that the research design consists of overlapping and complementary analyses in accordance with Fairclough's (2001) conceptualization of discourse. As the triadic CDA approach dictates the text and context, the text-context interaction, and the effects of context on the text-context interactions all needed to be addressed in the research design, as additional measures were taken to assure rigor, reflexivity, and trustworthiness. Therefore, to meet this challenge, in addition to CDA other aforementioned analyses were used for methodological, and data source triangulation. (see Chapter 3, 3.8 Research Rigor)

**Figure 3.2**

*Primary Methods Used According to Fairclough's CDA Framework in the Research Design*



In the research design, the VOSviewer co-citation maps were utilized to investigate the social conditions of the science education literature since these maps were used to locate the epistemic communities. The reviewed literature was the main source of information for the context of this research. However, the co-citation and co-occurrence maps produced with the VOSviewer program provided detailed information regarding the context, in other words, the epistemic communities

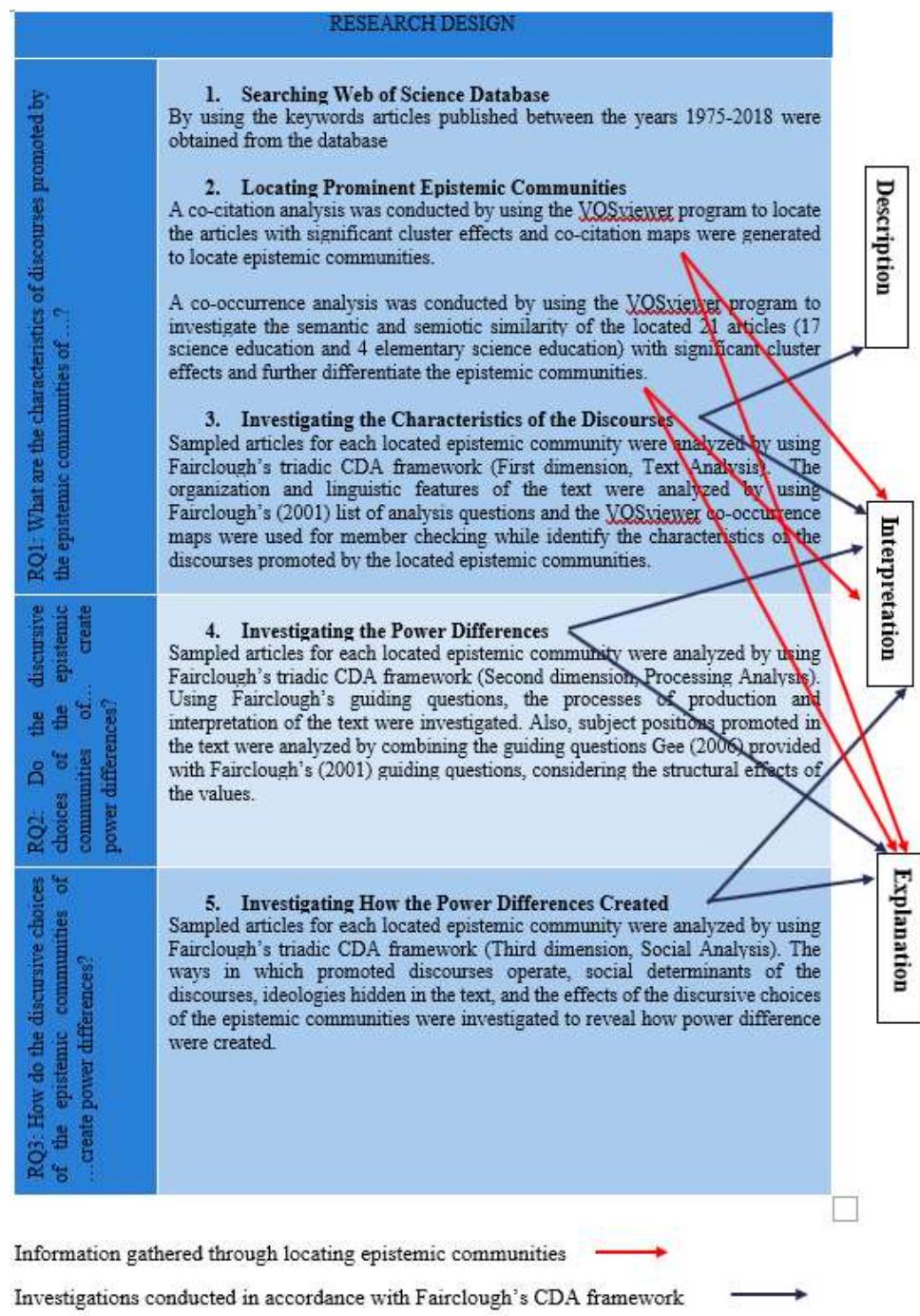
themselves. Reflexivity was used to make the social conditions of the context and the text-context interaction accessible to the reader through the researcher's perspective. VOSviewer co-occurrence maps were also used as a tool for member checking for text analysis which contributed to the reflexivity at both textual and contextual levels by enabling the comparison of the researcher's interpretations with the outcomes of this program. Moreover, Gee's (2004) approach to discourse analysis, emphasizing situated meanings and subject positions of the text, incorporated with Fairclough's (2001) triadic approach, within the CDA second step, the processing analysis (interpretation). With this choice, in the research design, subject positions promoted by the discursive choices of the epistemic communities were investigated exclusively to provide information regarding text-context interaction and promoted power difference.

Even though CDA involves all three elements of discourse, it does not particularly focus on the text on a micro level or context on a macro level. CDA focuses on the interaction between text and context and tries to explain the process of interpretation. To investigate the interaction between text and context, CDA combines the information gathered from all the elements of a discourse. Therefore, the findings of the text analysis, the first step of the triadic approach focusing on linguistic features were also used to investigate the text production process, the second step of the triadic approach. Likewise, findings of the production process (interpretation) were used in the third step, the social analysis. Moreover, since all three elements, text, interaction, and context together constitute discourse, all three stages of CDA; description, interpretation, and explanation occur at the same time. Further explanations on this topic will be provided in the data analysis section (see Chapter 3, 3.6 Data Analysis). The following section offers a design schema to illustrate the correspondence between the research questions, research design, and Fairclough's triadic CDA framework (2001).

### 3.4. Research Design Schema

**Figure 3.3**

*Research Design: Corresponding Research Questions and Analysis Dimensions*



### **3.5. Data Collection**

In the following section, (a) the prior assumptions that guided the data collection process, (b) data sources, (c) the sampling procedure, and (d) the VOSviewer citation mapping program used to locate epistemic communities and collect textual data were explained in detail.

#### ***3.5.1. Priori Assumption of Data Collection***

As stated before, prior research on prominent epistemic communities in science education literature was insufficient. Therefore, to assure that the sample of this research was representative of the epistemic communities of science education, first of all, these communities had to be located within the literature. In accordance with Haas's definition of epistemic communities (1992), the community of researchers with significant contributions to the core knowledge of science education and with influence as a group was considered to be an epistemic community in science education literature (see Chapter 4, Locating Epistemic Communities). Moreover, due to the critical nature of this research, a purposeful sampling procedure was used to select the distinctive articles produced by these communities as the representative text for the investigation of these communities' discursive choices. Thus, the following priori assumptions in line with the aforementioned CDA frameworks (Fairclough, 2001; van Dijk 2003, Gee, 2004; Wetherell et al., 2001) were assumed to be true.

- Both theoretical and research-based articles published and accessible to the science education community constitute the core knowledge source of science education practice and promote certain discursive choices.
- The citation relationships among articles can be a way to understand the pattern of the influences in the field (Khun, 1996; Smith, 1981) since they constitute intertextual references.
- More frequently cited articles can be assumed to have more influence than the less frequently cited ones.

These assumptions led the sample to be selected among the most cited and most influential articles within the published articles listed in the Web of Science core collection database. Instead of utilizing multiple databases and allocating a shorter time frame for published articles, this research deliberately focused on one prominent database for its entirety to extend the analyzed period and control the possible contextual impact of databases. In addition, VOSviewer, a citation mapping program, was used to create maps of the relevant research in science education and elementary science education as listed in the Web of Science core collection.

One point here to be careful about in this process is that the generated maps included citations that were not just articles. Even though only the articles were obtained from the Web of Science core collection, the cited reference in these articles were not limited to one type of scientific text. Therefore, some of the most frequent citations were not included in the sample simply because they were not articles; they were books or some other type of text. As a result, the priori assumptions were intentionally expressed in a way that specifically highlights the articles among other texts. Further explanations were given regarding this process in the following sampling procedure section.

Since the VOSviewer program allowed the researcher to visually observe which articles were most frequently cited in the field and the citation relationships of these articles by showing which articles have the highest cluster effects, therefore most influence, another priori assumption was adopted.

- Among the frequently cited articles, articles with the highest cluster effects can be claimed to have more influence in the field.

These priori assumptions provided a way to locate the significantly influential works in the field, including theoretical and research base articles for purposeful sampling.

### **3.5.2 Data Sources**

Web of Science database was the primary data source of this research, and through data mining, the obtained data was organized and investigated at different levels. At

the first level, all articles published within the years 1975-2018 (covering all accessible articles in the Web of Science database) using the keywords ‘science education’ and ‘elementary science education’ were drawn from the Web of Science database to investigate the epistemic communities. As the number of citations was considered to be indicative of the articles’ effect on the literature, studies after 2018 were omitted since there was not enough time to be cited and have a consequential effect on the literature. Considering that the obtained data for this research took a few years to analyze, fact-checking for this choice was also conducted as of June 2022. Among the published articles between the years 2018 and 2022, there were no articles with significant cluster effects or a number of citations to contradict this choice. At the second level, using the VOSviewer program, 21 articles with the highest cluster effect were located among the articles drawn from the Web of Science database. These 21 articles, 17 in science education and four in elementary science education literature were used as the data source for the further investigation of the epistemic communities and their discursive choices. Finally, a representative article for each located epistemic community was selected according to their citation frequency and influence in the field. These articles were the main data source of the CDA. Moreover, in addition to these purposefully sampled articles, due to the overlapping characteristics of Fairclough’s analysis dimensions, the findings of the first research question, corresponding to the description dimension, were used as a data source to answer the second research question. Similarly, the findings of the second research question corresponding to the interpretation dimension were used as a data source to answer the third research question. Table 3.1 summarized how data sources corresponded to the specific research questions.

**Table. 3.1**

*Data Sources for Each Research Question*

Data Sources	
RQ 1	1. Web of Science Database 2. Articles with the highest cluster effect (Locating Epistemic Communities) 3. Purposefully sampled articles for each prominent epistemic community
RQ2	4. Purposefully sampled articles for each prominent epistemic community 5. Findings of the text analysis
RQ3	6. Purposefully sampled articles for each prominent epistemic community 7. Findings of the processing analysis

### ***3.5.3. Sampling Procedure***

The sampling procedure of this research was also complex and had different levels to be in accordance with the research design. First, the articles constituting science education and elementary science education literature were identified. Afterward, by investigating the cited references in these identified articles, the articles with the highest citation frequency and co-citation cluster effect in the corresponding literature were determined to locate the epistemic communities. Finally, a representative article for each located epistemic community was selected according to their citation frequency and influence (co-citation cluster effect) in the field to conduct CDA.

The search using the keywords “science education” with no time restrictions on the Web of Science core collection revealed that 58227 scientific texts existed in the

database. Limiting the search with the “articles” option reduced this number to 37161 articles. Since the VOSviewer citation mapping program used for the sampling procedure can only process approximately 5000-6000 articles and 100.000-200.000 citations at a time, these 37161 articles were explored, generating 8 separate maps. The articles dated back only as far as 1975 because the Web of Science core collection provided access to articles from this year.

The 8 maps (see Appendix A), generated by the VOSviewer citation mapping program using the data obtained from the Web of Science core collection, showed the most cited articles and the co-citation groupings among the 37161 articles in 7 clusters of 5000 and 1 cluster of 2161 articles. Since the most cited articles were of interest to this research, references with low citation rates were eliminated. VOSviewer program allows researchers to set a “the minimum number of citations of a cited reference” criterion for map generation. For this research, this criterion was set to 25. Therefore, for a referenced citation to be included in the generated map, it had to be co-cited at least by 25 articles between the years 1975-2018 in the database.

The same procedure was repeated for Elementary Science Education articles. The search revealed that there were 2091 scientific texts existed in the database. Limiting the search with the “articles” option reduced this number to 1504 articles. Since Primary Science Education and Early Science Education can be used interchangeably with Elementary Science Education in the literature, they were used as keywords, and separate maps (see Appendix A) were generated for each of these keywords. For Primary Science Education, the search provided 3821 results, 2623 of these scientific texts were articles. For Early Science Education, the number was 3400, and 2438 of them were articles. Analysis showed that there were not enough citations that met “the minimum number of citations of a cited reference” criterion (minimum 25). Therefore, all the articles attained from Web of Science using these three keywords (Elementary, Primary, and Early Science Education) were treated as one group, and a map was generated for this group. The citation distributions of the maps generated by the VOSviewer program can be seen in Table 3.2.

**Table 3.2**

*Citation Distributions of the Maps Generated by the VOSviewer Program.*

Map	Number of Articles	Number of cited references	Minimum number of citations of a cited reference	The number of citations meets the threshold
Science Education 1	5000	140015	25	43
Science Education 2	5000	170032	25	79
Science Education 3	5000	168962	25	96
Science Education 4	5000	158730	25	101
Science Education 5	5000	141077	25	67
Science Education 6	5000	133278	25	27
Science Education 7	5000	118431	25	40
Science Education 8	2161	40796	25	6
Elementary Science Education	1504	30781	25	23
Primary Science Education	2623	69002	25	10
Early Science Education	2438	70110	25	4
Elementary/Primary/Early Science Education	6565	147587	25	80

Cross analysis of these maps revealed that 17 science education articles and 4 elementary science articles had a significant cluster effect in the literature based on their link strength scores. The list of science education articles with citation frequency and link strength scores provided by the VOSviewer program was presented in Table 3.3. The list of elementary science education articles with citation frequency and link strength scores was shown in Table 3.4.

**Table 3.3***List of Science Education Articles with Citation Frequency and Link Strength Scores*

- 
1. Brown, J. S., Collins, A., & Duguid, P. (1989). Situated Cognition and the Culture of Learning. *Educational Researcher*, 18(1), 32-42.

MAP	1	2	3	4	5	6	7	8
Citation					60		43	
Link strength					195		87	

2. Driver, R., Asoko, H., Leach, J., Scott, P., & Mortimer, E. (1994). Constructing scientific knowledge in the classroom. *Educational Researcher*, 23(7), 5-12.

MAP	1	2	3	4	5	6	7	8
Citation						40		
Link strength						96		

3. Driver, R., Newton, P., & Osborne, J. (2000). Establishing the norms of scientific argumentation in classrooms. *Science Education*, 84(3), 287-312.

MAP	1	2	3	4	5	6	7	8
Citation	33	37	54	58	48			
Link strength	85	189	345	329	226			

4. Duschl, R., & Osborne, J. (2002). Supporting and promoting argumentation discourse. *Studies in Science Education*, 38, 39-72.

MAP	1	2	3	4	5	6	7	8
Citation			34					
Link strength			160					

5. Erduran, S., Simon, S., & Osborne, J. (2004). TAPping into argumentation: Developments in the application of Toulmin's argument pattern for studying science discourse. *Science Education*, 88(6), 915-933.

MAP	1	2	3	4	5	6	7	8
Citation			31					
Link strength			159					

Table 3.3 (continued)

6. Eylon, B. S., & Linn, M. C. (1988). Learning and instruction: An examination of four research perspectives in science education. *Review of Educational Research*, 58(3), 251-301.

MAP	1	2	3	4	5	6	7	8
Citation							26	
Link							8	
strength								

7. Jimenez-Aleixandre, M. P., Rodriguez, A. B., & Duschl, R. A. (2000). "Doing the lesson" or "doing science": Argument in high school genetics. *Science Education*, 84(6), 757-792.

MAP	1	2	3	4	5	6	7	8
Citation			25					
Link			148					
strength								

8. Lederman, N. G. (1992). Students' and teachers' conceptions of the nature of science: A review of the research. *Journal of Research in Science Teaching*, 29(4), 331-359.

MAP	1	2	3	4	5	6	7	8
Citation				51	51	34	29	
Link				285	195	76	80	
strength								

9. Lederman, N. G. (2007). Nature of science: Past, present, and future. In S. K. Abell, K. Appleton, & D. L. Hanuscin (Eds.), *Handbook of Research on Science Education*, 2, 831-879.

MAP	1	2	3	4	5	6	7	8
Citation		40						
Link		91						
strength								

Table 3.3 (continued)

10. Magnusson, S. J., Krajcik, J. S., & Borko, H. (1999). Nature, source, and development of pedagogical content knowledge for science teaching. In J. Gess-Newsome & N. G. Lederman (Eds.), *Examining pedagogical content knowledge: The construct and its implications for science education* (pp. 95–132). Kluwer Press.

MAP	1	2	3	4	5	6	7	8
Citation	35				34			
Link		106				164		
strength								

11. Osborne, J., Simon, S., & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications. *International Journal of Science Education*, 25(9), 1049-1079.

MAP	1	2	3	4	5	6	7	8
Citation			83					
Link			136					
strength								

12. Osborne, J., Erduran, S., & Simon, S. (2004). Enhancing the quality of argumentation in school science. *Journal of Research in Science Teaching*, 41(10), 994-1020.

MAP	1	2	3	4	5	6	7	8
Citation	34	42	49					
Link		121	172	304				
strength								

13. Posner, G. J., Strike, K. A., Hewson, P. W., & Gertzog, W. A. (1982). Accommodation of a scientific conception: Toward a theory of conceptual change. *Science Education*, 66(2), 211-227.

MAP	1	2	3	4	5	6	7	8
Citation				78			62	32
Link				259			143	13
strength								

Table 3.3 (continued)

14. Sadler, T. D. (2004). Informal reasoning regarding socioscientific issues: A critical review of research. *Journal of Research in Science Teaching*, 41(5), 513-536.

MAP	1	2	3	4	5	6	7	8
Citation				47				
Link					241			
strength								

15. Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, 15(2), 4-14.

MAP	1	2	3	4	5	6	7	8
Citation	77		91	91	75	43	34	
Link	160		259	299	240	71	86	
strength								

16. Shulman, L. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review*, 57(1), 1-23.

MAP	1	2	3	4	5	6	7	8
Citation	54		73	79	64	50	41	
Link	114		225	288	253	80	85	
strength								

17. Zohar, A., & Nemet, F. (2002). Fostering students' knowledge and argumentation skills through dilemmas in human genetics. *Journal of Research in Science Teaching*, 39(1), 35-62. (1987).

MAP	1	2	3	4	5	6	7	8
Citation	30	42						
Link	89	261						
strength								

**Table 3.4**

*List of Elementary Science Education Articles with Citation Frequency and Link Strength Scores*

---

1. Akerson, V. L., Abd-El-Khalick, F., & Lederman, N. G. (2000). Influence of a reflective explicit activity-based approach on elementary teachers' conceptions of nature of science. *Journal of Research in Science Teaching*, 37(4), 295-317.

MAP	Elementary / Primary/ Early
Citation	29
Link strength	113

2. Abd-El-Khalick, F., & Lederman, N. G. (2000). Improving science teachers' conceptions of nature of science: a critical review of the literature. *International Journal of Science Education*, 22(7), 665-701.

MAP	Elementary / Primary/ Early
Citation	28
Link strength	102

3. Lederman, N. G., Abd-El-Khalick, F., Bell, R. L., & Schwartz, R. S. (2002). Views of nature of science questionnaire: Toward valid and meaningful assessment of learners' conceptions of nature of science. *Journal of Research in Science Teaching*, 39(6), 497-521.

MAP	Elementary / Primary/ Early
Citation	25
Link strength	95

4. Pajares, M. F. (1992). Teachers' beliefs and educational research: Cleaning up a messy construct. *Review of Educational Research*, 62(3), 307-332.

MAP	Elementary / Primary/ Early
Citation	44
Link strength	100

---

These 21 articles with high citation frequency and cluster effect were the most influential articles in science and elementary science education literature. Through further investigation of these 21 articles in terms of the authors, the journals in which they were published, the frameworks that they utilized, in addition to investigating the terminologies (nouns, and noun clauses) used in these articles via VOSviewer co-

occurrence maps, epistemic communities were located in the relevant literature. (See, Chapter 4 Locating Epistemic Communities). In the literature three prominent epistemic communities, two in science education and one in elementary science education were located consistent with Haas's (1992) epistemic community definition. These epistemic communities were named 'the nature of science epistemic community in science education literature' and 'the nature of science epistemic community in elementary science education literature' and 'the argumentation epistemic community in science education literature'. While the nature of science epistemic community was located in both science education literature and elementary science education literature, a corresponding community for the argumentation epistemic community was not located in elementary science education literature. Since there was no prior research regarding epistemic communities, the research was designed to investigate the discursive choice of epistemic communities in two embedded contexts to have a comparative reference point to support the findings. Therefore, further investigations regarding the Argumentation epistemic community were not conducted. As a result, one representative article for each located epistemic community was selected based on their link strength scores and consistent citation history. Lederman's (1992) article, and Akerson, Abd-El-Khalick, & Lederman's, (2000) article were sampled as representative texts for the nature of science community in science education and the nature of science community in elementary science education literature respectively for the CDA to answer the research questions.

In this research, the sampling procedure relied heavily on the VOSviewer Co-Citation and Co-occurrence Maps. Co-citations maps were used to investigate the relationships in the literature, while Co-occurrence maps were used to semantic similarities of the located articles. Therefore, a brief description was given in the following section to explain how these maps were generated to help the reader understand the function of these maps.

### ***3.5.4. Generating VOSviewer Co-Citation and Co-occurrence Maps***

VOSviewer is an open-source computer program allowing the user to create maps based on network data. van Eck and Waltman (2010) explain the procedure that the

VOSviewer program uses to construct a map in three steps. First, a co-occurrence matrix is generated for the items, these items can either be a citation from bibliographic data or a word from text data. Afterward, a similarity matrix is calculated by normalizing this co-occurrence matrix. A similarity matrix is calculated by simply correcting the former matrix for differences in the total number of occurrences or co-occurrences of the items depending on the type of analysis. VOSviewer uses the similarity measure called association strength. Therefore, the similarity between the two items that occurred in the input data is calculated using the association strength to map out their relative positions. Finally, a two-dimensional map is constructed using the similarity matrix. All the items in this matrix are positioned on the map based on the calculated similarity of any pair of items, while items with high similarity are located close to each other, items with low similarity are located far from each other. This mapping technique aims ‘to minimize a weighted sum of squared Euclidean distances between all pairs of items’ (van Eck & Waltman, 2010). Thus, the distance between the items or the cluster of items provides information about their association strength. As a result, based on the observed location of the items or cluster of items on the maps some inferences can be made.

By using this program, it is possible to create maps of “scientific publications, journals, researchers, countries or keywords based on co-authorship, co-occurrence, citation, bibliographic coupling, or co-citation networks” (van Eck & Waltman, 2016) extracted from Web of Science. There are three visualizations of the handled data provided by the program; the network visualization, the overlay visualization, and the density visualization. For the sampling procedure, all three visualizations were used to explore the maps produced by the program, however, network visualization was used primarily since it provided simple yet detailed visualization of the relationship among the items located in the generated maps.

VOSviewer program enables researchers to use five types of analysis (co-authorship, co-occurrence, citation, bibliographic coupling, and co-citation), three units of analysis (cited references, cited sources, and cited authors), and two counting methods (full and fractional). For this research co-citation analysis of cited references were used to determine the most influential research articles in the field, and co-occurrence

analysis was used to investigate the characteristic of the textual data. Also, the full counting method was employed for the items to avoid any missing data.

### **3.6. Data Analysis**

In the following sections, the three overlapping analysis procedures, namely Critical Discourse Analysis (CDA), Analysis of the VOSviewer Co-Occurrence Maps, and Analysis of the Linguistic Features of the Text, used by this research were briefly explained.

#### ***3.6.1. Fairclough's CDA Approach***

This research utilized Fairclough's (1999; 2001; 2013) model for CDA. This CDA approach consists of three interrelated processes of analysis which are corresponding to the three interrelated dimensions of discourse. These three dimensions of discourse are:

1. Text, the object of analysis: In this research, the objects of the analysis were the selected articles.
2. Interaction, the processes by which the object is produced and received; In this research, the language structures and the meaning-making processes were considered to be indicative of the interaction between text and context.
3. Context, the socio-historical conditions that govern the aforementioned processes; In this research, the socio-historical conditions were the conditions in which selected articles and the science education and elementary science education epistemic communities were formed and operated.

According to Fairclough each of these dimensions requires a different kind of analysis:

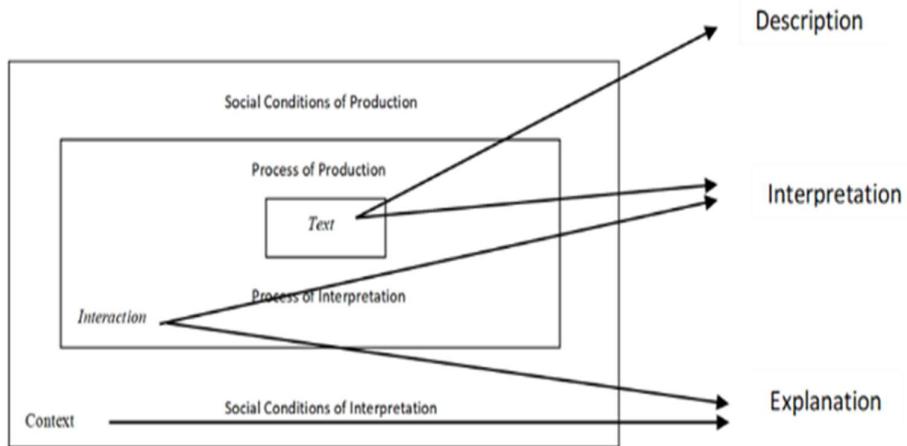
1. Text analysis (description); The analysis of the text involves the study of the language structures produced in discursive practice. For the description dimension of the CDA of this research, the frequencies, distributions, and co-occurrences of the words in the text were analyzed by using the VOSviewer program. Linguistic features of the text were used to study the characteristics of the discourses promoted in the

texts, and the list of analysis questions provided by Fairclough (2001) was used as a guideline to determine these linguistic features.

2. Processing analysis (interpretation); Fairclough's (2001) processing analysis involves the analysis of the processes of production, and interpretation of the text. This dimension is concerned with how people interpret and reproduce or transform texts. The interpretation dimension of the CDA of this research combined the analysis of the Linguistic features of the text, including subject positions which were analyzed with the guideline questions Gee (2004) provided, with Fairclough's (2001) guideline questions considering the structural effects of the values. The information obtained from VOSviewer co-occurrence maps and contextual information gathered while locating the epistemic communities were also used in this dimension of the analysis.
3. Social analysis (explanation); The third dimension, socio-cultural practice, is concerned with issues of power-power being a construct that is realized through interdiscursivity and hegemony. Analysis of this dimension includes exploration of the ways in which discourses operate in various domains of society. In this dimension of the CDA, social determinants of the discourses, ideologies hidden in the text and the effects of the discursive choices of the epistemic communities were investigated. Analysis of the linguistic features, especially subject positions and all the information gathered regarding epistemic communities were combined. Elements of discourse and corresponding analysis dimensions in CDA can be seen in Figure 3.4 and further explanations were provided in the following 3.7 Step by Step Explanation of the Analysis Procedure section.

**Figure 3.4**

*Elements of Discourse and Corresponding Analysis Dimensions in CDA*



**3.6.2. Step by Step Explanation of the CDA Procedure**

One of the challenges this research faced was to make it accessible for the reader. First, as dictated by the research design and Fairclough's (2001) CDA framework, the analysis of this research had an overlapping and repetitive characteristic. Second, using the VOSviewer program added another layer to an already complex analysis procedure since this program was used for two specific purposes within the research design. It was used as a tool for bibliographic co-citation analysis to map out the literature while locating the epistemic communities for the sampling procedure. It again was used for member checking and data triangulation as a text analysis tool investigating co-occurrences of the words within the sampled articles to support the critical discourse analysis of the texts. Moreover, Gee's (2004) analysis of subject positions was incorporated to Faircough's triadic CDA approach to see whether the discursive choices of the text create power differences, and if so, how these differences were created at the textual level and though text-context interaction. Therefore, to assure rigor and reflexivity and make it more accessible to the reader, the CDA procedure followed in this research was explained step-by-step in this section.

In this section, the CDA procedure was explained in a step-by-step manner. However, some of these steps were naturally performed simultaneously during the analysis due to their overlapping characteristics. Provided examples intentionally chosen to show this overlap while giving detailed information about the process.

*Step 1.* The researcher read the article with no predisposition to criticize and asked the following questions. What is the topic of this article? What is the main thesis of this article? What is the writer's position? To whom is the text addressed?

While reading the text, the researcher should keep in mind that the topic of the text refers to the general subject, but it does not provide enough information for the reader to understand what the writer is trying to prove. Moreover, to find the text's thesis, the reader should understand both the topic and the writer's claims about that topic. One simple way to find the thesis is simply to ask, "What is the point the writer is making about the topic?" However, if we are not aware of our position as a reader in relation to the text, the answer to this question may not render the intended answer. One fundamental assumption of CDA is that reading is 'a socially situated activity' (Wallace, 1992). According to Fairclough (2001, p. 65), to make sense of the whole text, the researcher needs to figure out 'how the parts of the text link to each other' and 'establish a fit between text and the world.'

The readers make sense of the text by using their members' resources (MR). Fairclough (2001) defines MR as the common-sense assumptions and expectations of the interpreter. Therefore, while reading the text, the researcher had to consciously make an effort to examine how she was using her members' resources. For this reason, the researcher kept journals and had discussions about the research process with the members of her thesis committee and other professionals in the field.

*Step 2.* The researcher reread the article multiple times in a critical manner.

Fairclough's (2001) CDA framework provides a practical guide for the researchers who do not have much footing in language and discourse studies. This guide consists of ten main questions and some sub-questions helping the researcher understand the particular choices generating the formal features of a specific text. Since these formal

features are based on particular choices, with these questions, Fairclough (2001, p. 92) urges the researchers “to take account of what other choices might have been made among the available options in the discourse types which the text draws upon.” Therefore, these questions help researchers investigate the particular choices under three categories; vocabulary, grammar, and textual structures, but they are not intended as an exhaustive or all-encompassing list. They simply point out that there are different directions and areas in the analysis that could be investigated. Researchers could use these questions or different versions of these questions while reading the text critically and utilize them for guidance throughout all three dimensions of the analysis. These questions are listed below.

a. Vocabulary

1. What experiential values do words have?

- What classification schemes are drawn upon?
- Are there words which are ideologically contested?
- Is there rewording or overwording?
- What ideologically significant meaning relations are there between words?

2. What relational values do words have?

- Are there euphemistic expressions?
- Are there markedly formal or informal words?

3. What expressive values do words have?

4. What metaphors are used?

b. Grammar

5. What experiential values do grammatical features have?

- What types of process and participants predominate?
- Is agency unclear?
- Are processes what they seem?
- Are nominalizations used?
- Are sentences active or passive?
- Are sentences positive or negative?

6. What relational values do grammatical features have?

- What modes are used?
- Are there important features of relational modality?
- Are the pronouns we and you used, and if so, how?

7. What expressive values do grammatical features have?

- Are there important features of expressive modality?

8. How are sentences linked together?

- What logical connectors are used?
- Are complex sentences characterized by coordination or subordination?

- What means are used for referring inside and outside the text?
- c. Textual structures
9. What interactional conventions are used?
    - Are there ways in which one participant controls the turns of others?
  10. What larger-scale structures does the text have? Fairclough (2001: 92-93)

Moreover, according to Fairclough (2001), formal features of the text may have experiential, relational, and expressive values. Investigating these three types of values associated with formal features provides a solid foundation for CDA. Structural effects of values in relation to dimensions of meaning were summarized in Table 3.5.

**Table 3.5**

*Structural Effects of Values in Relation to Dimensions of Meaning*

Dimensions of meaning	Values of Features	Structural Effect
Content	Experiential	Knowledge/beliefs
Relation	Relational	Social relations
Subjects	Expressive	Social identities

Analyzing a formal feature with an experiential value gives us information about how ‘the text producers’ experience of the natural or social world’ is portrayed and how power is represented in discourse in terms of contents, knowledge, and beliefs. Based on this portrayal, the researcher interprets the text writers’ worldview. Relational value is another useful tool for CDA. It offers information about the relations and social relationships enacted in the text. It assists the researcher in identifying the perceived social relationships, like the relationship between the writer of the text and its reader. The third value that requires the researcher’s attention in the CDA framework is the expressive value. Expressive value is concerned with subjects and social identities. It provides information about ‘the producer’s evaluation (in the widest sense) of the bit of the reality it relates to’ (Fairclough, 2001, p. 93). Therefore, the researcher had to

pay extra attention to the structural effects while answering the aforementioned questions.

For example, “The development of adequate student conceptions of the nature of science has been a perennial objective of science instruction regardless of the currently advocated pedagogical or curricular emphases.” (Lederman, 1992, p. 331)

*Researcher's interpretation:* In one of the sampled articles, the way ‘students’ (Subjects) were presented in the text had a structural effect that implied a certain social identity. In this text, consistently passive sentence structures were used whenever the text referred to students. This grammatical choice presented students in a position that something was being done to them. Moreover, students were frequently referred to within a nominalization, as seen in the sampled quote. As a result, a critical analysis of this discursive choice was interpreted by the researcher and concluded that this consistent preference (Expressive) of the author presented students as passive participants (Social identity).

Researchers could reach a much deeper understanding of the text by paying attention to formal features that may have experiential, relational, and expressive values. As seen in the listed questions (Fairclough, 2001), formal features may possess different values at the same time. Some or all words may have experiential, relational, and expressive values depending on the subjective interpretations of the researchers. Therefore, in the analysis, all values should be considered for formal features of the text.

*Step 3. Text Analysis (Description),* the researcher described the text with all its accessible properties.

The first step of Fairclough’s (1995, 2001) triadic approach is the description of the text. According to the research design, this step corresponded to the first research question since it revealed some characteristics of the discourses promoted by the texts. To describe the texts, CDA researchers look for certain descriptors. For this research, the general organization of the text, word choices, co-occurrences of the words, and linguistic features were the descriptors that the analysis mainly focused on because the

triadic framework emphasized them and the critical reading of the texts revealed that these descriptors carry importance.

To analyze the textual structures, the aforementioned guiding questions were used. Since the questions provided by Fairclough (2001) were inclusive, intended to support researchers conducting written text analysis and conversation analysis. As suggested by Fairclough (2001), some of the relevant questions were utilized by this research, and the correspondence between the analysis and guiding questions was adjusted according to the research design. For example, some of the Fairclough's (2001) guiding questions in reference to textual structures were as follows.

- c. Textual structures
- 9. What interactional conventions are used?
  - Are there ways in which one participant controls the turns of others?
- 10. What larger-scale structures does the text have? Fairclough (2001: 92-93)

Question 9 was irrelevant for this research since it could only be used for conversation analysis. However, question 10 could be answered and provided valuable information.

Titles and sub-titles were the large-scale structure that stood out for the analyzed texts. First of all, the organizations of the texts were analyzed through titles and subtitles as they were actively used to direct the reader's attention while giving information about the context of each section (Ball, 2009). Afterward, the text's vocabulary, word choices, and order of the words in sentences were analyzed since they provided semantic information (Sinclair, 1991). Finally, linguistics features of the text were analyzed, such as genre, passive-active sentence, nominalizations, agency, etc., to understand how these features were used to convey writers' intended message (Fairclough, 1993, 2001; Halliday, 1994). Further explanations and definitions were provided in the sections regarding the linguistic features analyzed by this research (see Chapter 2, 2.3.3 Linguistic Features, Chapter 3, 3.6.2 Analysis of the Linguistic Features of the Text).

In the following, a brief example of the analysis of the linguistic features was provided on the previously used quotation to show how the different steps of the analysis overlapped. “The development of adequate student conceptions of the nature of science has been a perennial objective of science instruction regardless of the currently advocated pedagogical or curricular emphases. (Lederman, 1992, p. 331)

*Researcher’s interpretation:* Positive, passive sentence structure with no clear agency. A hidden subject is insinuated as the sentence answers the question, “who is responsible for the development of the adequate students’ conception.” It is “a perennial objective of science instruction”; therefore, subjects/agents of science instruction are responsible. Authority is backgrounded through hidden subject “who is advocating current pedagogical or curricular emphases” is not specified. Nominalizations used; ‘adequate student conception,’ ‘science instruction,’ ‘advocated pedagogical emphases,’ and ‘advocated curricular emphases.

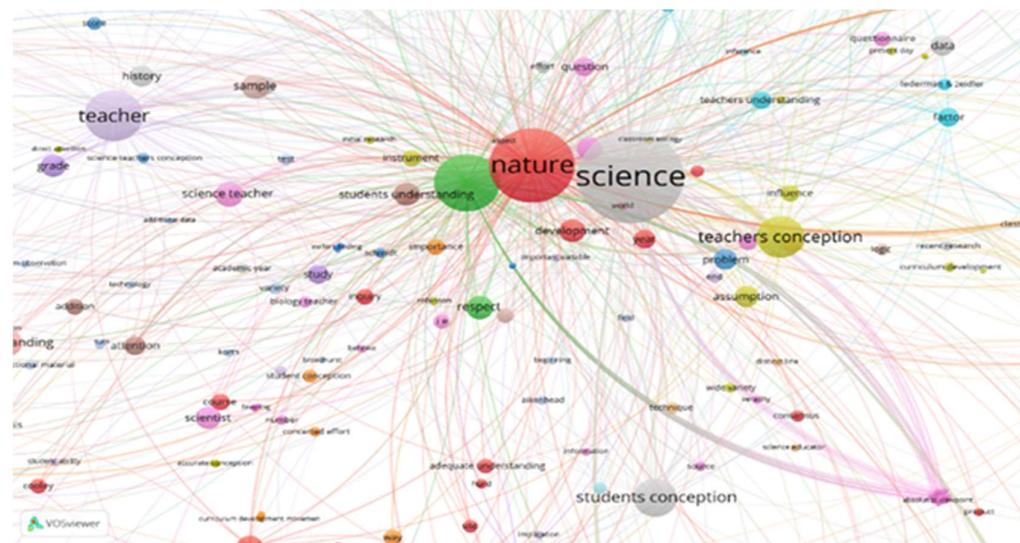
For the text analysis, the researcher analyzed the text accumulatively, word by word, sentence by sentence, paragraph by paragraph, section by section, and whole text. The accumulated information regarding all the descriptors provided a general view of the text describing the organizational preferences, frequently used words, word order choices, word co-occurrences, linguistic features, and the types of values associated with the formal features of the texts. Two other experts also analyzed sections of the text in terms of linguistic features, and over 90% consensus was achieved. In addition, the VOS viewer text analysis program was also used for member checking and further investigation of the text’s vocabulary and linguistic features as an unbiased source of information. Given that it was able to map out the whole text in terms of occurrences and co-occurrences of the nouns (e.g., subjects) and noun phrases (e.g., nominalizations) based on each item’s Chi-square score. Further information on the VOSviewer program and how to interpret the maps generated by this program can be seen in Chapter 3. (See, 3.5.5 VOSviewer Citation Mapping, and 3.6.2 Analysis of the VOSviewer Co-Occurance Maps)

*Step 4.* Generating VOSviewer co-occurrence maps to compare with the text analysis findings and further investigate the vocabulary and linguistic features of the text.

VOSviewer data visualization program was used to map out the co-occurrences among the words within one of the sampled articles, and the following map was generated. As can be seen from Figure 3.5, this program allowed researchers to see which words were favored by the writer based on the items' sizes. Also, the proximity of the items indicated their relations based on co-occurrence. In this map, the size of science (gray circle) and nature (red circle) items indicated how many times they were used in the text. The distance between the items indicates how close their connection is. Moreover, the lines connecting them to the other items showed the connection of these items to the whole text. As nouns nominalizations like "teacher conception" (yellow circle) and student conception (light gray circle), etc., were also analyzed as separate items.

**Figure 3.5**

### *Example Co-occurrence Map*



Tables similar to Table 3.6 can be used to organize the information provided by the maps. Occurrence shows how frequently text uses a certain word; links show how many other words the word co-occurred. Total link strength shows how connected the word is to the whole text compared to all the words presented on the map. Therefore, total link strength is a good indicator of the writer's wording preferences.

**Table 3.6***Example Occurrence and Link Strength Table*

Item	Occurrence	Links	Total Link Strength
Science	239	1293	12385
Nature	155	1198	8255
Student	93	856	5242
Teacher	73	713	3840
Research	53	609	2431
Teachers' Conception	48	599	2150
Students' Conception	41	540	2191

*Step 4.* Processing analysis (interpretation); by using both Fairclough's (2001) and Gee's (2004) guiding questions, researchers look for discursive choices of the text that lead the reader to make certain interpretations. Especially the subject positions promoted by the text were investigated to see whether the discursive choices of the text create power differences, and if so, how these differences were created at the textual level and through text-context interaction.

Similar to Fairclough's (2001) guiding questions, Gee (2004) provides a list of questions to use while investigating subject positions and their relationships.

1. What identities (roles, positions), with their concomitant personal social, and cultural knowledge and beliefs(cognition), feelings (affect), and values, seem to be relevant to, taken for granted...?
2. How are these identities stabilized or transformed...?
3. In terms of identities, activities, and relationships, what Discourses are relevant (and irrelevant) ...? How are they made relevant (and irrelevant), and in what ways? (p.111)

By using these questions as a guideline, the subject positions created by the texts and the relationship among these subject positions were investigated. For example:

“The development of adequate student conceptions of the nature of science has been a perennial objective of science instruction regardless of the currently advocated pedagogical or curricular emphases” (Lederman, 1992, p. 331).

*Researcher's Interpretation:*

1. Use of passive sentence structure and nominalization position ‘student’ as passive participants. In classroom culture, passive participants do not have any power or authority.
2. By using nominalization, student’s agency is backgrounded, and semantically student’s conceptions are portrayed as the product of science instruction. Thus, the passive participant role is emphasized by the text.
3. By hiding certain agencies (who advocates? who emphasize pedagogy or curriculum), and foregrounding science instruction (perennial objective belongs to science instruction) an authoritative/ objective voice is adopted.

Researchers make assumptions about the writer’s interpretations of reality by answering these questions. Therefore, as explained before, according to the critical paradigm (see Chapter 3, 3.1.1 Critical Paradigm), the researcher interprets the writer’s interpretations. CDA compares two accounts of the reality, the writer’s and the reader’s accounts. While investigating written texts, the writer’s interpretation of reality could only become accessible through the researcher’s interpretation. Therefore, instead of the text, CDA research utilizes the context to provide alternative accounts of the reality.

There are four levels of context CDA can utilize, immediate language; interdiscursive relations; immediate social context; broad social context (Wodak, 2011). In this research, all four levels of context were included in the analysis by investigating the discursive choices of both prominent epistemic communities of science education and elementary science education. For immediate language, the sampled article; for interdiscursive relations, discursive interactions within the text and within the articles the sample was selected; for immediate social context epistemic communities

themselves, and for broad social context science education literature, in general, were taken into account for CDA.

For example, when reporting the findings regarding students' conceptions being portrayed as the product of science instruction following contextual considerations were presented in the results.

*Researcher's Contextual Considerations:* A similar process-product perspective can also be observed in the nature of science literature. While there are a sheer number of researches investigating what teachers, curriculum developers, researchers can do to improve students' conceptions/ understanding/ view/ belief of nature of science (Clough, 2018; Matthews; 2017), there is a considerable gap in the literature regarding research investigating what students can do to improve their own conception/ understanding/ view/ belief of nature of science, since most research exclusively studying students in the literature mainly focuses on the descriptive and demographic aspects of students conception/ understanding/ view/ belief of nature of science (Deng et al., 2011; Leach, 1996; Lederman; 2007).

*Step 5.* Social analysis (Explanation); The researcher investigated the text-context interactions and effects of context on text-context interactions to understand how discursive choices of the text create power differences. To achieve that, the researcher focused on both the contextual effects of the discursive choices and these choices' effect on the context. Some discursive choices of the text gain meaning not only at the textual level but also at the contextual level, giving us some information about the reciprocal relationship between discourse and epistemic communities.

*Researcher's Interpretation:* The descriptive analysis of the text revealed an inconsistency in the used nominalizations consisting nature of science. When the text-context interaction was investigated in terms of this observation, it was seen that there was noteworthy discussion about the definition of the nature of science in the literature, which could explain this observation. When the text was investigated again to see how the discussions in the literature affected the discursive choices, it led to

other observations, which were furthermore analyzed in terms of text context interaction.

In this dimension of the CDA, social determinants of the discourses and ideologies hidden in the text were considered. Also, the effects of the discursive choices of the epistemic communities were investigated. All the information gathered from all analysis steps regarding epistemic communities was combined to explain the reasons behind the observed discursive choices and their effects.

### ***3.6.3. Analysis of the VOSviewer Co-Occurrence Maps***

In VOSviewer maps (van Eck & Waltman, 2010), the size of the clusters indicates the number of citations or words belonging to the cluster. Larger clusters reflect close associations indicating a higher cluster effect. Items in such clusters usually have higher link strength scores. The distance between the clusters indicates the relatedness of the clusters in terms of citation or co-occurrences depending on the nature of the generated map. Clusters that are located close to each other indicate a strong relationship while clusters that are located far from each other show a weak relationship. Since the distance between clusters are proportional based on this information the relationship between clusters can be compared. Moreover, the thickness of the curved lines between the clusters represents the number of citations or co-occurrence between the two clusters. Therefore, based on the thickness and the number of the lines more information can be obtained regarding the relationship between clusters. VOSviewer map has a zoom in- zoom out option which also allows the researcher to focus specifically on one cluster and the relationship within that cluster. For this research, all these available features of the VOSviewer program were used to analyze generated co-citations and co-occurrence maps.

### ***3.6.4. Analysis of the Linguistic Features of the Text***

Fairclough's (2001; 2013) CDA approach requires paying attention to certain linguistic features of the text, as they provide specific information, about the writer's discursive choices and how these choices create power differences in the text. Since this research adopted an exploratory perspective instead of adopting a theoretical

framework to narrow its focus, the critical focus of this research was on the linguistic features of the texts, not the emerging themes of a theoretical framework. Therefore, the linguistic features of the text were used as codes for analysis instead of emerging themes for this research. As, there are numerous linguistic features defined by discourse studies (Baker & Ellece, 2011) the texts were analyzed by using the most relevant linguistic features to the research questions. Through the analysis, if other linguistic features were observed in the texts, they were added as code for analysis. Native English speakers and experts in rhetorical studies were consulted for member-checking. Since these features were socially and linguistically agreed-upon constructs, over 90% agreement was reached. Extra attention was paid to the codes that differ since these differences occurred due to some overlaps among the features. The linguistic features that were used in the analysis were explained extensively with the relevant research in the literature review.

Even though they are considered one of the linguistic features of the text, subject positions were not treated as a code for analysis since the texts could promote various subject positions with different hierarchical roles. Therefore, this linguistic feature was treated differently from the other linguistic features listed above. Subject positions were investigated separately since they were one of the most significant indicators of promoted power differences in the text.

Davies and Harré (1990) define positioning as “the discursive process whereby selves are located in conversations as observably and subjectively coherent participants in meaning making. There can be interactive positioning in which what one person says positions another, and there can be reflexive positioning in which one positions oneself” (p 48). Therefore, in discourse, social actors or individuals are ascribed certain roles and identities which are referred to as subject positions.

In this research, Gee’s (2004) theory of discourse was used to investigate ideal subject positions promoted by the texts. Gee provides a list of questions to use while investigating subject positions and their relationships.

1. What identities (roles, positions), with their concomitant personal social, and cultural knowledge and beliefs(cognition), feelings (affect), and values, seem to be relevant to, taken for granted...?
2. How are these identities stabilized or transformed...?
3. In terms of identities, activities, and relationships, what Discourses are relevant (and irrelevant) ...? How are they made relevant (and irrelevant), and in what ways? (Gee, 2004, p.111).

By using these questions as a guideline, and combining them with the Fairclough's (2001) guiding questions, the subject positions created by the texts and the relationship among these subject positions were investigated.

### **3.7. Research Rigor**

Rigor is a challenging aspiration for any researcher who focuses on the language and language in use (discourse). Language is hermeneutic in nature; it involves interpretations and constructed meanings. When investigating discourse, researchers superimpose another level of interpretation. Habermas (1984) calls it, 'double hermeneutic'. Through language, we create a representation of the world as a speaker/writer and as a listener/reader we interpret the already interpreted world. In this sense, CDA research is similar to interpretive research. Therefore, regardless of their research design trustworthiness and especially reflexivity needs to be addressed to assure rigor in any research using CDA.

#### **3.7.1. Trustworthiness**

There are four strategies to achieve trustworthiness in qualitative research; credibility, transferability, dependability, and confirmability (Guba, 1981; Shenton, 2004). Since CDA research theoretically rejects a neutral, objective stance in any research (Mullet, 2018), only three of these four strategies can be used for CDA research. Instead of confirmability, generally different triangulation strategies are employed in CDA research to demonstrate the consistency of the analysis. For this research, three triangulation strategies were used in addition to credibility, transferability, dependability strategies. Also, subjectivity issues were particularly addressed to assure trustworthiness.

*Methodological triangulation:* Two types of methodological triangulation were defined in the literature, ‘across method’ and ‘within method’. Methodological triangulation attained through combining data collection methods based on different paradigms is called ‘across method’, while, combining two or more data collection methods based on the same paradigm is called ‘within method’ (Casey & Murphy, 2009). For this research, across methods, methodological triangulation was used. Fairclough’s (2001) CDA framework allowed this research to utilize more than one method for the investigation. VOSviewer program used the Chi-square analysis to determine the link strength scores for the co-citations and co-occurrences to map out these relationships, therefore, it provided technical knowledge. The discursive analysis of the linguistic features provided hermeneutic knowledge, and the CDA provided contextual knowledge. Since this research used different data collection techniques embedded in different paradigms, ‘across method’ methodological triangulation was attained.

*Theoretical or perspective triangulation:* In CDA research if a written text is being investigated instead of a conversational text, the researcher could not compare different accounts of the reality. While investigating a written text CDA simply compares two accounts of the reality, the writer’s and the reader’s accounts. Yet, in the analysis process, the writer’s interpretation of the reality could only become accessible through the researcher’s interpretation. Therefore, instead of the text CDA research utilizes the context to provide alternative accounts of the reality. There are four levels of context CDA can utilize, immediate language; interdiscursive relations; immediate social context; broad social context (Wodak, 2011). In this research, all four levels of context were included in the analysis by investigating the discursive choices of both prominent epistemic communities of science education and elementary science education. For immediate language, the sampled articles; for interdiscursive relations, discursive interactions within the located epistemic communities; for immediate social context epistemic communities themselves, and for broad social context science education, in general, were taken into account for CDA.

*Data source triangulation:* This research benefitted from data triangulation as well. The data obtained to locate the epistemic communities in the literature combined with

the data collected for different epistemic communities enabled the data triangulation. Moreover, the overlapping nature of the Fairclough's (2001) CDA approach contributed to data triangulation as well. Each analysis dimension provided additional data for the following analysis. Observed characteristics of the discourses were used to investigate power differences and hierarchical roles promoted by these discourses and the determined hierarchical roles were used to investigate how power differences were created.

*Credibility:* To support credibility in the research, adequacy of the data, adequacy of interpretation, and accessibility issues were handled specifically. *Adequacy of the data*, the data utilized for this research initially entailed all the published articles between the years 1975-2018 in science education which was accessible through a Web of Science database. It was necessary to reduce the number of articles to a manageable size for CDA since unavoidable spurious relationships could be observed simply because of the size of the data, 'Ramsey Theory' (Robertson, 2021). Therefore, purposeful sampling was used with strict control of the researcher effect. The sampled articles were chosen according to a set of thresholds which allowed this research to obtain adequate data. Any research following the same purposeful sampling procedure could reach the same data. *Adequacy of interpretation*, when the number of the different analyses utilized by this research is considered it becomes clear that repeated forays into the same data have occurred. To assure adequacy of interpretation further the researcher utilized the questions provided by both Fariclough (2001) and Gee (2004) which led to repeated critical readings of the texts.

*Accessibility:* According to Wodak (2009) to assure trustworthiness in CDA research, accessibility should be assured. The research should be comprehensible for the targeted audience to attain its emancipatory purpose. This research was specifically presented in accordance with a Ph.D. thesis format and its organization and discursive consistency were predetermined. In addition to this superimposed format, extra attention was paid to the readability and transparency of the text.

*Dependability:* Native English speakers and an expert in rhetorical studies were consulted for member-checking to address dependability issues. Two native English

speakers were science education researchers over ten years of experience with PhD's. The rhetorical studies expert was a Turkish researcher over ten years of experience with a master's degree in the field of English Rhetorical Studies. All experts were informed about the details of the research and analysis procedures. While native English speakers were consulted only for member-checking, more consulting sessions were held with the rhetorical studies expert.

*Transferability:* Transferability issues were addressed by providing detailed and reflexive descriptions of the research design process and data collection and analysis procedures. By doing so, this research aimed to provide enough information for the reader to identify relevant knowledge, produced by this research, which could be implemented and generalized for their context.

### **3.7.2. *Subjectivity***

Attributable to its deep roots in critical theory, CDA research is cautious about the power that critical researchers possess. It accepts that the knowledge constructed by the researcher as well is ideological and socially constructed (Lazar, 2007). Therefore, the trustworthiness of CDA research is intimately connected to the researchers' standpoint (van Dijk, 1993). For this research the researcher's positionality was addressed within the text with references to the reader, through self-criticality, reflexivity. The decisions made by the researcher throughout the whole research and the reasoning behind these decisions were shared with the reader.

## **3.8. *Reflexivity***

The dictionary definition of reflexivity states that it is 'the fact of someone being able to examine his or her own feelings, reactions, and motives and how these influences what he or she does or thinks in a situation' (Cambridge Dictionary, n.d.). In research terms, this can be translated as a thoughtful, self-aware analysis of the intersubjective dynamics between researcher and researched (Finlay 2008). Reflexivity requires critical self-reflection of the ways in which researchers' social background, assumptions, positioning, and behavior impact on the research process (Lynch, 2000). Yet it differs from reflection, thinking about something after the fact, since reflexivity

involves continuous self-awareness within the moment, throughout the whole process of research.

Discourse studies, especially critical discourse studies often criticized for not paying enough attention to reflexivity (Zienkowski, 2017; Rogers, et al., 2005). Yet, these critics also recognized the fact that reflexivity can be addressed in different forms within the CDA research framework. For example, intertextuality, interdiscursivity, and many other aspects of discourse analysis are strongly related to the reflexive functions of language. Therefore, because reflexivity is a part of discursive processes, it is sometimes overlooked and not presented distinctively by some discourse studies. As Alvesson and Skoldberg (2000) point out researchers' intentions regarding reflexivity could vary in a significant spectrum. At one end of this range of reflexive intentions, reflexivity can be used as a tool for rigor in the research addressing the quality components like reliability and validity, and on the other end, it can be used to question the authenticity of the researcher while handling the research quality issues from a more relativistic perspective. If the reflexivity process is successful the reader could see through the researcher's beliefs, feelings, and motives and decide for themselves freely, where the intentions of the researcher lay between a deterministic to relativistic spectrum.

This research is presented as a Ph.D. thesis, therefore, its formal structure dictated how the researcher's voice could exist in this text. While formal - informal voice transitions can be used to make the researcher's beliefs, feelings, and motives accessible for the reader, this discursive choice could result in power differences in researchers' perceived stance. Simply by switching between formal to informal voice, the researcher could appear to be switching her stance from objective to subjective and vice versa. Since this research aims to increase the readers' awareness of how discursive choices create power differences and to show knowledge produced by the researchers is not value-free, the subjective nature of this research is presented through the transparency of the decision-making processes and a detailed explanation of these processes instead of adopting an informal voice. Reflexivity was addressed explicitly in the following paragraphs of this section. Furthermore, ideological imperatives and epistemological presuppositions that informed this research as well as subjective,

intersubjective, and normative reference claims made by the researcher (Kincheloe & McLaren, 1994) were presented in sections explaining the researcher's decision-making processes which are exclusively dedicated to the reflexive process.

It is possible that not many researchers of CDA address reflexivity explicitly since they believe questions of bias and subjectivity have always been a problem and they strive for a reflexive discourse in their own text since if they could achieve to produce a reflexive discourse all these concerns would be address seamlessly within the text. I have to admit even though that was what I strive for throughout this text I cannot claim to achieve that as a Ph.D. student who needs to convince a group of esteemed science educators and researchers that this thesis is worthy of a Ph.D. degree. Therefore, addressing reflexivity issues explicitly with few paragraphs in this section with an informal voice was the best choice for me.

Talking about power structures and not positioning myself within these structures as the researcher and the writer of this text would be almost an impossible task. Our discursive choices reveal unintentionally shared knowledge, they even reveal the workings of our subconsciousness and biases. Therefore, the genre, the sentence structures, and the wording of this text already revealed a lot about who I am. Also, since I explained the research process and the decisions I made throughout this process in detail, my readers also have some understanding regarding the way my reasoning works and the level of my prior knowledge. Moreover, throughout the text, the intertextual references that I used gave various clues and within the cracks of the strict academic objective voice, my reader could also sense my passion and interests. However, how this process affected me as an educator and researcher cannot be easily deduced by my reader through this text. Therefore, it might be beneficial to share some more information about me, the researcher.

First of all, it took me several years to conduct this research, and during this time my understanding of discourse changed, matured, and reconstructed substantially. I was primarily interested in classroom discourse and its effects on students' life. However, the more I read about this topic, I started to comprehend the extent of discursive interactions. The context has a considerable effect on our discursive choices and the

way we navigate in life through these choices. Therefore, the perceived and constructed power structures by discourse literally shapes our life, pun intended. As these structures become more visible to me my interest in classroom discourse shifted to macro-level interactions in science education literature. This topic was particularly interesting to me since I decided to take part in this field as a researcher and gain membership in its communities. Therefore, gaining more information about the discursive choices of the researchers of science education became my passion. Combining my knowledge in the science education field with the knowledge I attain through several Ph.D. level courses on CDA, rhetorical studies, and philosophy, I decided to conduct research that is founded on a multidisciplinary framework. I have to admit having a brother who had post-graduate degrees in rhetorical studies also led me to this path and was very helpful.

With this research, I gained the awareness that for the people in the position of power discourse became a tool for preservation or transformation depending on their intention, and for the people who do not have power, discourse can be a tool to gain power or to challenge the current status quo. Both positions carry responsibility for future generations. Particularly, in academia, every choice we make as researchers and educators has a ripple effect that we cannot refuse to take responsibility for. As Pierre Bourdieu et al., (1996) suggest, the use and abuse of philosophical and technical jargon is a problem in academia. We could recognize this problem or overlook it but one way or another new generation of academics will play their hand and force us to transform. Since “every effort to transform the system which is not accompanied by an attempt to transform attitudes towards the system (and conversely) is doom to failure” (Bourdieu et al., 1996, p.3) to change our attitudes, it is necessary to gain awareness of the intricate relations of power structures underlying the systems of academia and education. Therefore, in my humble opinion questioning the discursive choices of epistemic communities can be a good start for this endeavor.

### **3.9. Limitations**

Critical research aims for a change through emancipation but it is not always guaranteed. Especially when power structures are well established and both researcher

and research topic are part of this established power structure. Being aware of the nature of this research as a Ph.D. thesis, it was unavoidably embedded into the power structures of both the academic and science education fields. More than anything, this thesis was structured in a way that was acceptable by a group of educational researchers. Congruently, it was subjected to the discursive choices of the epistemic communities of the science education that it was investigating. Even though the association with the investigated power structures was the most obvious limitation of this research, it also served for its emancipatory objective. Since, it can be claimed that within its own small research community, all the members involved in this process gained some awareness about the role of epistemic communities and how their discursive choices create power differences in science education.

Another specific limitation of this research was the gap it was trying to address in the literature. This research was pointing out an area in the literature in which there was almost no readily available prior research. Every decision made by the researcher, no matter how profound they were, was not following the footsteps of prior researchers. While relying on the available experiences and knowledge in the field, the design choices significantly affected the findings of this research. Whether to investigate epistemic communities of science education from a wide or a narrow perspective was one of the biggest design challenges faced to address the gap in the literature. A wider perspective was adopted and the discursive choices of both science education and elementary science education epistemic communities were investigated together. The rationalization of this choice was explained in detail before, yet further research on this topic in the field will reveal the actual outcomes of this choice.

For CDA research there are a variety of linguistic techniques available for the analysis but within the scope of this research, only certain discursive elements were used. Moreover, the analysis was conducted by a non-native English speaker. Even though the researcher was specifically trained in CDA research and native English speakers and experts in rhetorical studies contributed to the member checking, these limitations should also be taken into account while interpreting the findings of this research.

A data mapping program (VOSviewer program) was used to locate epistemic communities in science education, therefore, the researcher's effect on the purposeful sampling procedure was strictly controlled. However, due to the overwhelming number of co-citations included in the raw data, there were some thresholds determined by the researcher to limit the processed data. While these thresholds were simple frequency of occurrences, this research, by all means, could not claim to figure out all the relationships and to locate all the epistemic communities in science education.

Moreover, since the number of texts used for CDA was limited, the findings of this research could only provide very limited information regarding the discursive choices of the epistemic communities in science education literature. It should be kept in mind that; this research was also context-bound and affected by the societal and discursive power relations that exist in the science education community. Therefore, further research is needed with more texts and methodological variety to achieve its ultimate goal, to understand the power relations in science education and be a means for an emancipatory awareness that could lead to a more democratic future.

## **CHAPTER 4**

### **LOCATING EPISTEMIC COMMUNITIES**

The purpose of this research was to investigate the discursive choices of epistemic communities of science education and elementary science education to reveal the characteristics of the discourses promoted by them as well as the power differences and the ways these differences were created by their discursive choices. This purpose led the research to look into the prior research, as it was made accessible by the Web of Science database, to locate the epistemic communities in science education and elementary science education literature since these communities have not been fully described in the literature. The investigation of science education and elementary science education literature not only aided this research in locating the epistemic communities but also yielded useful information about the social conditions in which these epistemic communities were formed.

In this section, (a) a brief description of the method used to locate the epistemic communities in both science education and elementary science education was given (a detailed explanation was given in Chapter 3, 3.5. Data Collection, 3.5.3 Sampling Procedure), and (b) a detailed explanation of how epistemic communities of science education and (c) elementary science education was located in the literature was presented. Also, (d) as the context of this research, the observed characteristics of the most influential articles located in the literature and what could be inferred regarding the located epistemic communities based on these observations were discussed. Finally, (e) the information gathered concerning epistemic communities was presented with in summary to support one of the main assumptions of this research with evidence. Thus, the data collected within the scope of this research supported the assumption that there are prominent epistemic communities in science education and elementary science education literature and enabled this research to locate some of these epistemic communities.

#### **4.1. Locating Epistemic Communities**

In accordance with Kuhn's (1996) 'scientific community' notion, epistemic communities can be defined as a group of individuals from shared or similar disciplines whose endeavors of knowledge production involve a common paradigm. Even though Burkhard Holzner (1972) and John Ruggie (1975) are considered to be the primary sources of the term epistemic community, the popularity of this term in current literature is attributed to Peter Haas (1992). Haas (1992) defines an epistemic community as networks of knowledge-based experts and claims that certain conditions need to be met to form an epistemic community.

According to Haas (1992), epistemic communities have

1. a shared set of normative and principled beliefs, which provide a value-based rationale for the social action of community members;
2. shared causal beliefs, which are derived from their analysis of practices leading or contributing to a central set of problems in their domain and which then serve as the basis for elucidating the multiple linkages between possible policy actions and desired outcomes;
3. shared notions of validity- that is, intersubjective, internally defined criteria for weighing and validating knowledge in the domain of their expertise; and
4. a common policy enterprise- that is, a set of common practices associated with the set of problems to which their professional competence is directed, presumably out of the conviction that human welfare will be enhanced as a consequence. (p.3)

In addition to these characteristics, members of an epistemic community are expected to have "a shared intersubjective understanding," "a shared way of knowing," "shared patterns of reasoning," and "shared discursive practices" (p.3).

Summarizing Haas (1992) approach, to form an epistemic community, experts should have shared normative beliefs, which are based on a set of agreed-upon principles, and causal beliefs, which are derived from their analysis of practices, as well as shared notions of validity. Moreover, their recognized expertise within a particular domain should assure an authoritative claim over produced knowledge. Therefore, researchers

investigating epistemic communities usually focus on social relationships and semantic similarities, in other words, common discursive choices, to understand how these networks of experts are formed (Roth & Bourgine, 2003).

Guided by Haas's (1992) definition, this research looked for the networks of experts in science education and elementary science education literature with some social relationships and common discursive choices to locate epistemic communities. VOSviewer program was used to reveal these networks in the literature by mapping the ways science education researchers cite each other's works since the ways researchers cite each other's work would indicate a certain relationship among them as well as common discursive tendencies. Being cited by other researchers and co-citing each other's work consistently shows that these researchers (experts) shared some normative beliefs, which are based on the frameworks (a set of agreed-upon principles) which are derived from previous research in the field and causal beliefs (the analysis of practices), as well as shared notions of validity. Therefore, to locate the epistemic communities, the analysis of the science education literature through co-citations was the best match for Haas's definition and criteria of epistemic communities (Haas, 1992).

Co-citation analysis allows researchers to determine with what frequency two articles are cited by other articles in the literature and enables researchers to observe the citation relationships within a field (Small, 1973). Also, if two articles are co-cited frequently, this indicates a strong correlation (Grover et al., 2006) and semantic similarity (Small, 1973; Sanguri et al., 2020). Even as a useful way to reveal the knowledge and relationship structures, co-citation analysis has some limitations. Information gathered through co-citation analysis is time-dependent since the knowledge and relationships in any field change and evolve in time (Trujillo & Long, 2018). Also, co-citation analysis assumes two articles are semantically similar based on co-citation (Özçınar, 2015). However, the content of the articles could also provide much-needed information about the semantic similarity (Boyack et al., 2013). Therefore, to address these limitations, while locating epistemic communities in the literature extended time span was used for the article selection, and VOSviewer co-

occurrence maps were generated and used to track semantic similarities in addition to the generated VOSviewer co-citation maps.

To locate the prominent epistemic communities, science education and elementary science education articles published within the years 1975-2018 that were accessible through Web of Science data-based were used. For science education literature, 37,161 articles with 1,071,303 cited references, and for elementary science education literature, 6,565 articles with 147,587 cited references were investigated. The VOSviewer co-citation mapping of these articles provided detailed information about the most cited texts and the co-citation clusters that specified the communities formed in the literature, indicating the existence of epistemic communities. Within the scope of this investigation, 21 articles were located in the literature with a significant cluster effect, 17 of these articles were located in science education literature, and four of these articles were located in elementary science education literature (The lists of these articles and a detailed explanation of the mapping procedure were given in Chapter 3, 3.5.3 Sampling Procedure). This investigation also rendered an important result. Since locating these epistemic communities by mapping out the co-citation clusters they created in the literature, it became possible to determine the most influential articles representative of these epistemic communities.

Locating the articles with significant cluster effects in science and elementary science education literature enabled this research to investigate the semantic and semiotic similarities observed in the actual texts of these articles, especially in terms of terminological choices (noun and noun phrases) with VOSviewer co-occurrence maps. These maps also further differentiate the epistemic communities represented within the 21 articles. By creating a map of the co-occurrences of common nouns and noun phrases within all 21 articles, it became possible to partially investigate the discourses promoted by different epistemic communities and differentiate them. Three co-occurrence maps were generated to explore the characteristic word choices of the 21 articles. First, all 21 articles were treated as a single text together to reveal the general word choice tendencies. Afterward, two separate co-occurrence maps were generated, treating 17 articles located in science education literature as one text and four articles in elementary science education literature as another to investigate the similarities and

differences between the articles with high cluster effects in science education and elementary science education literature. Thus, this analysis was able to distinguish and locate three epistemic communities, two in science education and one in elementary science education. More importantly, it enabled this research to purposefully sample the most influential articles representative of these epistemic communities to conduct CDA and investigate the discursive choices of these epistemic communities in detail. In the following sections, how the epistemic communities were located in science and elementary science education literature was further explained.

#### **4.2. Epistemic Communities of Science Education**

Determining the most influential articles of science education with VOSviewer co-citation maps enabled this research to investigate the authors of these articles and their relationships in the literature. When the located 17 science education articles were organized based on the first authors (see, Table 4.1), it was observed that Driver, R., Lederman, N. G., Osborne, J., and Shulman, L. S., Brown, J. S., Duschl, R., Erduran, S., Eylon, B. S., Jimenez-Aleixandre, M. P., Magnusson, S., Posner, G. J., Sadler, T. D., Zohar, A., were the first authors of these articles. Driver, R., Lederman, N. G., Osborne, J., and Shulman, L. S. were the first author of two articles, while the remaining researchers were observed as the first authors of only one article.

**Table 4.1**

*The First Authors of the Located Articles of Science Education*

First Authors	Articles
Driver, R.	Driver, R., Newton, P., & Osborne, J. (2000).
	Driver, R., Asoko, H., Leach, J., Scott, P., & Mortimer, E. (1994).
Lederman, N. G	Lederman, N. G. (2007).
	Lederman, N. G. (1992).

Table 4.1 (continued)

First Authors	Articles
Osborne, J.	Osborne, J., Erduran, S., & Simon, S. (2004).
	Osborne, J., Simon, S., & Collins, S. (2003).
Shulman, L. S	Shulman, L. S. (1986).
	Shulman, L. (1987).
Brown, J. S.	Brown, J. S., Collins, A., & Duguid, P. (1989).
Duschl, R.	Duschl, R., & Osborne, J. (2002).
Erduran, S.	Erduran, S., Simon, S., & Osborne, J. (2004).
Eylon, B. S.	Eylon, B. S., & Linn, M. C. (1988).
Jimenez-Aleixandre, M. P.	Jimenez-Aleixandre, M. P., Rodriguez, A. B., & Duschl, R. A. (2000).
Magnusson, S.	Magnusson, S., Krajcik, J., & Borko, H. (1999).
Posner, G. J.	Posner, G. J., Strike, K. A., Hewson, P. W., & Gertzog, W. A. (1982).
Sadler, T. D.	Sadler, T. D. (2004).
Zohar, A.	Zohar, A., & Nemet, F. (2002).

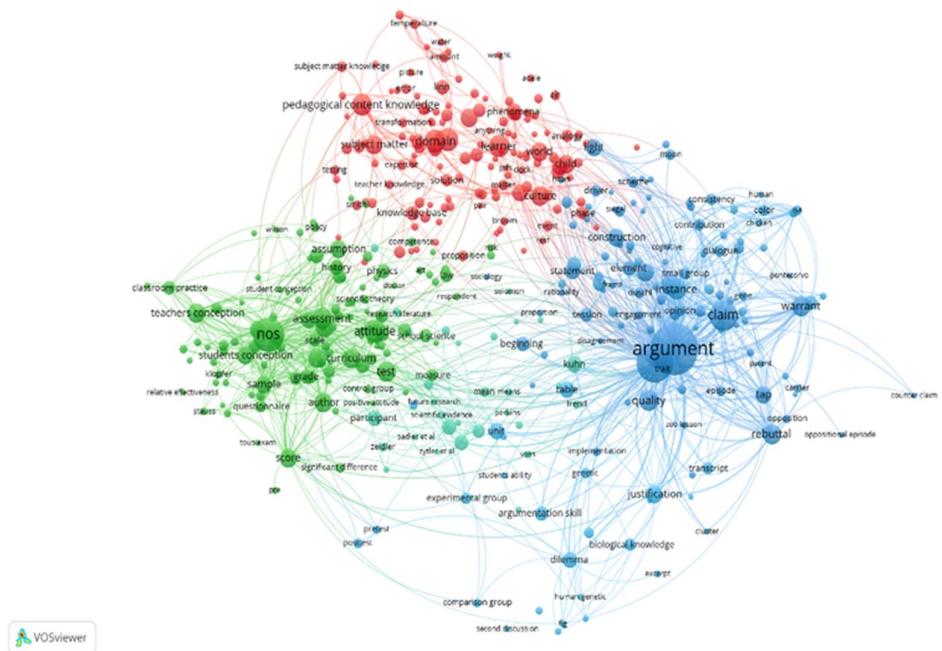
These 17 articles were treated as one whole text and analyzed with VOSviewer program to see the general discursive tendencies of the authors of these articles. The co-occurrence map of the science education articles based on text data generated with this program (Figure 4.1) revealed that there were 3 clusters indicating distinctive discursive choices within these articles. These clusters were indicative of epistemic communities with distinctive terminological and discursive choices.

Argumentation, nature of science, and pedagogical content knowledge frameworks and their distinguishing discursive choices were observable in this map, especially in terms of their terminologies. When the 17 science education articles were investigated

further regarding their theoretical frameworks, the investigation revealed that the argumentation framework was used by 6 of the 17 articles, while the pedagogical content knowledge framework was used by three articles, and the nature science framework was used by two articles. However, despite the significant difference in the number of articles utilizing the argumentation framework compared to the other two frameworks, the frequency distributions (represented by the size of the cluster bubbles in the map) of the terminologies and their networking effects (represented by the number and thickness of lines between clusters) were not proportional to this difference.

**Figure 4.1**

*Co-occurrence Map of the Science Education Articles Based on Text Data*



All three frameworks were distinctly observable in the co-occurrence map (Figure 4.1), and the number of clusters they created was not resembling the same ratio among the number of articles that utilized these frameworks. Within the networks of co-occurrences, there were 134 clusters (blue colored) associated with argumentation, 141

clusters (red-colored) associated with pedagogical content knowledge, and 119 clusters (green colored) associated with the nature of science frameworks. This disproportionality was noteworthy since it could be an indication that discursive choices of these frameworks might also be shared by other frameworks which were utilized by the remaining articles, and the choices associated with argumentation, nature of science, and pedagogical content knowledge frameworks could have more general use. Moreover, 11 out of 17 articles were utilized these three frameworks, and the domination of the discursive choices of these frameworks was also apparent through the absence of clusters that could be associated with other frameworks in the co-occurrence map. The frameworks which were used by the remaining six articles, student attitudes, situated cognition, conceptual change, learning and instruction, and socio-scientific issues, were not distinguishable through their terminological choices within the co-occurrence map of science education articles.

Only a few terms like socio-scientific issues and attitude appeared as items in the co-occurrence map. However, since these terms were also used by the argumentation framework as well as the nature of science framework, their networking effect vacillated depending on the set thresholds. It could be possible to detect the distinguishing choices of the frameworks utilized by the remaining 6 articles with a bigger sample. Yet, considering the fact that all the articles were chosen based on their cluster effects in the literature, the bigger sample size would not change the dominating position of the argumentation, nature of science, and pedagogical content knowledge frameworks. As a result, by investigating the ways science education researchers cite each other's works, this research was able to locate three distinctive groupings in science education literature. These groupings were formed based on theoretical frameworks outlining the agreed-upon principles and the discursive choices shared by the authors of these articles.

Based on these findings, this research located three central frameworks which were commonly used and cited by the researchers in science education literature; argumentation, nature of science, and pedagogical content knowledge. As Cross (2013) suggests, epistemic communities could arise from a common scientific outlook and shared disciplinary theories. Therefore, these groupings based on frameworks

were indicative of epistemic communities in science education. However, bearing in mind the hierarchical structure of the education field, just like the way elementary science education literature is embedded in science education literature, science education literature is also embedded in education literature and influenced by it. When these three located frameworks are reconsidered, argumentation and nature of science frameworks are particular frameworks of science education due to the role of argumentation in scientific inquiry (Mirza, & Perret-Clermont, 2009) and the nature of science framework's particular focus (Lederman, 2007).

Even though pedagogical content knowledge is a well-established framework in science education, it is a generally used framework in education literature. Therefore, there was not enough information to determine whether the pedagogical content knowledge framework observed in the data was due to the effect of an epistemic community in education literature or present itself as an indicator of a specific epistemic community in science education literature. Since the scope of this research was limited to science education and elementary science education literature, only two frameworks' community-building effects were supported by the data. Therefore, this research was able to locate two epistemic communities in science education literature and they were referred to as argumentation epistemic community and nature of science epistemic community.

#### **4.3. Epistemic Communities of Elementary Science Education**

The investigation of the elementary science education literature with VOSviewer co-citation maps based on bibliographic data rendered four articles with high cluster effects (see Chapter 3, 3.5.4 Sampling Procedure). Since elementary science education literature is naturally embedded in science education literature, the cluster effects of the previously located science education articles were present in the VOSviewer co-citation maps of the elementary science education articles as well. Despite the presence of the science education articles' cluster effects, these located four articles had significantly high cluster effects in elementary science education literature. Therefore, it was deduced that even though the research frameworks and epistemic communities of science education had a direct effect on elementary science education literature,

there were some distinctive groupings particular to elementary science education literature.

**Table 4.2**

*The First Authors in the Located Articles of Elementary Science Education*

First Author	Articles
Abd-El-Khalick, F.,	Abd-El-Khalick, F., & Lederman, N. G. (2000).
Akerson, V. L.	Akerson, V. L., Abd-El-Khalick, F., & Lederman, N. G. (2000).
Lederman, N. G.	Lederman, N. G., Abd-El-Khalick, F., Bell, R. L., & Schwartz, R. S. (2002).
Pajares, M. F.	Pajares, M. F. (1992).

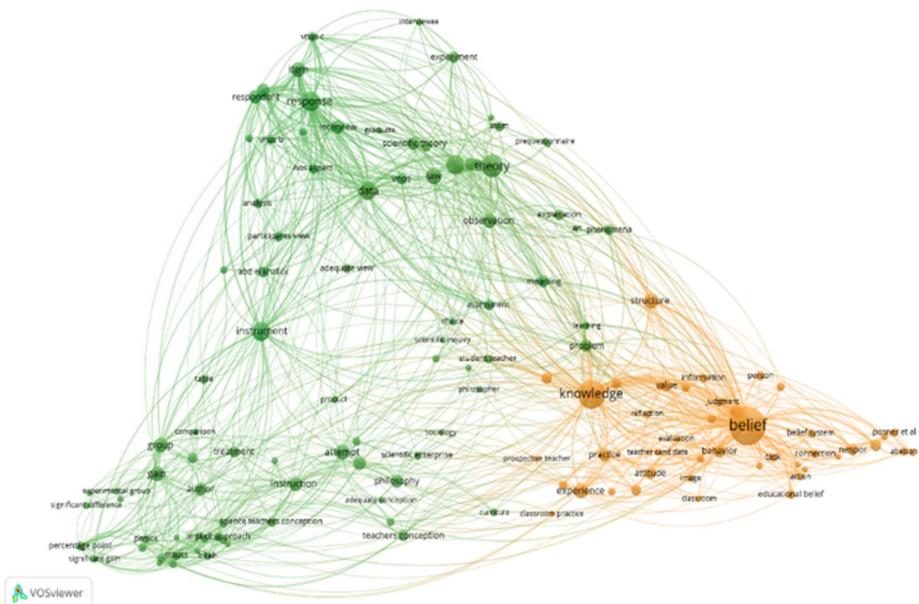
Lederman, N. G., Abd-El-Khalick, F., Akerson, V. L., and Pajares, M. F. were the first authors of the located four articles in elementary science education literature (Table 4.2). Although the first authors of these articles were different, two researchers, Lederman, N. G., and Abd-El-Khalick, F., contributed to three of the four articles located in elementary science education literature. Considering the number of the located articles with high cluster effects in elementary science education literature, the contribution of these researchers was significant.

The four articles located in elementary science education literature were also treated as a whole text and analyzed with the VOSviewer program to see the general discursive tendencies of the authors. The co-occurrence map of the elementary science education articles based on text data (Figure 4.2) generated with this program revealed that there were two clusters indicating distinctive discursive choices within these articles. The nature of science and teachers' belief frameworks and their distinguishing terminological choices were observable in the co-occurrence map. Within the networks of co-occurrences, there were 89 clusters (green colored) associated with the

nature of science framework and 44 clusters (orange colored) associated with the teachers' belief framework.

**Figure 4.2**

Co-occurrence Map of the Elementary Science Education Articles Based on Text Data



Again, since teachers' belief framework was a general framework in education literature, there was not enough information to determine whether teachers' belief framework was observed in the data due to the effect of an epistemic community in education literature or presented itself as an indicator of a specific epistemic community in elementary science education. Moreover, teachers' belief framework was not observed among the frameworks utilized by the articles with high cluster effects in science education literature. Therefore, it was not possible to investigate this framework by comparing its effect in both science education and elementary science education literature. Since the scope of this research was limited to science education and elementary science education literature, only one framework's community-building effect was supported by the data. Thus, this research was able to locate one

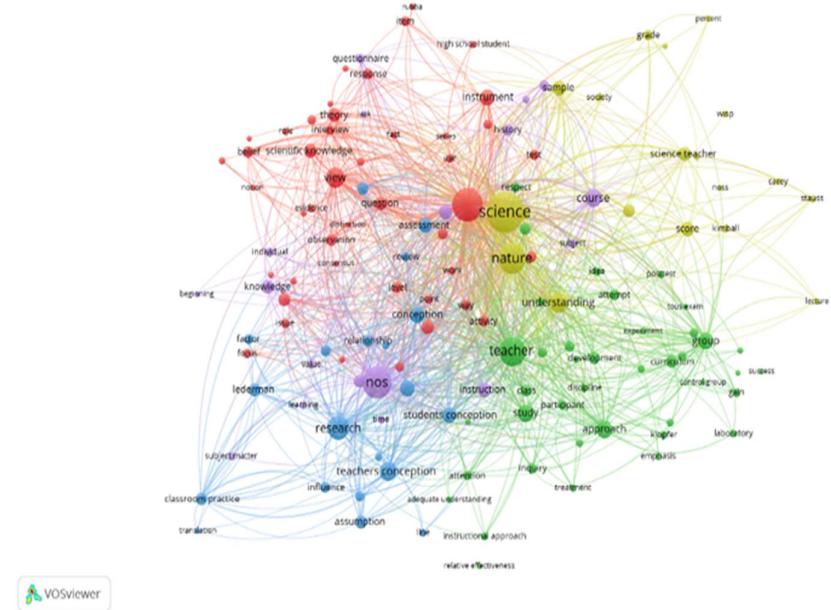
epistemic community in elementary science education literature, which was the nature of science community.

The nature of science community was located in elementary science education literature again, even though the articles located in science education literature were left out of the analysis. The two articles authored by Lederman which had already been located in science education literature were present in the elementary co-citation maps. Yet in addition to these articles, more articles utilizing the nature of science framework co-authored by Lederman with high cluster effects were present in elementary science education literature. Further, investigations were conducted to determine whether this observation was an indication of the previously located the nature of science community's effect on elementary science education literature or if there was a particular community utilizing the nature of science framework in elementary science education literature. When the located articles employing the nature of science framework in elementary science education literature were compared with previously located articles in science education literature employing the nature of science framework, some differences were observed.

The two articles located in science education literature using the nature of science framework were review articles and authored by Lederman as the only author. These two articles were investigated as a whole text and a VOSviewer co-occurrence map was generated (Figure. 4.3). Out of four articles located in elementary science education literature, three of them were using the nature of science framework. Two of the three located articles employing the nature of science framework in elementary science education literature were mainly focused on the assessment of the nature of science conceptions. The remaining article was a review article about improving science teachers' nature of science conceptions. Therefore, the three articles using the nature of science framework were investigated as a whole text as well and a VOSviewer co-occurrence map was generated (Figure 4.4).

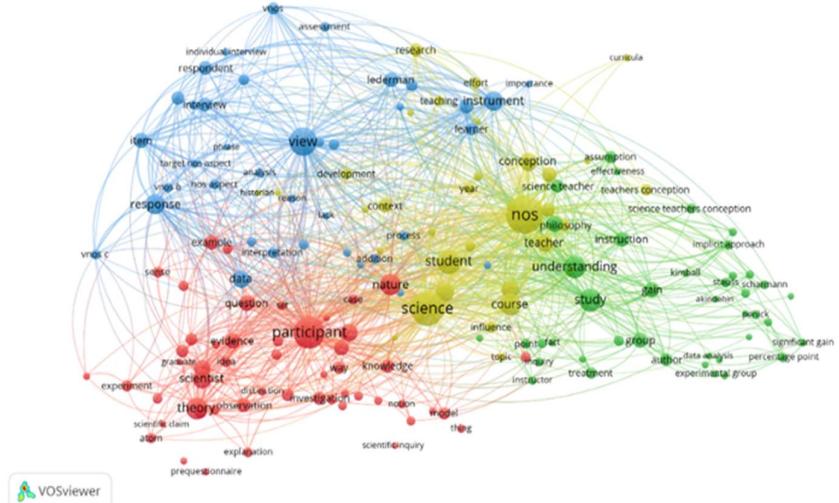
**Figure 4.3**

## *Co-occurrence Map of the Located NOS Articles in Science Education Literature*



**Figure 4.4**

## *Co-occurrence Map of the Located NOS Articles in Elementary Science Education Literature*



Afterward, the two-co-occurrence maps were compared to see whether there was a significant semantic difference between these texts indicative of distinctive communities. As expected, there were not any significant terminological differences observed in the maps. However, in terms of the linguistic features, especially the frequency of various nominalizations observed in the maps, there were some significant differences. The comparison showed that in the articles utilizing the nature of science framework in science education literature, the nominalizations ‘teachers’ and students’ conception’ and ‘teachers’ and students’ understanding’ were more frequently used. While in the articles utilizing the nature of science framework in elementary science education literature nominalizations including ‘view’ was the most frequently used nominalization. Therefore, the differences observed in these co-occurrence maps led this research to investigate the discursive choices of the nature of science communities in science education and elementary science education separately. A detailed description and explanation of the discursive choices of the nature of science communities in science education and elementary science education literature were given in the following chapters (Chapter 5, and Chapter 6)

#### **4.4. Located Articles and Epistemic Communities as Context**

Epistemic communities in science education and elementary science education literature are the general context of this research. However, there is very limited information available in the science education literature regarding epistemic communities. This gap in the literature made it necessary for this research to conduct a preliminary investigation to locate some epistemic communities in science education and elementary science education literature and gather some information about them. Therefore, the 21 located articles with the highest cluster effects and the located epistemic communities in science education and elementary science education literature constituted the actual context of this research. These 21 articles were just a representative sample of the works of these communities as well as the researchers forming these communities. Still, these articles’ significant cluster effects were indicative of the authority of these articles’ (therefore, their authors’) discursive choices within these epistemic communities and in the field.

In the previous sections, information gathered regarding epistemic communities of science education and elementary science education were presented separately. The embedded nature of elementary education literature in science education literature allows this research to assume that the located articles constitute one context. Therefore, in this section, further groupings within these 21 articles were presented to provide additional information regarding the context of this research.

To investigate the different groupings of the located articles both science education and elementary science education articles were organized together. These 21 articles were grouped based on the first authors as seen in Table 4.3 This table revealed that while some of the first authors contributed to only one article in the list others contributed up to five articles. Lederman was the first author of the 3 articles out of 21 articles. Driver, Erduran, Osborn, and Shulman each authored 2 articles and the remaining researchers each authored 1 article among the 21 articles as the first author.

**Table 4.3**

*First Authors of Located Articles and Their Contributions*

First Authors	Articles
Abd-El-Khalick, F	Abd-El-Khalick, F., & Lederman, N. G. (2000). <i>Not first author but listed among authors</i>
	Lederman, N. G., Abd-El-Khalick, F., Bell, R. L., & Schwartz, R. S. (2002).
	Akerson, V. L., Abd-El-Khalick, F., & Lederman, N. G. (2000).
Lederman, N. G	Lederman, N. G. (2007). Lederman, N. G. (1992).
	Lederman, N. G., Abd-El-Khalick, F., Bell, R. L., & Schwartz, R. S. (2002).

Table 4.3 (continued)

First Authors	Articles
Lederman, N. G	Not first author but listed among authors  Abd-El-Khalick, F., & Lederman, N. G. (2000).  Akerson, V. L., Abd-El-Khalick, F., & Lederman, N. G. (2000).
Osborne, J.	Osborne, J., Erduran, S., & Simon, S. (2004).  Osborne, J., Simon, S., & Collins, S. (2003).  Not first author but listed among authors  Driver, R., Newton, P., & Osborne, J. (2000).  Duschl, R., & Osborne, J. (2002).  Erduran, S., Simon, S., & Osborne, J. (2004)
Driver, R.	Driver, R., Newton, P., & Osborne, J. (2000).  Driver, R., Asoko, H., Leach, J., Scott, P., & Mortimer, E. (1994).
Erduran, S.	Erduran, S., Simon, S., & Osborne, J. (2004).  <i>Not first author but listed among authors</i>  <i>Osborne, J., Erduran, S., &amp; Simon, S. (2004).</i>
Shulman, L. S	Shulman, L. S. (1986).  Shulman, L. (1987).
Akerson, V. L.	Akerson, V. L., Abd-El-Khalick, F., & Lederman, N. G. (2000).
Brown, J. S.	Brown, J. S., Collins, A., & Duguid, P. (1989).
Duschl, R.	Duschl, R., & Osborne, J. (2002).
Eylon, B. S.	Eylon, B. S., & Linn, M. C. (1988).

Table 4.3 (continued)

First Authors	Articles
Jimenez-Aleixandre, M. P.	Jimenez-Aleixandre, M. P., Rodriguez, A. B., & Duschl, R. A. (2000).
Magnusson, S.	Magnusson, S., Krajcik, J., & Borko, H. (1999).
Pajares, M. F.	Pajares, M. F. (1992).
Posner, G. J.	Posner, G. J., Strike, K. A., Hewson, P. W., & Gertzog, W. A. (1982).
Sadler, T. D.	Sadler, T. D. (2004).
Zohar, A.	Zohar, A., & Nemet, F. (2002).

However, regardless of their author position, Lederman, and Osborn, each contributed to 5 articles out of 21 selected articles. Together these two writers contributed to almost half of the articles located in the literature with the highest cluster effects. When all the authors who contributed to these located articles were considered, two co-authoring groups were observable within this list. The first group consisted of Abd-El-Khalick and Lederman, and the second group consisted of Erduran, Osborn, and Simon.

A table, Table 4.4, created to show how the 21 articles were grouped based on their frameworks. This table revealed that Argumentation, Nature of Science, Pedagogical Content Knowledge, Teachers' Beliefs, Student Attitudes, Situated Cognition, Conceptual Change, Learning and Instruction, and Socio-scientific Issues frameworks were utilized by these articles. Some of these frameworks appeared to be more general and applicable in other fields of education like pedagogical content knowledge, teachers' beliefs, students' attitudes, learning and instruction, situated cognition, and conceptual change. Yet two frameworks stand out among these frameworks: argumentation and nature of science frameworks. There were not only more articles utilizing these frameworks but also the authors of these articles appeared to be consistently working together. Abd-El-Khalick and Lederman's collaboration

consistently was seen in the nature of science framework, and Erduran, Osborn, and Simon's collaboration was seen in the argumentation framework. Argumentation framework was used by 6 of the 21 articles and Osborn contributed to 4 of these articles. The nature of science framework was used by 5 of the 21 articles and Lederman contributed to all of these articles. These two frameworks were utilized by more articles than the articles that utilized the remaining seven frameworks combined.

**Table 4.4**

*The Theoretical Frameworks Represented in the Located Articles*

Theoretical Frameworks	Articles
Argumentation	Driver, R., Newton, P., & Osborne, J. (2000). <b>(RWA)</b>  Osborne, J., Erduran, S., & Simon, S. (2004). Enhancing the quality of argumentation in school science. Journal of <b>(RA)</b>  Zohar, A., & Nemet, F. (2002). <b>(RA)</b>  Duschl, R., & Osborne, J. (2002). <b>(RWA)</b>  Erduran, S., Simon, S., & Osborne, J. (2004). <b>(RA)</b>  Jimenez-Aleixandre, M. P., Rodriguez, A. B., & Duschl, R. A. (2000). <b>(RA)</b>
Nature of Science	Lederman, N. G. (2007). <b>(RWA)</b>  Lederman, N. G. (1992). <b>(RWA)</b>  Lederman, N. G., Abd-El-Khalick, F., Bell, R. L., & Schwartz, R. S. (2002). <b>(RA)</b>  Akerson, V. L., Abd-El-Khalick, F., & Lederman, N. G. (2000). <b>(RA)</b>  Abd-El-Khalick, F., & Lederman, N. G. (2000). <b>(RWA)</b>

Table 4.4 (continued)

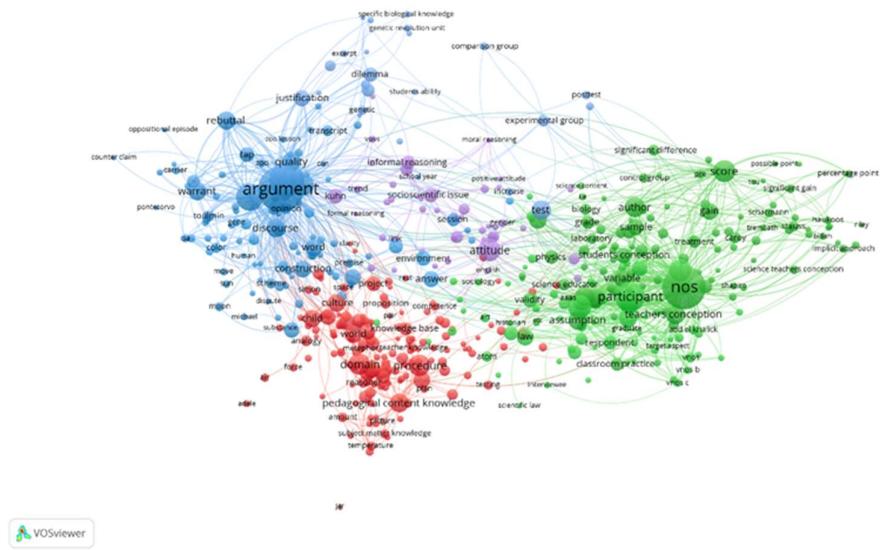
Theoretical Frameworks	Articles
Pedagogical Content	Shulman, L. S. (1986). (TA)
Knowledge	Shulman, L. (1987). (RWA) Magnusson, S., Krajcik, J., & Borko, H. (1999). (RWA)
Learning and Instruction	Eylon, B. S., & Linn, M. C. (1988). ( <b>RWA</b> ) Driver, R., Asoko, H., Leach, J., Scott, P., & Mortimer, E. (1994). ( <b>RWA</b> )
Teachers Beliefs	Pajares, M. F. (1992). Teachers' beliefs and educational research: Cleaning up a messy construct. <i>Review of educational research</i> , 62(3), 307-332. ( <b>RWA</b> )
Students' Attitudes	Osborne, J., Simon, S., & Collins, S. (2003). ( <b>RWA</b> )
Situated Cognition	Brown, J. S., Collins, A., & Duguid, P. (1989). ( <b>RWA</b> )
Conceptual Change	Posner, G. J., Strike, K. A., Hewson, P. W., & Gertzog, W. A. (1982). ( <b>RA</b> )
Socio-scientific Issues	Sadler, T. D. (2004). ( <b>RWA</b> )

These two frameworks' significant cluster effects were also observed in the co-occurrence map (Figure 4.5) generated with VOSviewer program. When all 21 located articles were treated as a whole text, the co-occurrence map showed the distinctive clustering effects of argumentation, nature of science and pedagogical content knowledge frameworks. Compared to the co-occurrence map of the science education articles, the clustering effects of the other frameworks were more observable but still not distinctive. This finding showed that with a bigger sample, clustering effects of the other frameworks could be observed. Compared to the co-occurrence map of the elementary science articles previously generated by controlling the effect of science education articles, however, the cluster effect of the teachers' beliefs framework was

not distinctive. This finding showed that due to their embedded nature, the community-building effects of the frameworks in elementary science education literature could be masked by the effects of the frameworks in science education literature. Therefore, by investigating the science education and elementary science education literature together this research was able to detect the aforementioned masking effects to a degree that the sample size allowed it.

**Figure 4.5**

### *Co-occurrence Map of the 21 Located Articles Based on Text Data*



The grouping of the frameworks also showed that these frameworks were mostly utilized by review articles. The only exception was the conceptual change framework. Out of 21 located articles, 13 of them were review articles. This finding showed that review articles had significant cluster effects in the literature. This could be attributed to this genre's characteristic of summarizing the prior research in the field and providing a useful starting point for further research (Boote & Beile, 2005) which is naturally encouraging co-citations among researchers and the formation of communities in the field.

A table, Table 4.5, was created to show how the articles were based on the mediums they were published. This table revealed that Journal of Research in Science Teaching, Science Education, Educational Researcher, Review of Educational Research, International Journal of Science Education, Harvard Educational Review, Studies in Science Education journals, as well as Handbook of Research on Science Education and In Examining Pedagogical Content Knowledge handbooks were the mediums in which most influential works of science education literature were published. Among 21 located articles 10 were published in Journal of Research in Science Teaching and Science Education journals. Even though, the articles use both argumentation and the nature of science frameworks represented in all science journals listed in the table, articles employing the nature of science framework were mainly published in ‘Journal of Research in Science Teaching,’ while articles employing argumentation framework were published mainly in ‘Science Education.’

**Table 4.5**

*The Journals and Handbooks the Located Articles were Published*

Journals and Handbooks	Articles
Journal of Research in Science Teaching	Lederman, N. G. (1992).
	Akerson, V. L., Abd-El-Khalick, F., & Lederman, N. G. (2000).
	Lederman, N. G., Abd-El-Khalick, F., Bell, R. L., & Schwartz, R. S. (2002).
	Zohar, A., & Nemet, F. (2002).
	Sadler, T. D. (2004).
	Osborne, J., Erduran, S., & Simon, S. (2004).

Table 4.5 (continued)

Journals and Handbooks	Articles
Science Education	Posner, G. J., Strike, K. A., Hewson, P. W., & Gertzog, W. A. (1982).  Driver, R., Newton, P., & Osborne, J. (2000).  Jimenez-Aleixandre, M. P., Rodriguez, A. B., & Duschl, R. A. (2000).  Erduran, S., Simon, S., & Osborne, J. (2004).
Educational Researcher	Shulman, L. S. (1986).  Brown, J. S., Collins, A., & Duguid, P. (1989).  Driver, R., Asoko, H., Leach, J., Scott, P., & Mortimer, E. (1994).
Review of Educational Research	Eylon, B. S., & Linn, M. C. (1988).  Pajares, M. F. (1992).
International Journal of Science Education	Osborne, J., Simon, S., & Collins, S. (2003).
Harvard Educational Review	Abd-El-Khalick, F., & Lederman, N. G. (2000). Shulman, L. (1987).
Studies in Science Education	Duschl, R., & Osborne, J. (2002).
Handbook of Research on Science Education	Lederman, N. G. (2007).

Different groupings of the articles showed that there were distinct groups of researchers working together with a common theoretical framework, and publishing articles in certain journals more frequently than in other journals. When the editorial boards of the journals and editors of the handbooks are considered, it is not surprising to see some associations with certain epistemic communities. For example, the researchers working with the nature of science framework who were also observed in this data, frequently appear in the editorial board of the Journal of Research in Science

Teaching. Moreover, the association between NAST conference and Journal of Research in Science Teaching is a well-known fact that it is even promoted on their websites. Therefore, there could be other networking options like conferences that support the formation of epistemic communities and also be affected by these epistemic communities. As a result, the effect of epistemic communities in science education appeared to be not limited to discursive choices. Whether researchers have a membership to these epistemic communities as a factor could mitigate the opportunities to be published in certain journals. From this perspective, the reciprocal relationship between ideologies and discourse became clear. As the discursive choices of epistemic communities promote certain ideologies as norms of conduct in journals and conferences, these ideologies control the language in use through granting access to epistemic communities by certain discursive choices. As a result, even, these simple groupings of the articles showed that there were prominent epistemic communities in science education literature and their influence on science education should not be overlooked.

#### **4.5. Summary**

Investigating science education and elementary science education literature from Haas's (1992) epistemic community lens provided rather a unique perspective for this research since the term 'epistemic communities' is more prevalent in political science literature than in science education literature despite its strong roots in the philosophy of science. Regardless of the long history of this notion which can be traced back to Thomas Khun's (1962) idea of 'scientific communities, Michel Foucault's (1973) concept of 'episteme' and Ludwick Fleck's (1979) idea of 'thought collective,' defining what constitutes epistemic communities, identifying these communities and investigating why they form, how they form and how they develop and change over time are still a challenge. Epistemic communities wield tremendous influence in knowledge production but gaining awareness and understanding regarding epistemic communities takes effort. Studies on epistemic communities are only taking their first steps in science education, yet the potential of these studies appears to be significant and worthy of our efforts.

Epistemic communities naturally form. A whole knowledge field can be considered as an epistemic community like the education community. Big or small, epistemic communities usually emerge in relation to other epistemic communities. The relationships among epistemic communities usually are intricate, embedded, and hierarchical (Roth & Bourgine, 2003). Therefore, the assumption this research was based on regarding epistemic communities in science education was simple yet difficult to support. Since there was very little prior research available in the literature, claiming that there are distinctive epistemic communities in science education and elementary science education needed some substantial evidence. Also, investigating epistemic communities was the first step to understanding the power difference promoted in science education and elementary science education through their discursive choices.

As mentioned before, this research used Haas's (1992) definition of epistemic communities as a base for investigation. According to this definition, four characteristics of epistemic communities were operationalized to name networks of knowledge-based experts as an epistemic community. Haas (1992) suggests that to form an epistemic community, experts should have recognized expertise within a particular domain, shared normative beliefs, which are based on a set of agreed-upon principles, and causal beliefs, which are derived from their analysis of practices, as well as shared notions of validity. To meet these four criteria, researchers investigating epistemic communities generally look for experts who are naturally in a social relationship and show semantic similarities in their works (Roth & Bourgine, 2003). Therefore, this research followed a similar path while looking for the networks of experts in science education and elementary science education literature to locate epistemic communities. VOSviewer data mapping program was used to reveal these networks in the literature by mapping the ways science education researchers cite each other's works. Generated VOS viewer co-citation maps based on bibliographic data showed that some articles in the literature had significantly high cluster effects (see Chapter 3, 3.5.4 Sampling Procedure). In science education literature, 17 articles with significantly high cluster effects were located, and in elementary science education literature, four such articles were located. The co-citation maps showed that these 21

articles appeared to be significantly influential in building networks in science education literature due to their citation frequency and high cluster effects (link strength). High cluster effects of these articles indicated that the authors constituting these clusters had a tendency to cite each other's works or cited together more frequently than others.

Analysis of the 17 located articles in science education literature with a VOSviewer co-occurrence map based on text data to see the general discursive tendencies of the authors of these articles revealed three clusters indicating distinctive discursive choices within these articles. These clusters indicated that argumentation, nature of science, and pedagogical content knowledge frameworks have significant cluster effects in science education literature. Also, researchers working with these frameworks tend to cite these located articles more frequently. Therefore, the three frameworks' community-building effects were observed in science education literature. However, due to the embedded nature of science education literature in education literature, only two of these clusters' community-building effects in science education literature were supported with data. Therefore, two epistemic communities were located in science education literature. These communities were referred to as the argumentation and the nature of science epistemic communities.

The same analysis conducted for the four located articles in elementary science education literature revealed that there were two clusters indicating distinctive discursive choices within these articles based on their framework. These clusters indicated that the nature of science and teachers' beliefs frameworks have significant cluster effects in elementary science education literature and researchers working with these frameworks have a tendency to cite these located articles more frequently. Therefore, these two frameworks' community-building effects were observed in elementary science education literature. However, due to the embedded nature of elementary science education literature in science education literature, only one of these clusters' community-building effect in elementary science education literature was supported with data. Therefore, only one epistemic community was located in elementary science education literature, which was the nature of science epistemic community.

Observing the nature of science community both in science education and elementary science education literature led this research to investigate this overlap. This investigation showed that even though there was very little difference regarding the terminology used by these communities, their discursive choices differ to suggest that the nature of science community located in elementary science education literature could be considered a distinct community. Moreover, this investigation showed that the effects of epistemic communities of science education over elementary science education literature could mask the effects of particular epistemic communities of elementary science education. By investigating embedded epistemic communities in two different contexts (science education and elementary science education literature) and comparing them, this research was able to detect these masking effects to the degree that its sample size allowed.

Additionally, the 21 located articles were treated as the context of this research and investigated further. Investigating these articles based on their authors, frameworks, and mediums that they were published revealed that Driver, R., Lederman, N. G., Osborne, J., and Shulman, L. S., Brown, J. S., Duschl, R., Erduran, S., Eylon, B. S., Jimenez-Aleixandre, M. P., Magnusson, S., Posner, G. J., Sadler, T. D., Zohar, A., were the first authors of the 17 located articles in science education, and Lederman, N. G., Abd-El-Khalick, F., Akerson, V. L., and Pajares, M. F. were the first authors of the located four articles in elementary science education literature. Among the 21 located articles, two co-authoring groups were observed. The first group consisted of Abd-El-Khalick, and Lederman, and the second group consisted of Erduran, Osborn, and Simon.

Argumentation, Nature of Science, Pedagogical Content Knowledge, Teachers' Beliefs, Student Attitudes, Situated Cognition, Conceptual Change, Learning and Instruction, and Socio-scientific Issues frameworks were utilized in these articles. The argumentation framework was used in six of the 21 articles, and Osborn contributed to four of these articles. The nature of science framework was used in five of the 21 articles, and Lederman contributed to all of these articles. These two frameworks were utilized by more articles than the articles that utilized the remaining seven frameworks combined.

Journal of Research in Science Teaching, Science Education, Educational Researcher, Review of Educational Research, International Journal of Science Education, Harvard Educational Review, Studies in Science Education journals, as well as Handbook of Research on Science Education and In Examining Pedagogical Content Knowledge handbooks were the mediums in which most influential works of science education literature were published. Among 21 located articles, six of them were published in the Journal of Research in Science Teaching and four of them were published in Science Education journal. Also, while the articles employing the nature of science framework were mainly published in Journal of Research in Science Teaching, the articles employing the argumentation framework were published mainly in Science Education journal. As a result, the investigation of epistemic communities revealed that there were distinct groups of researchers working together with a common theoretical framework and publishing articles in certain journals in science education and elementary science education literature. Since these groups of researchers met Haas's (1992) conditions for a network of knowledge-based experts to be considered epistemic communities, this research was able to locate some prominent epistemic communities of science education and elementary science education literature and gather information about them within the scope of this research.

## **CHAPTER 5**

### **NATURE OF SCIENCE DISCOURSE IN SCIENCE EDUCATION**

As mentioned before, the findings of this research were reported in different chapters for each located epistemic community. Therefore, this chapter presented the discursive choices of ‘the nature of science epistemic community’ in science education literature. In the following, the findings were reported according to Fairclough’s (2001; 2011) triadic approach, which was explained comprehensively in the previous chapter (Chapter 3, 3.6 Data Analysis).

#### **5.1. Characteristics of Nature of Science Discourse in Science Education**

Lederman’s (1992) article was purposefully sampled to invest the characteristics of the discourse promoted by the nature of science epistemic community in detail since its citation frequency and link strength scores (its effect on the formation of citation clusters) were noteworthy over time compared to other articles (see Chapter 3, Table 3.3). The article was a review article published in April 1992 in Journal of Research in Science Teaching, volume 9, issue 4, pages 331-359. It was also presented at the 2nd International Conference on History, Philosophy, and Science, Queens University, Kingston, Canada, in May 1992. As a text, the article was 29 pages long with 109 references, and it was copyrighted by The National Association for Research in Science Teaching.

##### ***5.1.1. Organization of the Text***

As the first step of Fairclough’s CDA approach (2001), the text analysis revealed that the author made noteworthy discursive choices in terms of the organization of the text. The choices regarding the titles can be seen in Table 5.1.

**Table. 5.1**

*Organization of the Titles (Lederman, 1992)*

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Students' and Teachers' Conceptions of the Nature of Science: A review of the Research

Abstract

Assessment of Students' Conception of Nature of Science

Development, Use, and Assessment of Curricula Designed to Improve Student Conceptions of the Nature of Science

*Support for Curriculum Development  
Research Indicating No Curriculum Effects  
Emergence of Teachers' Importance  
Research Assumptions*

Assessment of, and Attempts to Improve, Teachers' Conceptions of the Nature of Science

*Attempts to Improve Teachers' Conceptions  
Recent Assessments of Teachers' Conceptions  
Summary and Analysis*

Relationship among Teachers' Conceptions, Classroom Practice, and Students' Conceptions

*Interviews Yield Essential Data  
What Have We Learned?*

Where Are We Headed?

*Recommendations*

References

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First, the main title and subtitles were structured to imply a particular relationship dynamic among students' conception of the nature of science, teachers' conception of the nature of science, curriculum and classroom practice. Second, some linguistic features were used to organize the titles. The use of foregrounding and backgrounding was observed in the titles, especially regarding the nominalizations 'students'

conception' and 'teachers' conception.' Finally, some differences were observed in the allocated space for the text sections associated with teachers' conception and students' conception.

Using Fairclough's (2001) guiding questions for textual structures, the organization of the titles and sub-titles was investigated to reveal the large-scale structures in the text. As a result, the following observations were made. The article was titled "Students' and Teachers' Conceptions of the Nature of Science: A review of the Research." Other than Abstract and References. There were six main titles and nine sub-titles in the text. Excluding the titles 'Abstract' and 'References,' the genre of the review article does not have a set title structure. Therefore, this genre allows writers to be flexible and use the titles and subtitles to serve their purpose.

Characteristic to review article genre, the titles in the sampled article were chosen purposefully instead of following a set format. The sequencing of the phrases used by the article's title was repeated in the organization of the text. The titles organized the text to present first 'students' conception' and then 'teachers' conception' of the nature of science. However, the title referring to the relationship between 'teachers' conception' and students' conception' reversed this sequence and introduced classroom practice as a factor in this relationship. Such choices in the organization of the titles were indicative of foregrounding and backgrounding in the text.

Foregrounding is generally used to give prominence to certain text parts (Baker & Ellece, 2011). Through physical placement, word choices, word orders, or syntactic structures, any part of the text (idea, information, subject, object, etc.) can be emphasized and portrayed as important (Hopper, 1979; Givon, 1987). The reverse is also true for backgrounding. Through language, any part of the text can be de-emphasized and portrayed as not as important. Since CDA pays attention to foregrounding and backgrounding, discursive choices of the text indicating emphasis were investigated further.

This investigation showed that three titles referred to "students' conceptions," while two titles and two subtitles referred to "teachers' conceptions," and one subtitle

referred to “teachers’ importance.” In addition, the curriculum was presented with the students’ conception in the title ‘Development, Use, and Assessment of Curricula Designed to Improve Student Conceptions of the Nature of Science.’ Under this title, four subtitles, the highest number of subtitles, were used. One of these subtitles directly referred to teachers; “Emergence of Teachers’ Importance.” Assessment and improvement of students’ conception of the nature of science were presented under two separate main titles. However, assessment and improvement of teachers’ conception of the nature of science were presented together under the same main title, while two subtitles were used to refer to them separately.

Moreover, efforts to improve teachers’ conception were presented as attempts in the main title and one of the subtitles. On the other hand, the word ‘attempt’ was not used in the title, referring to the improvement of student conceptions. The relationship between teachers’ and students’ conceptions was presented under the main title ‘Relationship among Teachers’ Conceptions, Classroom Practice, and Students’ Conceptions.’ The writer’s word order choice was especially noteworthy for this title since teachers’ conception, classroom practice, and students’ conception were presented in this order, which was reversed compared to the general organization of the text. Moreover, the positioning of classroom practice between teachers’ and students’ conception in the title appeared to be intentional since the title was not listing these components according to their similarity but in a way that could imply a special relationship.

The analysis of the organization of the text also revealed that the spaces allocated for each title in the text differ considerably. Within the text, the most space was allocated to the title “Assessment of, and Attempts to Improve, Teachers’ Conceptions of the Nature of Science” ( $\approx$ 3800words), followed by “Development, Use, and Assessment of Curricula Designed to Improve Student Conceptions of the Nature of Science” ( $\approx$ 2400words) and “Relationship among Teachers’ Conceptions, Classroom Practice, and Students’ Conceptions” ( $\approx$ 2050words). In comparison, the least space was allocated to the titles “What Have We Learned?” ( $\approx$ 600words), “Where Are We Headed?” ( $\approx$ 1300words), and “Assessment of Students’ Conception of Nature of Science” ( $\approx$ 1400words). Moreover, two out of the six titles were presented as

questions. Except for the functional titles ‘Abstract’ and ‘References,’ all six main titles and nine sub-titles were ‘thematic titles’ (Eyrolle et al., 2008), giving information about their referred textual unit.

The findings of the organization of the text revealed that discursive choices in terms of the organization and linguistic features of the titles and allocated space for the tiles were consistent. The titles were structured to imply a particular relationship dynamic among students’ conception of the nature of science, teachers’ conception of the nature of science, curriculum and classroom practice. Also, foregrounding and backgrounding were observed in the titles, especially regarding the nominalizations ‘students’ conception’ and ‘teachers’ conception.’ Finally, some differences were observed in the allocated space for the text sections associated with teachers’ conception and students’ conception. These consistent discursive choices further support the implied relationships among students’ and teachers’ conceptions of the nature of science, curriculum, and classroom practice. Thus, the organization of the text portrayed teachers’ conception of the nature of science, curriculum and classroom practice as tools to improve students’ conception of the nature of science. Therefore, the critical analysis and interpretation of how these relationships were portrayed with the discursive choices of the text are presented in the next section.

### ***5.1.2. Critical Analysis of the Organization of the Text***

The observed difference between the emphasis put on students’ and teachers’ conceptions of the nature of science in the titles was indicative of the foregrounding of students’ conception. The flow of the text directed the reader’s attention from the students’ conceptions to the teacher’s conception. The text insinuated a similar trend in the literature by using the subtitle “Emergence of Teachers’ Importance” under the main title “Development, Use, and Assessment of Curricula Designed to Improve Student Conceptions of the Nature of Science.” Furthermore, the extent of the allocated space for the teachers’ conception was indicative of this trend in the literature since reviewed research and their findings took more space. However, by mentioning students’ conception in main titles more frequently and presenting curriculum and teachers’ conception as tools to improve students’ conception, students’ conception of

the nature of science was foregrounded. In contrast, teachers' conception of the nature of science was backgrounded in the organization of the text by these choices. The discursive choices were indicative of the writers' intention to keep students' conception of the nature of science as the focal point of the text. This observation was consistent with the results of investigations conducted to locate the epistemic communities in science and elementary science education literature (see Chapter 4, Locating Epistemic Communities)

Previously generated VOSviewer maps locating epistemic communities and investigating semantic and semiotic similarities also showed the emphasized position of students and students' conception in science education literature (see Chapter 4, Figure 4.1, and Figure 4.3). This observation will be explained further in the vocabulary and linguistic features of the text section. Most of the articles associated with the nature of science epistemic community that were mentioned in the sampling procedure had references to certain research, position, or policy papers stating that "the development of an adequate student understanding of the nature of science is the desired outcome of science instruction" (Abd-El-Khalick & Lederman, 2000, American Association for the Advancement of Science, 1989; Hazen & Trefil, 1991; Kimbal, 1967, 1968; Klopfer, 1969; Lederman, 1992, 2007, 2014; National Science Teacher Association, 1982; Rutherford & Ahlgren, 1990). As Lederman and Lederman (2014) and Abd-El-Khalick, (2001) pointed out, this objective was also the most frequently expressed objective of science education.

The writer's choice of presenting curriculum, teachers, teachers' conception of nature of science, and classroom practice in association with students' conception of the nature of science through the titles was another noteworthy observation. It was indicative of the certain relationships emphasized within the nature of science research framework. Curriculum, teachers, teachers' conception of nature of science, and classroom practice were all presented as factors to improve students' conception of nature of science through explicit references in the titles. Moreover, the presentation of the relationship between teachers' and students' conceptions under a separate title, 'Relationship among Teachers' Conceptions, Classroom Practice, and Students' Conceptions,' was also noteworthy. When the general organization of the titles was

considered, the way the terms were put in order in this title appeared to be intentional and insinuating that classroom practice was a factor that the nature of science research pays attention to while investigating teachers' conception and students' conception of the nature of science.

These findings were also consistent with the general tendencies observed in the literature. Since the analyzed text was a review paper, it was expected that there were similar discursive choices in the relevant literature. However, the same discursive choices were also present in the recent research published after this review. In science education literature, the curriculum was often referred to as a useful tool to reveal "what students can be expected to learn about" the nature of science and "help students engage in meaningful learning" (Yeh et al., 2019, p.297). Also, teachers' conception of the nature of science and classroom practice were frequent research topics in the field and were usually investigated together (e.g., Abd-El-Khalick & Lederman, 2000; Bartos & Lederman, 2014; Mellado, 1997; Mellado et al., 2008). On the other hand, besides teachers' conception of the nature of science, in the recent literature, teachers' understanding (e.g., Cofre et al., 2019; Lederman, 1995), teachers' beliefs (e.g., Brickhouse, 1990; Pomeroy, 1993) and teachers' views (e.g., Dorsah, 2020; Tairab, 2001) of nature of science were frequently used nominalizations. Therefore, whether the writer's choice to use teachers' conception in the titles was also observed in the body of the text or the vocabulary of the text covered all the nominalization observed in the literature was further investigated in the analysis of the vocabulary and linguistic features.

Another noteworthy observation about the organization of the text was the way teachers' conception was presented. The efforts to improve teachers' conceptions were consistently referred to as 'Attempts' both in the main title and the subtitle mentioning these efforts. However, in the title referring to the improvement of students' conception, the word 'Attempt' was not used. According to van Leeuwen (2015), absence refers to 'something missing' that could be in language use. Therefore, paying attention to the absence in the analysis and acknowledging that what is missing in the text also contributes to the constructed meaning of what is present. This perspective helps to investigate the intentionality of the writer's choices in CDA. Therefore, based

on what was observed in the text, it was possible to speculate that the absence of the word “attempt” while referring to the improvement of students’ conceptions in the titles was intentional. Combining this observation with the constant use of the word attempt referring to the improvement of teachers’ conceptions indicated that teachers’ conceptions of the nature of science were perceived as challenging to improve compared to students’ conceptions. However, further investigation within the text was necessary to support this speculation. Thus, this observation was also investigated further in the analysis of the vocabulary and linguistic features.

The last two main titles of the analyzed text were ‘What Have We Learned?’ and ‘Where Are We Headed?’. These titles were presented as questions, which was not uncommon for articles in education literature. Characteristic to the review article genre, these summarizing titles are usually used to guide readers and prospective researchers by providing a historical perspective and new directions to inquiry (Hartley, 2008; Solar, 2007). Therefore, using these titles in question form indicated that these text sections were written with a specific audience in mind.

As a result, analysis of the organization of the text showed that students’ conception and teachers’ conception were central to the nature of science discourse in science education. Curriculum, teachers, and teachers’ conception of the nature of science and classroom practice were all promoted as factors to improve students’ conception by the discursive choices of the text. Consequently, improving students’ conception of the nature of science emerged as the objective of teachers, curriculum and classroom practice.

### ***5.1.3. Vocabulary and Linguistic Features of the Text***

Following Fairclough’s (2001) guiding questions, the analysis of the vocabulary and linguistic features of the text revealed that there were numerous nominalizations, and some of these nominalizations were favored in the text. CDA pays attention to nominalizations since they indicate the writers’ choice to use nouns and noun phrases over verbs or lengthy expressions and construct passive sentences over active sentences (passivization) (Fowler et al. 1979). Nominalizations and passivization can

hide the agents of the actions and limit the conveyed information (Billig, 2008) like the source of authority. They turn processes into entities, which is often how scientists create new terminology (Halliday & Martin, 1993). Through these kinds of choices, a particular discourse can be created. Halliday (2004) gives an example of this process by contrasting alternative expressions.

1. Glass cracks more quickly the harder you press on it.
2. Cracks in glass grow faster the more pressure is put on.
3. Glass crack growth is faster if greater stress is applied.
4. The rate of glass crack growth depends on the magnitude of the applied stress.
5. Glass crack growth rate is associated with applied stress magnitude. (p.34)

As Billig (2008) points out, the scientific community establishes communication norms for prospective members by creating specialized language and acting as gatekeepers. Therefore, nominalizations carry great importance for CDA in understanding promoted norms and terminologies and their ideological use.

The analysis of the vocabulary and linguistic features of the sampled text revealed that nominalization was frequently used in various ways within the text. Among the observed nominalizations, 'students' conception' and 'teachers' conception' were the most commonly used. This observation was also consistent with the observations previously reported regarding the organization of the text. Moreover, different variations of these nominalizations were also observed in the text. For example, the following variations were used regarding' students' conceptions.

- a. adequate student/s' conception/s
- b. student/s conception/s
- c. adequate conception/s
- d. inadequate student/s' conception/s
- e. inadequate conception/s

In addition, nominalization of certain verbs was also observed in the text. Understanding, teaching, and classroom practice were the most frequently observed nouns and noun phrases created from verbs. These nominalizations were used without any information regarding who was carrying out the process. On the other hand, previously mentioned nominalizations were used with the agents like student or teacher (student conception, teacher conception). Taking the structural effects of the values into account, the analysis of the linguistic features revealed that generally, the observed nominalizations were not used to hide who was carrying out the action; they appeared to give the text an ‘objective voice’ (Fairclough, 2001).

To analyze the variations in nominalizations and the different discursive choices observed within the text and present the finding in a more meaningful and visual way, instead of reporting frequencies with a table, VOSviewer maps were used. Since frequency tables would report the number of observations but not the overlaps or the associations with the rest of the text, VOSviewer maps were a useful alternative. One of the advantages of VOSviewer maps was their ability to portray the whole text, the significant connections and variations, and the difference in the frequencies altogether. Since VOSviewer maps were also used as a tool for member checking in this research, the observations regarding nominalizations were further explained in the Member Checking of the Observations Through VOSviewer Maps section.

The analysis of the vocabulary and linguistic features of the text also revealed that there were some promoted agencies in the text. If nominalizations are the indicators of how people use discourse (to create norms, etc.), agencies are the indicators of how discourse uses people (Potter et al., 1990). Discourses ‘contain subjects’ (Bacchi, 2005), and the discursive choices of the writer position these subjects and represent them in different ways that could affect our perception of them (Parker, 1990). According to Parker (1990), discourses can maintain institutions and establish power relations through these representations of subject positions. Fairclough (2001) also emphasizes the role of agency and how subjects are positioned within the text to investigate the relative hierarchical roles and power differences associated with these positions. Therefore, the agencies within the sampled text were specifically investigated. Since VOSviewer maps present all nouns and noun phrases and their

relationships, they were also helpful to see all the agencies in the text and used for further investigation of the agencies.

The analysis following the Fairclough's (2001) guiding questions revealed that the text used the subjects (subject positions) student, teacher, science teacher, scientist, researcher, and author. 'Student' and 'teacher' were the most frequently observed agencies in the text. The observed pairings of teacher - science teacher and researcher - author were noteworthy since they were occasionally used interchangeably in the text. Even though logically, 'scientist' could also be used interchangeably with 'researcher' or 'author,' the way the text used this subject position was distinctive and not part of any pairings. This specific position will be explained in the section analyzing the subject positions (see Chapter 5, 5.2 Subject Positions of Nature of Science Discourse in Science Education). The term teacher was generally used in reference to science teachers. The switch observed between 'science teacher' and 'teacher' as the agent in the sentences appeared to be intentional. When specific comparisons were made, the expression science teachers were used, while the expression teacher was used for generalizations and nominalizations. On the other hand, the expression 'author' was used to refer to the researchers who were the authors of the reviewed articles. Therefore, when the expression researcher was used, it was for the generalizations. Moreover, some agencies were absent or used rarely in the text, such as family, parent, community, and society; these agencies were expected to be observed in the text since they were considered among the stakeholders of science education. However, the expressions family, parent, and community were not used in the text, and society was only used a few times in reference to science. These observed findings were further investigated in the following section, Subject Positions of Nature of Science Discourse in Science Education, since they reveal how the discursive choices created power differences (Fairclough, 2001; Gee, 2004).

In terms of the voice of the text, the vocabulary and linguistic features analysis revealed that passive sentences were favored and used throughout the text. Nominalization and passivization were investigated together since they often accompany each other (Billig, 2008). Passive sentence structures reassign grammatical subjects; the object of an action becomes the subject of a sentence. Therefore, the

performer of the action can be removed from the sentence. Through nominalization and passivization, the subject of the sentence can be replaced by nominalization of the act, which is ‘an asymmetrical process’ (Langacker, 2000) since less information is shared with the reader. For example, the sentence ‘Bees attack the children’ can be transformed into ‘An attack on the children occurred.’ Considering the second sentence, without any additional information reader does not know the identity of the attacker. Thus, an active sentence cannot be constructed with limited information. Nominalization and passivization carry great importance for CDA research because they can be used to delete agencies (Langacker, 2000), to present nominalizations as agencies (Fairclough, 2003), and to maintain power relations by hiding the responsible parties (Halliday&Martin, 1993).

The vocabulary and linguistic features analysis also revealed that, combined with nominalizations, passive sentences gave the text an objective voice. When agencies in the text were considered in relation to this objective voice, nominalization and passive sentence structures created a hierarchy among the agencies presented in the text. Passive sentence structures more frequently positioned students as the passive participants. For example, in the following sentence, ‘the development of adequate student conceptions/understanding’ was presented as the objective of science instruction, and the students’ role in the process was omitted.

The development of adequate student conceptions of the nature of science has been a perennial objective of science instruction regardless of the currently advocated pedagogical or curricular emphases. (p. 331)

The development of an “adequate understanding of the nature of science” or an understanding of “science as a way of knowing” continues to be convincingly advocated as a desired outcome of science instruction (American Association for the Advancement of Science, 1989; Hazen & Trefil, 1991; Rutherford & Ahlgren, 1990). (p. 331)

On the other hand, teachers were grammatically placed in an active position even within the passive sentence structures since they were represented as capable, active figures to improve student conception.

When student ability was held constant, it was noted that teachers who asked more critical thinking questions impart a better understanding of the nature of

science to both Grade 7 and Grade 8 males and females than teachers who asked fewer questions of this type. (p.338)

In short, it was implied that a teacher could promote understandings of certain concepts without having an adequate understanding of the same concepts. (p. 339)

In contrast to both students and teachers, researchers were used as a subject more frequently in active sentences and positioned in active roles even in passive sentence structures.

When researchers turned their attention to teachers, the obvious first step was to assess teachers' conceptions of the nature of science. (p.339)

Because teachers cannot be expected to purposefully teach what they do not understand, many researchers focused their attention on the development and assessment of techniques designed to improve teachers' conceptions. (p.350)

These observations were noteworthy because due to the text's discursive choices, specific hierarchical roles were emerging. These hierarchical roles were investigated comprehensively in the Subject Positions of Nature of Science Discourse in Science Education section of the analysis.

The further investigation of the previous observations about the absence of the word 'attempt' revealed that even though the word 'attempt' was used in reference to the efforts related to students' conceptions of the nature of science within the text, "early attempt to assess students' conceptions of the nature of science" (p.333), it was referring to assessment not improvement of students' conception. Also, throughout the whole text, 'improvement of teachers' conceptions' was referred to as attempts only in the titles. Therefore, even though this observation was implicative, there was not enough information for inference.

Finally, the investigation of the text under two main titles presented as questions, 'What Have We Learned? and Where Are We Headed?', revealed a noteworthy difference between them in terms of nominalizations. While under the title 'What Have We Learned?' nominalizations containing conception, understanding, view, and belief were all observed. Under the title 'Where Are We Headed?' only the nominalizations containing the word 'conception' were observed. In this portion of the text, the word

‘view’ was used two times in reference to researchers’ perspectives, but the words ‘understanding’ and ‘belief’ were not used at all. Since these summarizing titles are generally used to guide prospective researchers (Hartley, 2008; Solar, 2007), this observed difference appeared to be intentional to promote the use of the nominalization ‘conception of nature of science’ for future research.

In summary, the analysis of the vocabulary and linguistic features of the text revealed that nominalizations and passive sentence structures were favored as the discursive choices of text representing the nature of science epistemic community in science education. In terms of nominalizations, ‘students’ conception’ and ‘teachers’ conception’ were more established nominalizations than the other nominalizations like students’ understanding/belief/view and teachers’ understanding/belief/view observed in the text. Moreover, the discursive choice of the text appeared to promote the nominalizations ‘students’ conception and teachers’ conception of the nature of science’ and encourage prospective researchers to follow this choice.

The analysis showed that the text used the subjects ‘student, teacher, science teacher, scientist, researcher, and author.’ Also, pairings of teacher - science teacher and researcher - author were observed in the text. These pairings were occasionally used interchangeably in the text. Even though they were expected to be used by the text as subjects since they are considered among the stakeholders of science education, family, parents, and community were not used in the text, and society was only used a few times in reference to science.

On the other hand, the analysis also revealed that certain agencies were created through discursive choices, and different hierarchical subject positions were promoted within the text. While passive sentence structures generally positioned students as passive participants in the educational processes, teachers and researchers were more frequently positioned as active participants through active sentence structures. In addition, when generalizations were made, teachers and researchers were favored as the grammatical subjects of the sentences or agents of the actions.

In the following section, VOSviewer co-occurrence maps of the sampled text were presented to see the consistency between visualized non-parametric analysis of the co-occurrences of the nouns and noun phrases within the text and the vocabulary and linguistic features analysis of the text based on Fairclough's (2001) guiding question. Moreover, the observed vocabulary and linguistic features of the text were investigated further with these co-occurrence maps.

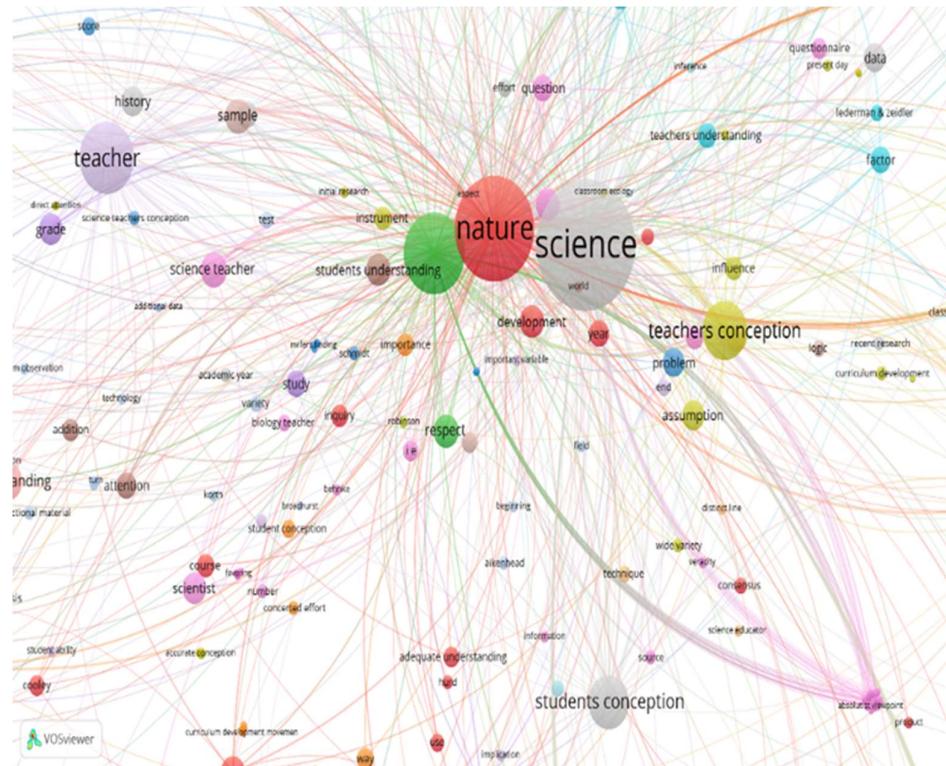
#### ***5.1.4. Member Checking and The Analysis of the Observations Through VOSviewer Maps***

VOSviewer data visualization program was used to map out the associations among the words within the sampled article. The following map (Figure 5.1), based on text data, was generated using full counting of the words and setting the minimum number of occurrences of the terms to one. VOSviewer program calculated a relevance score for 1375 items (words and phrases) in this text, and the largest set of connected items consisted of 1369 items. Within these 1369 items total of 46225 links were observed. Items were analyzed based on their association strength, and the minimum cluster size was set to one. This analysis generated 26 clusters, and the map was used to investigate the word occurrences and the extent of co-occurrences.

Occurrence means the item (noun or noun phrases) has links to other items (nouns and noun phrases), or the item co-occurred with other items on the map. Therefore, even though occurrences closely resemble the distribution of the word frequencies in the text, they do not report the actual frequencies. The co-occurrence map generated with the VOSviewer program revealed that science (grey), nature (red), student (green) and teacher (purple), teachers' conception (yellow), and students' conceptions (grey) were items with the highest occurrences, the number of links and links strengths in the map. The number of occurrences, links, and link strengths of these items can be seen in Table 5.2.

**Figure 5. 1**

*Co-occurrence Map of the Items in the Sampled Article for Nature of Science Epistemic Community in Science Education Based on Text Data without Threshold.*



**Table 5.2**

*Occurrence and Link Strength of the Most Observed Items*

Item	Occurrence	Links	Total Link Strength
Science	239	1293	12385
Nature	155	1198	8255
Student	93	856	5242
Teacher	73	713	3840
Research	53	609	2431
Teachers' Conception	48	599	2150
Students' Conception	41	540	2191

The nominalizations reported in the vocabulary and linguistic features analysis of the text section were also observed in the co-occurrence map with significant cluster effects. ‘Teachers’ conception,’ ‘teachers’ understanding,’ ‘teachers’ belief,’ and ‘teachers’ view’ were all observed within different clusters. Teachers’ conception item had the highest occurrence and cluster effect among these items. The number of occurrences, links, and link strengths of these nominalizations can be seen in Table 5.3.

**Table 5.3**

*Occurrence and Link Strength of the Nominalizations Related to Teachers*

Item	Occurrence	Links	Total Link Strength
Teachers’ Conception	48	599	2150
Teachers’ Understanding	9	193	575
Teaches’ View	2	80	115
Teachers’ Belief	1	31	38

Also, ‘students’ conception,’ ‘students’ understanding,’ ‘students’ belief,’ and ‘students’ view’ nominalizations were observed as items within different clusters in the co-occurrence map. Students’ conception had the highest occurrence and cluster effect among them. The number of occurrences, links, and link strengths of these nominalizations can be seen in Table 5.4.

**Table 5.4**

*Occurrence and Link Strength of the Nominalizations Related to Students*

Item	Occurrence	Links	Total Link Strength
Students’ Conception	41	540	2191
Students’ Understanding	15	411	768
Students’ View	4	127	455
Students’ Belief	1	57	76

There were 28 different variations of nominalizations containing the word conception (adequate conception, inadequate conception, etc.), 20 variations of nominalizations containing the word understanding (adequate understanding, basic understanding, improved student understanding, etc.), 20 variations of nominalizations containing the word view (tentative view, constructivist view, etc.) and six variations of nominalizations containing the word belief (individuals' belief, philosophical belief, etc.) observed in the co-occurrences map. A comprehensive list of these variations can be seen in the Appendix. Observing this many nominalizations in such variance was indicative of the discursive choice of text to use passive voice.

Moreover, consistent with the previous findings, nominalizations, understanding, teaching, and classroom practice were all observed in the co-occurrence maps with high occurrence and cluster effect. In addition, nominalizations 'development', 'assumption,' and 'instruction' were observed with high occurrence and cluster effect on the map. Unlike the nominalizations related to teachers and students, these nominalizations were not reported with any agency. The number of occurrences, links, and link strengths of these nominalizations can be seen in Table 5.5

**Table 5.5**

*Occurrence and Link Strength of the Nominalizations without Agency*

Item	Occurrence	Links	Total Link Strength
Understanding	21	475	1113
Classroom Practice	16	226	1017
Teaching	10	255	524
Development	15	439	805
Assumption	13	229	618
Instruction	10	323	597

Another noteworthy observation was the co-occurrence of the related or binary nominalizations in the same or different clusters. While some of these nominalizations like 'adequate student conception' and 'inadequate student conception' appeared as

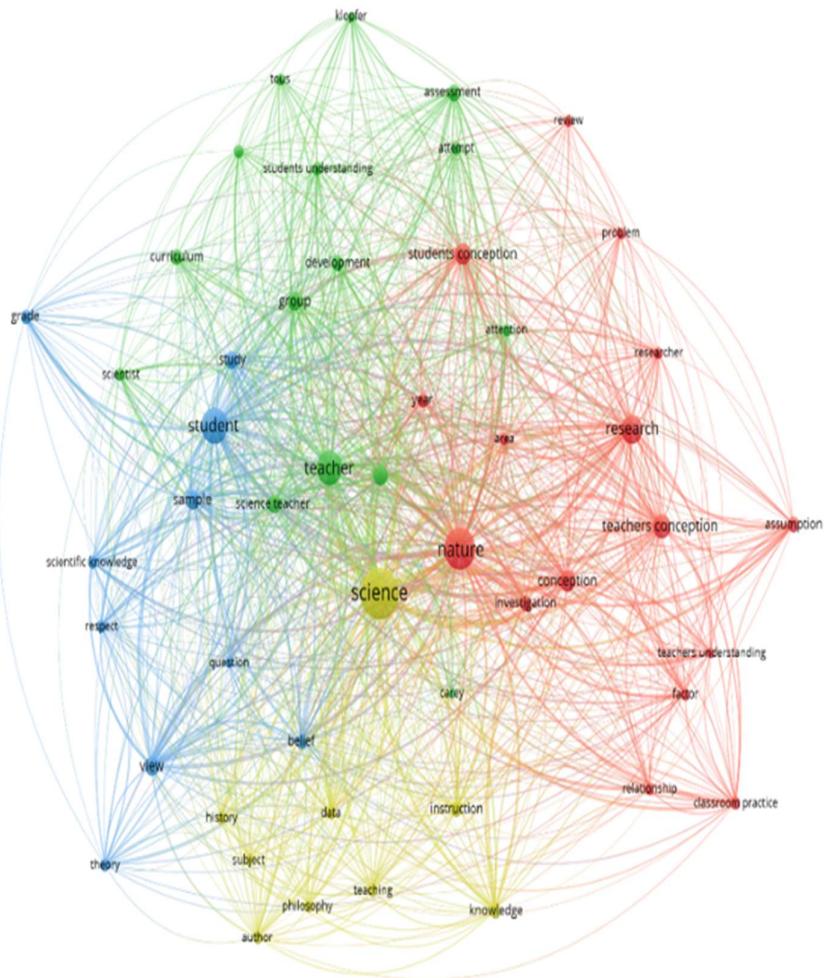
items within the same cluster. The same nominalizations without an associated subject like ‘adequate conception’ and ‘inadequate conception’ were located in different clusters. This inconsistency showed that the generated co-occurrence map could not distinguish the links among the items used in different forms in the text without a set threshold.

As seen in the Figure 5.1, there were too many clusters and connections to be analyzed since all the items in the text, even if they occurred only once, were included in the analysis regardless of their relevance score. Therefore, to focus on the strength of the links among the words and investigate the significant relationships among the linguistic features, another map was generated with a full counting method and a set threshold based on the number of co-occurrences. Since the VOSviewer program uses the Chi-Square distribution to analyze relationships among the items, the minimum number of co-occurrences was set to 9 to reduce the number of clusters while assuring each cluster has more than five items. Based on these criteria another co-occurrence map was generated which can be seen in the Figure 5.2.

After setting the minimum number of occurrences to 9, the VOSviewer program calculated a relevance score for 50 items (nouns and noun phrases). The largest set of connected items consisted of all these 50 items. Within these 50 items total of 1087 links were reported. This analysis generated four clusters which can be seen in the Figure 5.2 Co-occurrence Map of the Items in Sampled Article for Nature of Science Community in Science Education Based on Text Data with Threshold. Each of these clusters was represented with different colors. Since the number of items was considerably reduced from 1369 to 50, the number of reported links and calculated link strengths were also changed. Moreover, some co-occurrences, which were not considered significant in the previous Chi-Square distribution analysis, became significant compared to the first co-occurrence map. Therefore, the number of occurrences, links, and link strengths for all observed nominalizations were presented again in the following tables, Table 5.6 and Table 5.7.

**Figure 5. 2**

*Co-occurrence Map of the Items in the Sampled Article for Nature of Science Epistemic Community in Science Education Based on Text Data with Threshold.*



‘Teachers’ conception,’ ‘teachers’ understanding,’ ‘students’ conceptions,’ and ‘students’ understanding’ were the only nominalizations with agency observed in the co-occurrences map generated with a threshold. Previously observed nominalizations containing ‘belief’ and ‘view’ were missing in this map. This observation was indicative of the state that even though nominalizations ‘teachers’ conception’ and ‘students’ conception’ were favored, ‘teachers’ understanding’ and ‘students’ understanding’ were the competing discursive choices for these nominalizations.

**Table 5.6**

*Occurrence and Link Strength of the Nominalizations with Agency*

Item	Occurrence	Links	Total Link Strength
Teachers' Conception	55	49	1284
Teachers' Understanding	11	39	360
Students' Conception	42	47	1159
Students' Understanding	18	45	409

**Table 5.7**

*Occurrence and Link Strength of the Nominalizations without Agency with Threshold*

Item	Occurrence	Links	Total Link Strength
Understanding	38	48	960
Classroom Practice	17	37	523
Teaching	16	44	457
Development	24	47	561
Assumption	23	35	489
Instruction	24	49	635

On the other hand, previously observed nominalizations with high occurrences and cluster effects without agency were all present in this map. Also, compared to the nominalizations with an agency, the range of occurrences of these nominalizations was small. Therefore, it was possible to assume that the text more consistently used these nominalizations.

The generated co-occurrence map with a threshold also showed certain promoted agencies with the high occurrence and cluster effects in the text. These agencies were student, teacher, researcher, science teacher, scientist, and author. These observations also supported the findings of the analysis of the linguistic features of the text. Moreover, teacher and student were the most emphasized agencies in the text when

the number of occurrences was considered. Considering the previously observed agency pairs in the vocabulary and linguistic analysis section, there was a discrepancy regarding their occurrences in the co-occurrence map. While the number of occurrences was similar for the researcher-author pair (14-13 respectively), the difference was sizable for the teacher-science teacher pair (109-30 respectively). The number of occurrences, links, and link strengths of these agencies can be seen in Table 5.8.

**Table 5.8**

*Occurrence and Link Strength of the Agencies*

Item	Occurrence	Links	Total Link Strength
Student	120	49	2922
Teacher	109	48	2793
Science Teacher	30	48	719
Scientist	17	41	351
Researcher	14	42	468
Author	13	46	471

As a result, generated VOSviewer co-occurrence maps showed that the text used numerous nominalizations. Considering the number and variance of the nominalizations observed in the co-occurrence maps, it was possible to assume that passive voice was favored in the text. Moreover, co-occurrence maps also showed that nominalizations containing ‘conception’ were favored in the text, like teachers’ and students’ conceptions. The co-occurrence map generated with the threshold showed that the nominalizations, ‘students’ understanding,’ and ‘teachers’ understanding,’ had a high enough occurrence and cluster effect of being considered a competing discursive choice against the nominalizations, ‘students’ conception’ and ‘teachers’ conception.’ Another noteworthy finding was that ‘student’ and ‘teacher’ were the most used agencies among the agencies presented in the text. Unexpectedly, the number of occurrences was inconsistent regarding the paired agencies used

interchangeably on occasion by the text. While researchers and author agencies were used equally in the text, there was a distinct gap between the number of occurrences that teacher and science teacher agencies were in the text.

In summary, the analysis of VOSviewer co-occurrence maps revealed that the text used the nominalizations, teachers' conception/ understanding/ belief /view of nature of science, and students' conception/ understanding/ belief/ view of nature of science. The number of these nominalizations, the variation of these nominalizations, and other various nominalizations observed in the maps were indicative of the extensive use of passive voice in the text. These findings were consistent with the analysis of the vocabulary and linguistic features of the text. The VOSviewer co-occurrence maps also revealed that nominalizations 'students'/ teachers' understanding' and 'students' / teachers' conception' were competing discursive choices observed in the text. Complementary to this finding, the analysis of the vocabulary and linguistic features revealed that discursive choice of the text promotes the nominalizations 'students' conception and teachers' conception of nature of science' and encourages prospective researchers to follow this choice.

The findings of the VOSviewer co-occurrence maps also showed that teacher and student were the most emphasized agencies in the text, followed by science teacher, scientist, researcher, and author. However, contextually relevant nouns (agencies) like family, parent/s, community, and society were absent on the maps. These findings were also consistent with the analysis of the vocabulary and linguistic features of the text. However, the observed pairings of teacher - science teacher and researcher - author in the linguistic analysis could not be analyzed with VOSviewer maps. Therefore, the number of occurrences for these agencies was investigated with these maps. The maps showed that while the number of occurrences was very similar for the researcher-author pair (14-13 respectively), the difference was sizable for the teacher-science teacher pair (109-30 respectively). This observation was also consistent with the finding of the analysis of the vocabulary and linguistic features. Since this analysis concluded that when only specific comparisons were made, the expression science teachers were used, while the expression teacher was used for generalizations and nominalizations in the text.

VOSviewer co-occurrence maps and the vocabulary and linguistic features analysis based on Fairclough's (2001) guiding question have their unique way of investigating the text's descriptive features. Yet, both quantitative and qualitative analysis of the descriptive features of the text through these unique ways rendered consistent results. Since critical discourse analysis fundamentally asks the question "what discursive features of the text lead us to make certain deductions" consciously or unconsciously, it was assuring to reach these consistent results, which further interpretation and explanation of the text will be based upon in the following sections.

#### ***5.1.5. Critical Analysis of the Vocabulary and Linguistic Features of the Text***

The analysis of the descriptive features of the text revealed that the use of nominalizations, teachers' conception/ understanding/ belief /view of nature of science, along with students' conception/ understanding/ belief/ view of nature of science were distinguishing discursive choices of the text. As mentioned before, teachers' conception/ understanding/view/ belief of the nature of science are frequently used as nominalizations in the nature of science research (e.g., Cofre et al., 2019, Brickhouse, 1990; Dorsah, 2020). Nominalizations, students' conception/ understanding/ view/ belief of the nature of science are also frequently used and paid attention to by the nature of science research (e.g., Bell et al. 2003; Kılıç et al., 2005; Leach, 1996; Partin et al., 2013; Schwartz et al., 2004). Therefore, based on Halliday's (2004) explanation regarding how nominalizations can be used to create terminologies in science, it was concluded that these nominalizations were intended to be used as terminologies by the nature of science epistemic community in science education literature.

The other noteworthy observation about the discursive choices of the analyzed text was its consistent emphasis on the use of nominalizations, students' conception, and teachers' conception. However, all the alternative nominalizations used in the literature were present in the text. The previous analyses also showed that students' understanding and teachers' understanding were used consistently to be considered as competing discursive choices regarding these nominalizations. These competing nominalizations, in other words, this terminological inconsistency can be observed in

the literature even within the works of the same researcher like N. G. Lederman (1986; 1992; 1999; 2007; 2014), F. Abd-El-Khalick (1999; 2001; 2005; 2006; 2014) who were also emerged as the most influential figures in the nature of science epistemic community in the sampling procedure of this research. Even the previously discussed objective of science education (see Chapter 5, 5.1.2) is often mentioned in the literature by using different nominalizations “the development of an adequate student understanding/conception/view of the nature of science” (e.g., Abd-El-Khalick & Lederman 2000; Akerson, et al., 2000; Khishfe & Abd-El-Khalick, 2002; Urhahne et al., 2011), but referencing the same source, American Association for the Advancement of Science (AAAS, 1989). In reference to this objective, however, the expression ‘adequate student belief’ is not used in the literature. Instead, the word ‘adequate’ is usually removed when ‘belief’ is used in the nominalizations. The analysis of the vocabulary and linguistic features of the text also revealed that prospective researchers were encouraged to use the nominalizations ‘students’ ‘conception and teachers’ conception of nature of science’ by the analyzed text. However, terminological variance observed even within the works of the writer of the investigated text was inconsistent with this observation. As a result, it was concluded that even though the nominalizations ‘students’ conceptions’ and ‘teachers’ conceptions’ were favored, using multiple nominalizations interchangeably was one of the characteristic discursive choices of the nature of science epistemic community in science education literature.

Critical analysis of the vocabulary and linguistic features of the text revealed that through the use of nominalization and passive sentence structures, students were consistently positioned as passive participants in the educational processes. At the same time, teachers and researchers were more frequently positioned as active participants through active sentence structures. As these agencies were portrayed in different roles in the educational process, agencies like parents, family, community, or society were not given any roles by the discursive choices of the text. This perspective, assuming that students have little control over their conception of the nature of science, is also shared by the researchers in the literature. There is much research on students’ nature of science conception/ understanding/ view/ belief in the literature suggesting

that explicit and reflective teaching of philosophy of science, history of science, and nature of science promote students' nature of science conception/ understanding/ view/ belief, and discussing what teachers and researcher can do to improve students' conception/ understanding/ view/ belief nature of since (Clough, 2018; Matthews; 2017). Moreover, most research exclusively studying students' conception/ understanding/ view/ belief of the nature of science generally focuses on the descriptive and demographic data and reports the level of students' conception/ understanding/ view/ belief regarding the aspects of nature of science (Deng et al., 2011; Leach, 1996; Lederman; 2007). Nonetheless, there is almost no research readily accessible in the literature investigating parents', families', or community's involvement in the nature of science education or what students can do to improve their nature of science conception/ understanding/ view/ belief. Therefore, it was concluded that discursive choices of the nature of science epistemic community in science education literature were portraying students in a position with very little control over their conception/ understanding/ view/ belief of the nature of science while portraying teachers and researchers in a position with more power and control than any other stakeholders of the science education.

In the analyzed text, it was observed that when generalizations were made, teachers and researchers were favored as the grammatical subjects of the sentences or agents of the actions. Since the text was a review paper reporting and organizing various research results, it was necessary to distinguish the author of the specific research. Moreover, the text reported research results about teachers from multiple fields like biology, chemistry, physics, and educational levels like elementary, middle, and high school. Therefore, using teachers and researchers as the grammatical subjects of the sentences or agents of the actions could result from the genre of the text. As a result, there was not enough information to reach conclusions regarding this observation.

In conclusion, according to Fairclough's (2001) triadic approach, the descriptive analysis of the text revealed three characteristics of the discourse promoted by the nature of science epistemic community in science education. First, the nominalizations, teachers' conception/ understanding/ view/ belief of the nature of science, and students' conception/ understanding/ view/ belief of the nature of science

emerged as almost established terminology in this discourse. Second, although the nominalizations, students' conceptions, and teachers' conceptions were favored, using multiple nominalizations interchangeably was characteristic of this discourse. Finally, portraying students in a position with very little control over their conception/understanding/ view/ belief of the nature of science, while portraying teachers and researchers in a position with more power and control than any other stakeholders of science education was characteristic of the discourse promoted by nature of science community in science education.

It is important to note that these presented characteristics gave us clues about the discourse promoted by the nature of science epistemic community in science education. Since discourses can split, meld together, change or even die and replace one another, providing a complete account of discourse is almost impossible. For this reason, discourse studies, especially critical discourse studies, do not simply describe the characteristics of the discourse but aim to reveal "how and why language works the way it does when it is put into action"...and to contribute to our understanding of important issues and problems (Gee, 2004, p.8), Therefore, in the following sections whether these discursive choices of nature of science epistemic community in science education create power differences and if so, how do these choices create power difference will be investigated.

## **5.2. Subject Positions of Nature of Science Discourse in Science Education**

Descriptive analysis of the text revealed that certain agencies were given different roles, especially in terms of being presented as passive or active participants in the educational process. The most frequently observed agency in the text was 'student.' Besides science and nature items, this item had the highest cluster effect in the generated maps (see Figure 5.1, Figure 5.2), co-occurring with all the nominalization observed in the text. Out of the 50 items that occurred in Figure 5.2, 49 of them had links to this item. Therefore, the emphasis put on the students by the text was evident. However, the text constantly used passive voice to refer to students, and, in some cases, their agency was removed. For instance, in the following example, while teachers' behaviors were referred to as 'teaching behaviors,' keeping the agency intact

(teachers can enact teaching behaviors) by referring to the variables related to students as ‘student outcomes’, the agency of students was removed (students cannot enact outcomes). As a result, a ‘process-product’ relationship was constructed through discursive choices between teaching and students, which is also explicitly expressed in the following examples.

Recognition of the assumptions underlying research on the nature of science and the voluminous data generated by process-product research on the relationship between teaching behaviors/classroom environment and student outcomes perhaps facilitated the change in focus of this area of research to its contemporary perspective. (p.346)

If such teachers produced significant gains in their students’ scores, the design would have it appear that teachers scoring poorly on the TOUS were producing equally significant student gains as those teachers scoring well. (p.345)

Therefore, it was concluded that discursive choice of the text created power differences between teachers and students either by using passive versus active sentence structures or positioning students as products and teachers as the main actors of the educational processes.

A similar process-product perspective can also be observed in the nature of science literature. While there are a sheer number of researches investigating what teachers, curriculum developers, and researchers can do to improve students’ conceptions/ understanding/ view/ belief of the nature of science (Clough, 2018; Matthews; 2017), there is a considerable gap in the literature regarding research investigating what students can do to improve their own conception/ understanding/ view/ belief of nature of science, since most research exclusively studying students in the literature mainly focuses on the descriptive and demographic aspects of students conception/ understanding/ view/ belief of nature of science (Deng et al., 2011; Leach, 1996; Lederman; 2007).

Another agency observed in the text was ‘scientist.’ Scientists were presented explicitly or implicitly as professionals. Examples can be seen below.

During the validation of the NOSS, Kimball (1968) noted that philosophy majors actually scored higher than either science teachers or professional scientists. (p.341)

Using the TOUS and a comprehensive review of several nationwide surveys, Klopfer and Cooley concluded that high school students' understandings of the scientific enterprise and of scientists was inadequate. (p.333)

As professionals, they were expected to have adequate conception/ understanding/ view/ belief of science. As seen in the quote below, the findings point out that the misconceptions of scientists were considered discouraging or surprising by the text.

Over 50% of the science teachers felt that scientific findings were not tentative. Even more surprising was that 20% of the scientists felt the same way. Dismayed by the findings, Behnke concluded that... (p.340)

During the validation of the NOSS, Kimball (1968) noted that philosophy majors actually scored higher than either science teachers or professional scientists. (p.342)

Another noteworthy observation regarding the agencies was the subject position of the researchers. Throughout the text, 'researchers' generally used with active voice and were portrayed as having idealized positive characteristics. Examples can be seen below.

In short, the current state of affairs in the area of research on the nature of science is a coherent effort, with researchers building upon and informing each other's work. (p.351)

Instead, researchers worked almost as if their focus was the whole puzzle as opposed to just a piece. (p.351)

Semantically, the whole text portrayed researchers as the source of authority. They were the ones investigating the nature of science conception/ understanding/ view/ belief of other participants of the science educational processes like students, teachers, and even scientists and deciding what adequate or desired outcome is and putting effort to improve the current state of affairs and trying to solve the whole puzzle. In line with this observation, their authority appeared to be unchallenged, even within the science education literature. While there is little research investigating even the scientists' nature of science conception/ understanding/ view/ beliefs (e.g., Kimbal, 1968), the researchers' conception/understanding/ view/ beliefs of nature of science have never been a topic of interest in the literature. This could be attributed to the lack of an agreed-upon definition of the nature of science (Stanley & Brickhouse, 2001) because,

without a criterion (a well-defined definition), for evaluating what is adequate, research on the nature of science is in need of an authority (researchers) to decide what should be considered as an adequate conception/ understanding/ view/ belief of nature of science.

Furthermore, all the observed agencies, even though some of them were used in their plural forms, most agencies were referring to individual's conceptions/ understandings/ views/ beliefs of the nature of science. However, no agencies referring to a group like a classroom, family, community, etc., were used in the text. This observation begs the following questions: 'Can groups have a shared conception/ understanding/ view/ belief of the nature of science?'.

In summary, the analysis of the subject positions showed that the discursive choices of the nature of science epistemic community in science education create power differences most distinctively among students, teachers, and researchers. The discursive choices of this epistemic community portray researchers as the decision-makers regarding the improvement of both teachers' and students' conception/ understanding/ view/ belief of the nature of science. In contrast, teachers are characterized as the practitioners who implement the decisions made by the researchers, and students are portrayed as passive participants. Moreover, scientists are portrayed with less authority compared to researchers since the text questions their nature of science conception/understanding/view/belief but not researchers'.

### **5.3. Nature of Science Discourse in Science Education**

Using Fairclough's (2001) guiding questions, discursive choices observed in the text were also analyzed to reveal the complex and invisible relationships between the text and its social context. This analysis revealed that by not providing a clear definition but presenting alternative representations, the discursive choices of the text implied that defining the nature of science was challenging. Also, the observed competing nominalizations, "conception and understanding of the nature of science," were found to be contextually significant. Moreover, this observed variance of the nominalizations

appeared to be one of the consequences of the absence of an established definition in the literature. Therefore, in this section, these findings will be discussed in detail.

Previous descriptive analyses revealed an inconsistency regarding the used nominalizations in the text. One explanation for this inconsistency appeared to be the lack of a definition of the nature of science with clear boundaries. This struggle was evident throughout the text. Even though it was clearly stated that the text aims to “review the research related to students’ and teachers’ conceptions of the nature of science,” it did not provide an agreed-upon definition of the nature of science. Instead, the text referred to various representations, associations, and connections to the nature of science while summarizing the research on students’ and teachers’ conceptions, understandings, views, and beliefs of science, scientific knowledge, scientific process, and scientific enterprise, etc. in the literature. The only definition presented by the text was

Although the “nature of science” has been defined in numerous ways, it most commonly refers to the values and assumptions inherent to the development of scientific knowledge (Lederman & Zeidler, 1987). For example, an individual’s beliefs concerning whether or not scientific knowledge is amoral, tentative, empirically based, a product of human creativity, or parsimonious reflect that individual’s conception of the nature of science. (p.331)

It was self-referenced to the writers’ earlier work, but the most noticeable feature of this definition was the use of the phrase “it most commonly refers to.” Consequently, the definition was discrediting itself because semantically, this sentence was saying that ‘on rare occasions, the nature of science does not refer to the values and assumptions inherent to the development of scientific knowledge in definitions.’ In other words, the definition was presented cautiously by implying it is not an agreed-upon or complete definition. While the text did not give a full definition, certain logical deductions were repeatedly implied in the text regarding what constitutes the nature of science. These observations were consistent with the current approach to the nature of science research in the literature.

In the literature, many researchers accept that there is not a well-established definition of the nature of science. Most of these researchers also claim that since there is some

agreement on the general aspects of nature of science, the lack of definition can be overlooked, and these agreed-upon aspects can be studied (e.g., Akerson et al., 2000; Çetinkaya- Aydin & Çakıroğlu, 2017; Lederman et al. 2014). Alternative to this view, there are some attempts in the literature to change the notion of the nature of science by introducing it with a different focus and name, “features of science,” which emphasizes the epistemological, historical, psychological, social, technological, and economic elements of science (Matthews 2012). On the other hand, while researchers agree that “there is considerable disagreement on what version of the nature of science ought to be taught” (Stanley & Brickhouse, 2001, p.47), the rising popularity of the nature of science aspects adopted by science curriculums around the world has been constant for the last few decades (Olson, 2000). Therefore, it is evident that the lack of a definition is seen as problematic by the researchers studying the nature of science. Yet, the value and power this framework possesses in science education are so substantial that it is one of the most established frameworks of science education, which was also what the finding of this research suggested by recognizing it as an epistemic community.

As explained before, there were numerous representations of the nature of science observed in the text instead of a definition. These representations were the nature of science as an objective, a way of knowing, scientific knowledge, and a science process. In the following sections, all these representations will be discussed separately. Even though these representations cannot be considered definitions, within the analyzed text, they were used to explain the different versions of the nature of science.

*Nature of science as an objective:* Nature of science was presented as an objective with adjectives that emphasized its important, lasting, and repeating position in science education. The adjective choices like perennial and prominent were noticeable in the text since they were only used in reference to the nature of science. Examples of how this objective and these adjectives were used can be seen below.

The development of adequate student conceptions of the nature of science has been a perennial objective of science instruction regardless of the currently advocated pedagogical or curricular emphases. (p.331)

The prominent and perennially high status given to the nature of science as an objective of science curricula is quite clear. (p.332)

In a way, to make up for the lack of a clear definition of the nature of science, the text used a generally accepted nature of science objective. In the literature, this discursive choice was observed as well, since it was an established practice, almost as a norm, to mention this objective in the research on nature of science. Most of the texts associated with the nature of science epistemic community located within this research and reviewed articles in the literature had reference to either research, position, or a policy paper stating this objective (e.g., Abd-El-Khalick & Lederman, 2000, American Association for the Advancement of Science, 1989; Hazen & Trefil, 1991; Kimbal, 1967, 1968; Klopfer, 1969; Lederman, 1992, 2007, 2014; National Science Teacher Association, 1982; Rutherford & Ahlgren, 1990). Even the researchers questioning the nature of science framework and the effects of the absence of a definition in the literature stated this objective in their work (e.g., Alsop & Gardner, 2017; Hodson & Wong, 2001, Stanley & Brickhouse, 2001). As an objective, “development of adequate student conception” is well established in science education literature, and it has almost become a common-sense assumption. Therefore, it is possible to conclude that prospective researchers are expected to recognize the nature of science as the prominent objective of science education. Also, this common-sense assumption could easily be used as a gatekeeper for being accepted by the nature of science epistemic community of science education and gaining a voice in this community and the literature. As a result, there is not much room for prospective researchers to question this objective.

On the other hand, giving credit to the critiques of CDA and looking at these findings from a Positive Discourse Analysis (PDA) framework’s perspective (Bartlett, 2012), it is quite significant that the nature of science education epistemic community achieved through these discursive choices. This community established a framework and became maybe the most influential and powerful voice in the literature without having a clear agreed-upon definition of the very concept their framework was built upon. Therefore, this observation begs the question: ‘Are there other frameworks in the literature of education or other fields’ resembling this phenomenon?’ and ‘Is this

phenomenon showing a contrast between the approaches of science education and other fields in the literature?’ and ‘How/ Would the definition of science and the nature of science differ if they had agreed upon definitions?’

*Nature of science as a way of knowing:* Another noteworthy representation of the nature of science observed in the text was the “nature of science as a way of knowing.” This expression was an intertextual reference to Aikenhead’s (1979) curriculum, as it was also referenced directly in the text. Another reference in the text also suggests that this representation was adopted by other influential associations and researchers in the field.

More recently, Aikenhead (1979) developed and field tested a curriculum titled “Science: A Way of Knowing.” (p. 336)

The development of an “adequate understanding of the nature of science” or an understanding of “science as a way of knowing” continues to be convincingly advocated as a desired outcome of science instruction (American Association for the Advancement of Science, 1989; Hazen & Trefil, 1991; Rutherford & Ahlgren, 1990). (p.331)

Aikenhead’s (1979) article was not observed as an item with a high occurrence and cluster effect in the co-citation map generated to locate epistemic communities in this research. Also, the citation rate of this article was not considerably high. It was a short three-page article published in The Science Teacher Journal by National Science Teachers Association. However, in his works, Lederman (1983; 1992; 1998; 2000; 2001; 2013; 2014) consistently cited this article and used this expression. The co-citation maps generated in this research showed that Lederman’s contribution and influence in the field were substantial. Consequently, other researchers of the nature of science also used this expression in general, usually with no reference to Aikenhead or sometimes by referencing Lederman (e.g., Akerson & Donnelly; 2010; Dani, 2009; Meyer & Crawford, 2011).

The discursive choice of the nature of science epistemic community for representing the nature of science/ science as a way of knowing can be attributed to the effort to reach an agreement in the field. If how science was positioned in the sampled text with the highest number of occurrences and a cluster effect in the generated co-occurrence

maps, the sheer number, and variance of the observed nominalizations related to science and the semantic emphasis put on the “nature” of science is considered. More than anything, what was foregrounded by the discursive choices of the nature of science community was the question of “what science is.” Defining “what science is” has always been a challenge. Especially the demarcation of science was a vexing task for both philosophers and scientists (Chalmers, 2013; Taylor, 1996; Ziman, 2001). However, for the nature of science epistemic community, an agreed-upon definition of science has the potential to lead to an agreed-upon definition of the nature of science. Therefore, this community’s effort to present science and the nature of science in an agreed-upon way was consistent with the literature. Alsop and Gardner (2017) explain this effort with an analogy from physics, comparing “...pursuit of a theory of everything” with “... a unification theory about science for educational purposes” (p.29).

On the other hand, even in this effort to find a way to unite different perspectives of the nature of science, the power struggle was still there. The source of the certain terminology observed as a discursive choice might not always be the actual source of the terminology but instead the users’ shared intention to utilize this terminology. Therefore, we can never be sure to what end and by whom the representation “science as a way of knowing” was introduced to the nature of science literature. Yet, it appears that the “nature of science/science as a way of knowing” accomplished to unite the field to a certain degree, at least in terms of the nature of science standards.

Today, “science as a way of knowing” is one of the emphasized Next Generation Science Standards (National Science Teachers Association, 2013) regarding the nature of science understanding. Yet, the effect of the lack of definition, the terminological inconsistency, and the various representations of the nature of science can also be seen in this standard as well since even the matrix of the connections to nature of science listed under this standard combines the concepts of science as a way of knowing, nature of science, and scientific knowledge instead of distinguishing them. Therefore, it was possible to conclude that the effects of the discursive choices of the nature of science epistemic community in science education can be traced to the new generation standards and objectives of science education. Considering the emphasis put on these

objectives by the nature of science epistemic community, this community's observed effect on the objectives of science instruction shows how discourse maintains power relations through reciprocal interactions.

*Nature of science as scientific knowledge:* One more noteworthy observation regarding the various representations of the nature of science in the text was the way the connection between the nature of science and scientific knowledge was established. A few examples of this connection can be seen below.

For example, an individual's beliefs concerning whether or not scientific knowledge is amoral, tentative, empirically based, a product of human creativity, or parsimonious reflect that individual's conception of the nature of science. (p. 331)

It is important to note that during the early stages of research related to the nature of science, investigators had still not distinguished among science attitude, attitude toward science, and students' conceptions of the nature of science/scientific knowledge. (p. 333)

As seen in the first example, individuals' certain beliefs about scientific knowledge were assumed to reflect individuals' conception of the nature of science. In the second example, students 'conception of the nature of science was presented as similar or the same as their conception of scientific knowledge by simply placing a slash between them. These representations do not appear to be exceptional. However, they rely on our common sense.

Even though there are numerous researches on beliefs and conceptions (e.g., Chan, 2004; Entwistle et al., 2000; Thompson, 1992), there is no research readily accessible in the literature investigating how beliefs and conceptions are related, especially in terms of the nature of science. However, through the discourse promoted by the nature of science epistemic community, which is constantly using belief, conception, view, and understanding interchangeably, we have this common sense, and we do not question the axioms "beliefs reflect conceptions" or "individuals' beliefs about science reflect their conception of the nature of science." Common sense assumptions are implicit, and they are rarely questioned. However, they control our actions and the way we perceive and interpret others' actions (Fairclough, 2001). Particular forms of common sense are produced by ideologies (Billig & Sabucedo, 1994), and the role of

discourse in the production and reproduction of common sense is crucial (Crehan 2011; Fairclough, 2001; Kulyk, 2006). Since common sense is more concerned with acceptability than correctness (Kulyk, 2006), if we go back to the presented example, the existence of a relationship between beliefs and conceptions appears to be acceptable to deduce that one reflects the other. However, we do not have solid evidence to assume the correctness of this deduction. Moreover, if a researcher aims to question this common-sense assumption, “beliefs reflect conceptions” or “individuals’ beliefs about science reflect their conception of the nature of science” they have to face and convince a whole community that promotes this common-sense through their discursive choices.

The second common-sense assumption observed in the examples was that students’ conceptions of the nature of science are similar or the same as their conceptions of scientific knowledge. Scientific knowledge or aspects of scientific knowledge are consistently associated with the nature of science conception/ understanding/ view/ belief in the literature because of its undeniable connection to science. By using this connection and similar solid logical connections like the one between science and the process of scientific inquiry, the nature of science epistemic community comes up with certain agreed-upon aspects of the nature of science. A few examples of how the process of scientific inquiry and understanding/ conception of the nature of science are associated with the discursive choices of the text can be seen below as well.

He further stated that anyone who does not realize that scientific hypotheses and theories cannot be proven at all, but only disproven, could not be said to truly understand the nature of science. (p. 334)

Tamir assessed changes in students’ conceptions of the nature of science on the Science Process Inventory (Welch, 1967). (p. 337)

There are quite a few lists in the literature that claim to be providing some reference points regarding the agreed-upon aspects of the nature of science (Abd-ElKhalick et al., 1998; Lederman et al., 2002; McComas et al., 2000) however, even among these lists some inconsistencies can be observed. These lists of the nature of science aspects are also criticized for separating the nature of knowledge from the processes of scientific inquiry (Alsop & Gardner, 2017). Therefore, while the discursive choices of

the nature of science epistemic community support the common-sense assumption that the nature of science and the nature of scientific knowledge are similar, in the literature, this assumption is still being developed and debated.

*Conception vs. understanding or conception as understanding:* Descriptive analyses of the sampled text showed that among the various nominalizations, “conception of nature of science” and “understanding of nature of science” were the most emphasized nominalizations. In the following examples, it can be seen that these nominalizations were used interchangeably in the text. Sometimes they replaced each other as the objective of science instruction, and other times they were presented as the same or at least very closely related so that assessment of the one could reveal the adequacy of the other.

The development of adequate student conceptions of the nature of science has been a perennial objective of science instruction regardless of the currently advocated pedagogical or curricular emphases. (p. 331)

The development of an “adequate understanding of the nature of science” or an understanding of “science as a way of knowing” continues to be convincingly advocated as a desired outcome of science instruction (American Association for the Advancement of Science, 1989; Hazen & Trefil, 1991; Rutherford & Ahlgren, 1990). (p.331)

Initial assessments of students’ conceptions indicated that students did not possess adequate understandings of the nature of science and led to the conclusion that science teachers must not be attempting to teach the nature of science. (p. 350)

In 1961, Klopferand Cooley developed the Test on Understanding Science (TOUS) which was to become the most widely used paper-and-pencil assessment of students’ conceptions. (p.333)

If we check the dictionary meaning of these words in their verb forms, to conceive is seen as the synonym of to understand (Oxford, Miriam Webster n.a.). However, considering how nominalization changes the verbs to nouns, the nominalizations ‘understanding’ and ‘conception’ are rarely used as synonyms. In his recognized work “How We Think,” Dewey (1910) explains understanding and sheds some light on the relationship between understanding and conception. He defines ‘understanding’ as the grasped meaning and suggests that there are two types of understanding, apprehension,

and comprehension, in other words, direct and indirect understanding. Dewey defines conception as any meaning sufficiently individualized to be directly grasped and readily used, as thus fixed by a word. As it can be seen from these definitions, according to Dewey, conception is related to apprehension. To Dewey (1910), conceptions are instruments of identification, of supplementation, and of placing in a system (p.126). Hence the reason, research on cognition uses conception as a term (Shuell, 1986) but does not use it interchangeably with understanding.

The discursive choice to use understanding and conception interchangeably in a general sense, like as the objective of science instruction, might not be problematic. However, in terms of assessments and evaluation, there is not much information in the literature about whether this is a common-sense approach or validated by evidence. There is no scientific evidence presented by the researchers using conception and understanding interchangeably, suggesting that conception is equivalent or correlated to understanding and vice versa. Moreover, considering the numerous researches on students' conceptual understanding in science literature (e.g., Gabel, 2003; Knoicek-Morgan & Keeley, 2015; Pines & West, 1986), which provides ample source of information regarding the assessment and evaluation of conceptual understanding, it was noteworthy that the expression, "conceptual understanding" was not favored or even used by the nature of science epistemic community.

*Adequate conception/understanding of the nature of science:* It can also be seen in the aforementioned examples that there is a repeated reference to the adequacy of either conception or understanding of the nature of science as an objective. Adequate conception or understanding of the nature of science is repeatedly presented as a "desired outcome" of science instruction by the text. As previous findings suggested, due to the lack of an agreed-upon definition, the nature of science epistemic community relies on this objective to support their position in the field. Yet, this community has an observable effect on the objectives of science instruction. Therefore, what is considered to be an adequate conception/understanding of the nature of science as an objective of science instruction is determined by the same authority that is evaluating it in practice. Therefore, there is a risk of the monopoly of

power by a single authority over the nature of science education and research. There seems to be very little room for the voice of the outsiders within this loop.

#### **5.4. Conclusion**

As a result, this research was able to find answers to the research questions regarding the nature of science epistemic community in science education literature.

- What are the characteristics of discourses promoted by the epistemic community of science education?
- Do the discursive choices of the epistemic community of science education create power differences? If so...
- How do the discursive choices of the epistemic community of science education create power differences?

Even though these answers are not at all comprehensive, they can contribute to the understanding of the role of epistemic communities' discursive choices in science education literature.

First of all, findings showed that the discourse of the nature of science epistemic community in science education can be identified by its emphasis on certain nominalization like students' conception/ understanding/ view/ belief of nature of science and teachers' conception/ understanding/ view/ belief of nature of science. These nominalizations are used almost as terminologies in this discourse. However, they are often used interchangeably. Therefore, they cannot be considered established terminologies (Halliday & Martin, 1993). Moreover, even though the discursive choices of the text put some emphasis on the nominalization of the 'conception of nature of science' there is a substantial need for consistency to consider it as the terminology of this discourse.

Second, at the text level, the finding revealed that, the discursive choice of the text created power differences between teachers and students either by using passive versus active sentence structures or positioning 'students' as products and 'teachers' as the main actors of the educational processes. Moreover, 'researchers' generally used with

active voice and were portrayed as having idealized positive characteristics. Semantically, the whole text portrayed researchers as the source of authority. Therefore, at the sentence level, the discourse promoted by the nature of the science epistemic community in science education portrayed students as passive participants of science inquiry and positioned teachers and researchers as active participants and researchers as the authority. However, this promoted discourse does not refer to the groups like parents, family, community, society, etc., and does not give any roles to them.

Third, findings showed that, at the text level, ‘adequate conception/understanding of nature science’ as an objective was given a central role by this discourse. In the sampled text, nature of science as an objective was presented with adjectives that emphasized its important, lasting, and repeating position in science education. The adjective choices like perennial and prominent were noticeable in the text since they were only used in reference to the nature of science when it is presented as an objective. Moreover, the analyzed text appears to be emphasizing and using this objective in place of an agreed-upon definition of nature of science.

Finally, at the contextual level, the agreed-upon aspects of nature of science were associated with aspects of scientific knowledge since these aspects ultimately constitute scientific knowledge which has the ultimate authority position in science education literature. In the analyzed text, the way the connection was established between the nature of science and scientific knowledge with the discursive choices was more direct and logic-based compared to other representations of nature of science which were language-based.

Thus, the findings of this research showed that the use of certain nominalizations was characteristic of the discourse promoted by the nature of science epistemic community in science education literature, especially the “conception of nature of science.” The discursive choices of this epistemic community created power differences between teachers and students, and researchers either by using passive versus active sentence structures or positioning them. Also, ‘adequate conception/understanding of nature science’ as an objective was given a central role by using this objective in place of an

uncontroversial definition. Moreover, by associated with aspects of scientific knowledge since these aspects ultimately constitute scientific knowledge which has the ultimate authority position in science education literature. In the analyzed text, the connection constructed between the nature of science and scientific knowledge with the discursive choices was more direct and logic-based than other representations of nature of science, which were linguistic-based.

## **CHAPTER 6**

### **NATURE OF SCIENCE DISCOURSE IN ELEMENTARY SCIENCE EDUCATION**

This chapter presents the findings regarding the discursive choices of the nature of science epistemic community in elementary science education literature. As explained in Chapter IV, the findings were organized and presented according to Fairclough's (2001; 2011) triadic approach.

#### **6.1. Characteristics of Nature of Science Discourse in Elementary Science Education**

Akerson, Abd-El-Khalick, and Lederman's (2000) article was purposefully sampled to investigate the characteristics of the discourse promoted by the nature of science community in elementary science education in detail since its citation frequency and link strength scores (its effect on the formation of citation clusters) were noteworthy compared to other articles (see Chapter 3, Table 3.4). The text was a research article published in August 2000 in Journal of Research in Science Teaching, volume 34, issue 4, pages 295- 317. It was 23 pages long with 68 references. The article was copyrighted by John Wiley & Sons, Inc.

##### ***6.1.1. Organization of the Text***

The text analysis (description) revealed that the author made noteworthy discursive choices, especially in terms of the wording of the titles. Titles organize the text by providing consistent information about the relevant sections of the text and direct readers' attention (Ball, 2009). Therefore, they are expected to have common word choices. However, some significant discrepancies were observed in the titles of the sampled article. The choices regarding the titles can be seen in Table 6.1. First of all, the analysis revealed a discrepancy between the nominalizations used in the title of the

article and the titles used within the body of the text. Also, another inconsistency was observed between the presented goal of the study and the reported results.

**Table. 6.1**

*Organization of the Titles (Akerson et al., 2000)*

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Influence of a Reflective Explicit Activity-Based Approach on Elementary Teachers' Conceptions of Nature of Science	
<i>Abstract</i>	Improving Science Teachers' Views of NOS
	NOS
	Method
<i>Context of the Study: An Elementary Science Methods Course</i>	
<i>Data Collection and Instruments</i>	
<i>Intervention</i>	
<i>Classroom Discussions</i>	
<i>Written Reflections</i>	Data Analysis
	Results
<i>Preinstruction NOS Views</i>	
<i>Observation Versus Inference</i>	
<i>Functions of and Relationship between Scientific Theories and Laws</i>	
<i>Empirical and Tentative NOS</i>	
<i>Creative and Imaginative NOS</i>	
<i>Subjective, and Social and Cultural NOS</i>	
<i>Postinstruction NOS Views</i>	
<i>Observation Versus Inference</i>	
<i>Functions of and Relationship between Scientific Theories and Laws</i>	
<i>Empirical and Tentative NOS</i>	
<i>Creative and Imaginative NOS</i>	
<i>Subjective, and Social and Cultural NOS</i>	
	Discussions and Implication
	Appendix
	References

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Additionally, in the results section under the subtitles, Preinstruction and Postinstruction NOS View, the same five secondary subtitles were used; however, among these secondary subtitles, there was an inconsistency (NOS referring to nature of science). The first two were presented without any reference to NOS but the views related to scientific knowledge, and the following three were views related to some aspects of NOS.

The article's title was 'Influence of a Reflective Explicit Activity-Based Approach on Elementary Teachers' Conceptions of Nature of Science.' There were eight main titles and six sub-titles, and twelve secondary sub-titles in the text. The sampled article was a research article; therefore, the structure of the main titles was pre-determined. In the research article genre, authors are given flexibility regarding the textual structure while presenting the research framework and the results. Therefore, while investigating the titles' organization to reveal the text's large-scale structure, these sections carried more importance.

The organization of the titles was analyzed by utilizing Fairclough's (2001) guiding questions for textual structures. The first observation regarding these titles was the discrepancy between the title of the article and the main titles within the text. While the article's title utilized the phrase 'Teachers' Conception of Nature of Science,' there was no reference to 'conception' within the main titles and sub-titles and secondary subtitles. Considering the informative nature of titles and subtitles and their role in the reader's comprehension, titles and subtitles within the text were expected to be consistent with the article's title and provide clarification and organization to the text (Hartley, 2005). However, the discrepancy between titles appeared to be intentional for this article. Therefore, it was further investigated in the analysis of the vocabulary and linguistic features section.

The organization of the titles was analyzed by utilizing Fairclough's (2001) guiding questions for textual structures. The first observation regarding these titles was the discrepancy between the title of the article and the main titles within the text. While the article's title utilized the phrase 'Teachers' Conception of Nature of Science,' there was no reference to 'conception' within the main titles and sub-titles and secondary

subtitles. Considering the informative nature of titles and subtitles and their role in the reader's comprehension, titles and subtitles within the text were expected to be consistent with the article's title and provide clarification and organization to the text (Hartley, 2005). However, the discrepancy between titles appeared to be intentional for this article. Therefore, it was further investigated in the analysis of the vocabulary and linguistic features section.

In the article's introduction section, the title 'Improving Science Teachers' Views of NOS' was used. The results were presented under the two titles, 'Preinstruction NOS Views' and 'Postinstruction NOS Views.' Other than the functional titles, all main titles in these text sections referred to the NOS views. If the article's title was overlooked, there was consistency among the main titles because the nominalization 'conception of nature of science' was consistently replaced with 'NOS View.' Therefore, it was noteworthy that a study investigating the influence of reflective explicit activity-based approach on elementary teachers' conceptions of nature of science reported its results as the change between preinstruction and postinstruction nature of science views. Based on this observation, it was speculated that this discursive choice indicated that 'conception' and 'view' were being used interchangeably since titles were not referring to these nominalizations together or suggesting any relation between them. Thus, whether the nominalizations 'conception of nature of science' and 'NOS view' were used interchangeably by the text was investigated further in the analysis of the vocabulary and linguistic features.

Another noteworthy observation was about the subtitles of the results section and the way NOS views were presented in the secondary subtitles. As mentioned before, the results were presented under two subtitles Preinstruction NOS views and Postinstruction NOS views. Under each of these titles, five similar secondary sub-titles were used to categorize different aspects of NOS views and report the corresponding results. While two of these secondary sub-titles had no reference to NOS directly, 'Observation Versus Inference' and 'Functions of and Relationship between Scientific Theories and Laws,' the remaining three secondary sub-titles had explicit references to NOS, 'Empirical and Tentative NOS,' 'Creative and Imaginative NOS,' 'Subjective and, Social and Cultural NOS.' This discrepancy was also significant because, through

this representation, titles grouped NOS views, into two groups, views regarding “values and beliefs inherent to scientific knowledge” (Lederman, 2007) and views regarding some of the aspects of NOS. Therefore, this observation was also further investigated.

Since research articles have pre-determined organization and space constrictions, spaces allocated to the subtitles within sections, especially for the titles of the results section, were considered indicative of the writer’s organizational choices. The analysis revealed that the spaces allocated for the subtitles of the result section were different, but there was no pattern in these differences to suggest a specific discursive choice. ‘Preinstruction NOS Views’ (≈2000words): ‘Observation Versus Inference’ (≈190words), ‘Functions of and Relationship between Scientific Theories and Laws’(≈330words), ‘Empirical and Tentative NOS’(≈320words), ‘Creative and Imaginative NOS’ (≈310words), and Subjective, and Social and Cultural NOS (≈420words) and Postinstruction NOS Views’ (≈1500words): ‘Observation Versus Inference’ (≈220words), ‘Functions of and Relationship between Scientific Theories and Laws’(≈250words), ‘Empirical and Tentative NOS’(≈450words), ‘Creative and Imaginative NOS’ (≈180words), and Subjective, and Social and Cultural NOS (≈190 words).

In summary, the finding of the organization of the text revealed that writers’ discursive choices were different for the title of the article and the titles within the text. As a result, the nominalization used in the article’s title, ‘conception of the nature of science,’ was replaced with ‘NOS view’ in the main titles of the text. The main titles and subtitles of the article consistently favored the nominalization ‘NOS view,’ making the writer’s choice not to use this nominalization in the title of the article more noteworthy. Moreover, subtitles of the results section were grouping NOS views into two groups, views regarding “values and beliefs inherent to scientific knowledge” (Lederman, 2007) like observation-inference and theory-law relationships and views regarding some of the aspects of NOS. Thus, the study that investigated ‘Influence of a Reflective Explicit Activity-Based Approach on Elementary Teachers’ Conceptions of Nature of Science’ reported the change between pre- and post- instruction NOS

views of the teachers. The researcher's critical analysis and interpretation of these discrepancies are presented in the next section.

### ***6.1.2. Critical Analysis of the Organization of the Text***

The observed discrepancy between the word choices of the main title and the titles used within the text was indicative of the foregrounding of the 'Teachers' Conception of Nature of Science.' This nominalization was used in the title of the article, which was the first piece of information communicated to the reader. In contrast, the nominalization 'teachers' view of NOS,' was used consistently in the titles within the text. Foregrounding is generally used to give prominence to a certain piece of information (Baker & Ellece, 2011). However, in this case, possibly more than prominence, accessibility was the primary concern of the writers. Titles are tools to catch the readers' attention (Ball, 2009), and the nominalization 'Teachers' Conception of Nature of Science' appeared to be used in the article's title to catch the attention of the intended readers.

Using different nominalizations from the ones favored within the text or using two or more competing nominalizations together in the titles is not a rare observation in science education literature, especially for nature of science research (e.g., Lederman et al., 2002; Mesci & Schwartz, 2017). Studies on article titles suggest a relationship between article titles and citation rates (Jacques & Sebire, 2010; Rossie & Brand, 2020). Within and across disciplines, the use of nominalizations in the titles was found to show commonalities (Soler, 2007). Therefore, titles can be used to associate a text with a group or a research framework, which in return attracts the attention of that group or the researchers working with the same framework.

Moreover, previous findings regarding the discursive choices of nature of science epistemic community in science education also showed that the nominalization "teachers' conception of the nature of science" was favored by this community. Elementary science education literature is embedded in science education literature and affected by it. Hence, it can be concluded that through the use of nominalization 'teachers' conception of nature of science,' the text conforms to the discursive choices

of the nature of science epistemic community in science education to attract the attention of a wider audience. This observation also relates to the reciprocal relationship between ideologies and language in use (Billig, 2008; Wetherell et al., 2001). The discursive choices of this sampled text partially conformed to the norms of conduct promoted by the nature of science epistemic community in science education to associate with them. However, changing their discursive choices within the text, writers still favored the nominalization, NOS view. Even though it was not favored, ‘nature of science view’ was also among the nominalizations used by the nature of science epistemic community in science education. Therefore, it can be speculated that, while the nature of science epistemic community favors the nominalization ‘conception of nature of science,’ it also allows the variance of nominalizations. This enables researchers to associate with this community without adopting the nominalization favored by it as the norm of conduct. Thus, in return, the nominalizations promoted by the studies associated with the nature of science epistemic community in science education literature contributes to the observed variance of nominalizations in the discursive choices of this community.

The nominalization ‘NOS views’ was used consistently in the titles within the text. This observation was indicative of the text’s preference or at least the strong position of this nominalization as a discursive choice. The titles of Akerson’s, (one of the writers of the sampled text) more recent works in the literature supported this observation; they favored the nominalization ‘NOS view’ (e.g., Akerson et al., 2009a, 2009b, Akerson, & Donnelly, 2008; Akerson et al., 2006). Notably, Akerson and Abd-El-Khalick (two writers of the sampled text) had other published works together, and their titles appeared to favor both conception and view together or conception in general (e.g., Abd-El-Khalick & Akerson, 2004; Abd-El-Khalick & Akerson, 2009). Therefore, in the literature, it has been observed that different researchers and groups of researchers favor different nominalizations. However, it appears that recent studies in elementary science literature favor the nominalization ‘view of nature of science’ and its derivatives relatively more than ‘conception/understanding of nature of science’ in their titles. On the other hand, bibliographic references show that (Google

Scholar) the same writers' articles using the nominalization 'conception' in their title are cited more than those using the nominalization' view.'

As for the observation regarding the secondary sub-titles categorizing different aspects of NOS views in the literature, observation-inference, and theory-law differences were presented as the characteristics of scientific knowledge that students should be taught to understand nature of science (Lederman, 2007). Therefore, more information was needed to understand this organizational choice. Thus, this observation was investigated further.

In summary, analysis of the organization of the text showed that while the nominalization 'teachers' conception of nature of science was preferred for the title of the article, the nominalization NOS view was used for the main titles and subtitles. Therefore, this discrepancy was indicative of the preferred nominalization, 'conception of nature of science,' for searches in science education literature by the community, which the writers of the text targeted as the audience. On the other hand, the strong presence of the nominalization 'NOS view' in the titles within the text and the titles of the recent elementary science education research indicated that as a nominalization, 'NOS view' was somehow favored by the nature of science epistemic community in elementary science education. Therefore, the observed discrepancies appeared to be caused by the writers' intended audiences.

### ***6.1.3. Vocabulary and Linguistic Features of the Text***

Fairclough's (2001) guiding questions were used to analyze the vocabulary and linguistic features of the sampled text representative of the nature of science epistemic community in elementary science education. The analysis revealed that the text used various nominalizations. Among these nominalizations, the "NOS view" was emphasized. On the other hand, throughout the text but more specifically in the introduction and discussion sections of the text, the nominalizations "conception," "NOS conceptions," "understanding," and "NOS understanding" were used along with the nominalization "NOS view." Considering the previous findings regarding the organization of the text, the discrepancy between the title of the article and the titles

within the text, observing the use of the nominalization ‘conception’ and its variations throughout the text was noteworthy.

Moreover, another nominalization was observed to be used throughout the text, ‘target NOS aspects. This nominalization referred to the NOS aspects investigated by the analyzed text. Which was also providing some explanation for the discrepancy observed in the titles of the text in the results section. ‘Observation Versus Inference.’ ‘Functions of and Relationship between Scientific Theories and Laws,’ ‘Empirical and Tentative NOS,’ ‘Creative and Imaginative NOS,’ and ‘Subjective and, Social and Cultural NOS’ were referred to as ‘target NOS aspects’ by the text.

The analysis also revealed that nominalizations were frequently used in various forms within the text. Most notably, the abbreviation ‘NOS’ was preferred instead of ‘nature of science.’ Moreover, different variations of the nominalizations were also observed in the text. For example, regarding ‘view,’ the following variations were used.

- a. adequate views of NOS/ adequate views of tentative NOS
- b. participants’/students’/science teachers’ view
- c. pre-instruction/post-instruction NOS view
- d. naïve views

The analysis also revealed that nominalizations were frequently used with an agency. Nominalizations, teachers’ conception, science teachers’ conceptions, elementary science teachers’ conception, preservice elementary teachers’ conceptions, teachers’ understanding, teachers’ view, science teachers’ view, preservice teachers’ view, secondary science teachers’ view, preservice elementary teachers’ view, and most frequently participants’ view were all observed in the text. Considering the structural effects of the values, the analysis also revealed that frequent use of nominalizations with agency indicated the emphasis on agencies. In terms of the voice of the text, linguistic features analysis revealed that both active and passive sentence structures were used in the text. When explanations were made, active sentence structures were

preferred. Passive sentence structures were generally used in reference to literature and for generalizations.

Vocabulary and linguistics features analysis revealed that only the nominalizations with ‘view’ were used in the abstract section of the text. The nominalizations with ‘conception’ and ‘understanding’ were used more frequently than the ‘view’ in the literature and discussion sections. ‘Belief’ was used four times in the text and only once as ‘NOS beliefs.’ These observations suggested that writers’ discursive choices changed in different text sections considering the targeted audience and perceived authority in the field. In some cases, writers’ discursive choices regarding nominalizations changed even within a sentence. For example,

More graduate participants, however, held adequate views of the empirical and tentative NOS, whereas more undergraduates held adequate conceptions of the creative and imaginative NOS. (p.305)

Creative and Imaginative NOS. Most participants (76% of undergraduates and 84% of graduates) did not demonstrate adequate understandings of the role of human inference, imagination, and creativity in generating scientific claims. (p.307)

Moreover, the text did not promote the nominalization ‘NOS belief,’ even though the nominalizations NOS conceptions, NOS understanding, and NOS view were used interchangeably. This observation supported the previous speculations. It showed that studies could promote different nominalizations while partially conforming to the discursive choices of the nature of science epistemic community. On the other hand, the use of both ‘conception’ and ‘understanding’ in the literature and discussion sections further supported the finding suggesting that they are competing discursive choices of the nature of science epistemic community in science education.

‘Participants,’ ‘teachers,’ ‘researchers,’ ‘instructor,’ ‘graduate participants,’ ‘scientists,’ and ‘students’ were observed agencies in the text; however, ‘participants’ was the most frequently observed agency. Consistent with the observed discursive choices of the nature of science epistemic community in science education, some agencies were not used by this text, like family, parent, society, etc. However, considering the genre of this research article, these observations were expected

because the article was investigating and reporting participants' views, and mentioned groups were outside of its scope.

The analysis revealed that in the 'Improving Science Teachers' Views of NOS' section, active sentence structures more frequently positioned teachers as active participants of the science instructions who have the power to make decisions. For example,

A significant proportion of teachers, for example, did not endorse the tentative nature of scientific knowledge. (p.296)

The course aimed to help preservice elementary teachers develop (a) a theoretical framework for teaching science at the elementary level, (b) a repertoire of methods for teaching science, (c) favorable attitudes toward science and science teaching, and (d) deeper understandings of some science content area. (p.299)

Teachers were used in nominalizations often when the sentence's subject was researchers or the researchers in the name. By doing so, text positioned the researchers as the authority. For example,

Nonetheless, when the reviewed attempts, both implicit and explicit, were scrutinized in terms of the resultant science teachers' NOS understandings, Abd-El-Khalick and Lederman concluded that much is still desired in terms of fostering among science teachers' conceptions of NOS that would enable them to convey to students more adequate views of the scientific endeavor. (p.297)

In the 'Method,' 'Data Analysis,' and 'Results' sections, the use of the agencies 'participants,' 'graduate participants,' 'instructor,' and 'scientist' was more frequent. 'Participants' were used instead of 'undergraduate student teachers' and 'graduate participants' were used instead of 'graduate student teachers,' and, in some occurrences, 'participants' were used for both groups. 'Instructor' referred to the first author of the text, in other words, one of the researchers. Therefore, the instructor-participant relationship portrays to some extent the researcher-teacher and teacher-student relationships. For example,

During the first 6 h in the course, the instructor engaged participants in 10 different activities that explicitly addressed the seven target aspects of NOS. (p.300)

At this stage, the instructor's role shifted from prompting discussion about NOS to facilitating the discussion, providing focus, and helping participants to come to some sort of closure. (p.302)

Moreover, in the text, 'students' generally referred to either 'undergraduate student teachers' or 'graduate student teachers.' When 'students' did not refer to 'student teachers' but K-12 students in general, they were portrayed as the passive participants of science instruction through the use of nominalizations or passive sentence structures.

At present, despite their varying pedagogical or curricular emphases, agreement among the major reform efforts in science education [American Association for the Advancement of Science (AAAS), 1990, 1993; National Research Council (NRC), 1996] centers on the importance of enhancing K-12 students' conceptions of NOS. (p.295)

The text emphasized the fact that scientists are not perfect beings, they are human beings by frequently referencing their daily lives, personal background, etc. For example,

These questions started students thinking about the distinction between the finished products of science as they appear in professional journals and the actual work that scientists engage in during their daily activities. (p.301)

They failed to recognize that scientists use their imagination and creativity throughout scientific investigations, especially when interpreting data and inventing explanatory systems to explain those data. (p.308)

These observations were further explained in the 'Subject Positions of Nature of Science Discourse in Elementary Science Education' section of this research.

In summary, the analysis of the vocabulary and linguistic features of the text revealed that different nominalizations were favored within different sections of the text. The text's title favored 'conception,' while the abstract section and other main titles of the text favored 'view.' Moreover, the literature and discussion sections favored the nominalizations 'conception' and 'understanding' almost equally. However, nominalization 'belief' was not frequently used or promoted by the text. The use of the nominalization 'conception' and 'understanding' in the literature review and discussion section of the text was consistent with this research's finding regarding the

discursive choices of the nature of science epistemic community in science education. Therefore, the following conclusions were made. The use of ‘conception’ in the article’s title was intended to reach the general audience of the nature of science epistemic community. Moreover, nominalization ‘NOS view’ was consistently used in the abstract to inform the reader regarding the text’s preference. In the introduction and discussion sections, nominalizations with ‘conception’ and ‘understanding’ were used to associate with the nature of science epistemic community and position the research in the science education literature.

The analysis also showed that nominalizations were frequently used in various ways within the text. Abbreviations like ‘NOS’ and word order differences like ‘NOS views’ and ‘views of NOS’ were observed frequently in the text. First of all, the abbreviated use of ‘nature of science’ suggested that this nominalization was well established and easily recognized in the field. However, observing long nominalizations like ‘adequate views of tentative NOS’ or ‘target NOS view aspects’ indicated that it was also caused by the variance and intended to make the text more readable. Moreover, the analysis showed that the nominalizations promoted by the studies associated with the nature of science epistemic community by partially conforming to its discursive choices contribute to the variance of nominalizations observed. Furthermore, the text provided some concrete evidence that nominalizations were used interchangeably.

The nominalizations were frequently used with agencies like ‘participants view,’ ‘teachers’ conception,’ ‘science teachers view.’ This also contributed to the variance observed regarding the nominalizations. However, as seen in the science education context, agencies referring to groups like family, society, etc., were not used by the text. Also, in terms of the voice of the text, active sentence structures were used as much as passive sentence structures. Generally, functional sentence structures were used for explanations, and passive sentence structures were used for generalizations.

Finally, the hierarchical positions of teachers and researchers (instructor and participants) were established through the text’s discursive choices, teachers were portrayed to have some power and control over their decisions, and researchers were portrayed as authorities. On the other hand, students were portrayed as passive

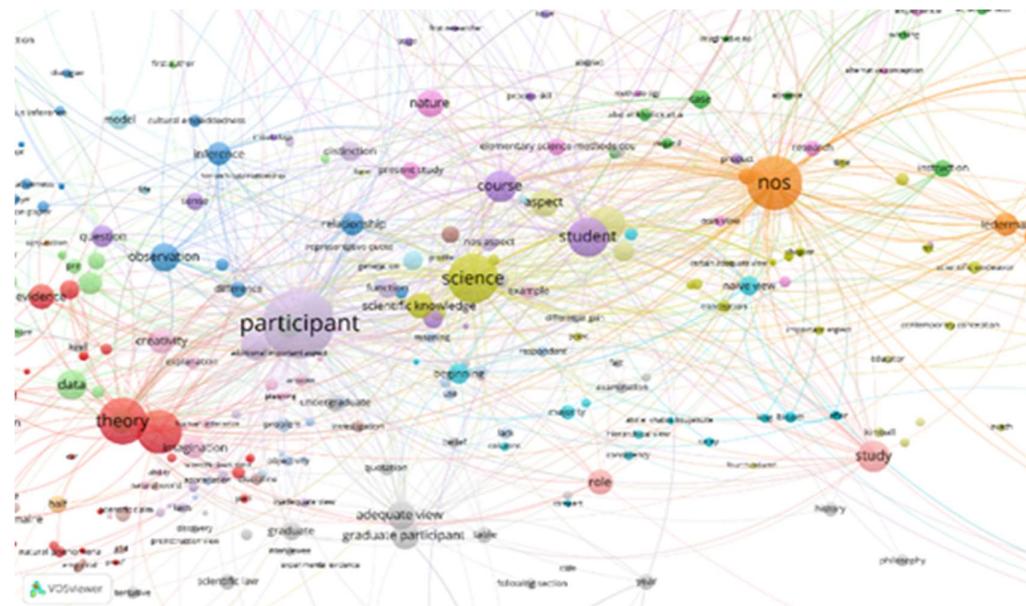
participants of science instruction through nominalizations or passive sentence structures.

#### 6.1.4. Member Checking and The Analysis of the Observations Through VOSviewer Maps

To map out the associations among the words within the sampled article, VOSviewer data visualization program was used. The following map (Figure 6.1), based on text data, was generated using full counting of the words and setting the minimum number of occurrences of the terms to one. The program calculated a relevance score for 980 items in the text, and the largest set of connected items consisted of 971 items. Within these 980 items total of 22044 links were observed. Items were analyzed based on their association strength, and the minimum cluster size was set to 1. The analysis generated 24 clusters, and the map was used to investigate the word occurrences and the extent of co-occurrences.

**Figure 6.1**

*Co-occurrence Map of the Items in the Sampled Article for Nature of Science Epistemic Community in Elementary Science Education Based on Text Data without Threshold.*



Generated co-occurrence map showed that participant (purple), NOS (orange), science (green), theory (red), scientist (red), student (purple), and view (green) items had the highest occurrences, number of links, and links strengths in the map. The number of occurrences, links, and link strengths of these items can be seen in Table 6.2.

**Table 6.2**

*Occurrence and Link Strength of the Most Observed Items*

Item	Occurrence	Links	Total Link Strength
Participant	115	591	3126
NOS	68	607	2363
Science	57	530	1636
Theory	51	366	993
Scientist	44	326	717
Student	37	334	821
View	31	323	984

There were various nominalizations observed in the text. However, not many of these nominalizations had high occurrence and cluster effects due to the variations. Moreover, overall occurrences of the nominalizations were not notable in the co-occurrence map to conclude that the text favored passive sentence structure. In the co-occurrence map, the nominalizations, view, adequate view, participants view, and naïve view had the highest occurrence and cluster effect among all observed nominalizations. The number of occurrences, links, and link strengths of these nominalizations can be seen in Table 6.3.

Nominalizations, teachers' NOS conception, science teachers' conceptions, teachers' conception, elementary teachers' conception, NOS understanding, teachers' understanding, participants' understanding, teachers' view, science teachers' view, preservice teachers' view, secondary science teachers' view, preservice elementary teachers' view were all observed in the text at least once.

**Table 6.3***Occurrence and Link Strength of the Nominalizations*

Item	Occurrence	Links	Total Link Strength
View	31	323	984
Adequate view	19	187	505
Participants view	14	164	417
Target NOS aspect	10	147	407
Naïve view	9	177	393
Target aspect	9	150	298
Science teachers' conception	4	124	176
NOS understanding	4	62	77
Science teachers' view	3	96	119
Teachers' understanding	2	54	69
Secondary science teachers' view	1	54	65
Participants' understanding	1	38	46
Teachers' view	1	38	44
Teachers' NOS conception	1	37	43
Teachers' conception	1	34	36
Preservice teachers' view	1	19	21
Preservice elementary teachers view	1	17	24
Elementary teachers' conception	1	5	5

Also, ‘target NOS aspects’ and ‘target aspects’ were observed to be used by the text. However, the text did not use the nominalization ‘teachers’ beliefs,’ so it was not observed as an item in the co-occurrence map. Noticeably, Lederman and Abd-El-Khalick (second and third writer of the sampled text) were reported as items in the co-occurrence map and placed in a close relationship with NOS, which indicated that these researchers cited in the text quite frequently.

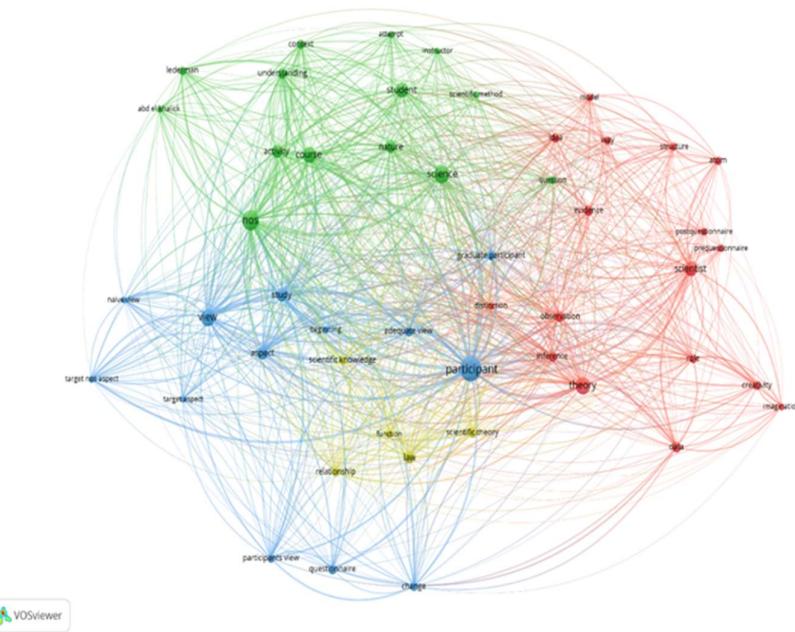
Since all the items that occurred in the text, even if they occurred only once, were included in the analysis regardless of their relevance score, there were too many clusters and connections to be analyzed. Therefore, to focus on the strength of the links among the words and investigate the significant relationships among the linguistic features, another map was generated with a full counting method and by setting a threshold based on the number of co-occurrences. Since the VOSviewer program uses the Chi-Square distribution to analyze relationships among the items, the minimum number of co-occurrences was set to 9 to reduce the number of clusters while assuring each cluster has more than five items. Based on these criteria following map was generated.

After setting the minimum number of occurrences to nine, VOSviewer program calculated a relevance score for 49 items, and the largest set of connected items consisted of all these 49 items. Within these 49 items total of 937 links were reported. This analysis generated 4 clusters which can be seen in the Figure 6.2 showing the co-occurrence map of the items in the sampled article for nature of science community in elementary science education based on text data with a threshold. Each of these clusters was represented with different colors. Since the number of items was considerably reduced from 971 to 49, the number of reported links and calculated link strengths were also changed.

Moreover, some co-occurrences, which were not considered significant in the previous Chi-Square distribution analysis, became significant. Especially, the number of occurrences for the item ‘view’ increased significantly from 31 to 58. This was indicative of the emphasis on this item. After random occurrences were removed from the co-occurrence map with a set threshold, it becomes the fourth item with a high number of occurrences and cluster effect in the co-occurrence map. It was the only item that changed place in the ranking. The emphasized positions of ‘Participants’, ‘NOS,’ and ‘Science’ stayed the same as expected. The number of occurrences, links, and link strengths of the most observed nominalizations were presented again in the following table, Table 6.4.

**Figure 6. 2**

*Co-occurrence Map of the Items in the Sampled Article for Nature of Science Epistemic Community in Elementary Science Education Based on Text Data with a Threshold.*



**Table 6.4**

### *Occurrence and Link Strength of the Most Observed Items with Threshold*

Item	Occurrence	Links	Total Link Strength
Participant	119	47	1555
NOS	75	45	1074
Science	60	46	684
View	58	42	817
Theory	57	47	530
Scientist	45	46	346
Student	45	44	406

In the co-occurrence map generated with a threshold, the nominalizations, view, adequate view, participants view, and naïve view were all observed with the highest occurrence and cluster effect. Also, only one of these nominalizations contained agency, participant. The previously observed variance and agencies with very low co-occurrences were removed with the set threshold. The number of occurrences, links, and link strengths of these nominalizations can be seen in Table 6.5.

**Table 6.5**

*Occurrence and Link Strength of the Nominalizations with View*

Item	Occurrence	Links	Total Link Strength
View	58	42	817
Adequate view	20	42	319
Participants view	16	33	417
Naïve view	9	35	185

The generated co-occurrence map with a threshold also showed certain promoted agencies with a high number of occurrences and cluster effects in the text. These agencies were participant, scientist, student, graduate participant, and instructor. This observation also supported the findings of the analysis of the linguistic features of the text. The occurrence and link strength of these agencies can be seen in Table 6.6.

**Table 6.6**

*Occurrence and Link Strength of the Agencies*

Item	Occurrence	Links	Total Link Strength
Participant	119	47	1555
Scientist	45	46	346
Student	45	44	406
Graduate participant	17	42	245
Instructor	9	34	118

Thus, VOSviewer co-occurrence maps showed that the text used various nominalizations. This observation suggested that passive sentence structures were used in the text. On the other hand, only the nominalizations with ‘view’ were observed in the co-occurrence map generated with a threshold, suggesting that other nominalizations were not used consistently. The text favored the nominalizations ‘view,’ ‘adequate view,’ ‘participants view,’ ‘naïve view,’ and agencies ‘participant,’ ‘scientist,’ ‘student,’ ‘graduate participant,’ and ‘instructor.

In summary, the analysis of VOSviewer co-occurrence maps revealed that observed nominalizations and agencies were consistent with the analysis of the vocabulary and linguistic features of the text. Even though various nominalizations were used by the text, conforming to the discursive choices of the nature of science epistemic community in science education, nominalizations with ‘view’ were favored by the sampled text of the nature of science epistemic community in elementary science education. Since ‘belief’ was not observed in the VOSviewer maps, it was concluded that there were no additional competing discursive choices. Also, ‘target NOS aspects,’ and ‘target aspects’ were observed as frequently used nominalization in the VOSviewer co-occurrence maps suggesting that the nature of science discourse in elementary science education favors this nominalization.

Generated co-occurrence maps also showed that the text favored agencies ‘participant,’ ‘scientist,’ ‘student,’ ‘graduate participant,’ and ‘instructor. This observation, at first glance, was not consistent with the previous findings regarding discursive choices of the nature of science epistemic community in science education literature. However, the analysis of the vocabulary and linguistic features revealed that ‘Instructor’ referred to the first author of the text, in other words, one of the researchers. Also, ‘participants’ were used instead of ‘undergraduate student teachers’ and ‘graduate participants’ were used instead of ‘graduate student teachers.’ In some occurrences, ‘participants’ or ‘students’ were used for both groups. This was probably one of the reasons that the total link strength of the participants was so high compared to the other items in (Table 6.5) since it was used to refer to more than one group. Therefore, considering the genre of the text as a research article, observation of the alternative expressions like participants was not surprising. Yet, participants (student

teachers) pointed out another subject position among the represented researcher – teacher-student interactions due to their unique position.

As a result, the findings of the VOSviewer maps and the analysis of the vocabulary and linguistic features of the text were consistent. Moreover, their findings complement each other providing further information to each other's explanations. For example, VOSviewer maps lacked the contextual information that linguistic analysis provided, like 'who the participants were referring to,' and linguistic analysis was lacking to present the extent of the participants' connections in the text that VOSviewer maps provided.

#### ***6.1.5. Critical Analysis of the Vocabulary and Linguistic Features of the Text***

The text analysis (description) revealed that the discursive choices of the nature of science epistemic community in elementary science education literature were more dependent on the audience and authority. Using different nominalizations from the ones favored within the text or using two or more competing nominalizations together in the titles, or using different nominalizations for the different sections of the text was indicative of this tendency (e.g., Abd-El-Khalick et al., 2001; Abd-El-Khalick & Akerson, 2009; Mesci & Schwartz, 2017). However, even though the sampled text used the nominalization 'conception' in its title, text analysis clearly showed that it favored the nominalization 'view' as a discursive choice. Moreover, there is an observable increase in the recent studies favoring the nominalization 'view.' (e.g., Cofré et al., 2019; Dorsah, 2020; Schellinger et al., 2019). This observation could be caused partially by the increasing popularity of the 'Views of Nature of Science Questionnaire' (Lederman et al., 2002) and later Views of Scientific Inquiry: The VOSI Questionnaire (Schwartz et al., 2008) in elementary science education research (e.g., Edgerly et al., 2022; Mesci & Schwartz, 2017).

Considering that discourse changes in time, it is almost impossible to provide a complete account. Without the support of prior research in the field, this research could explain only a few observed discursive choices of the nature of science community in elementary science literature, focusing more on its theoretical underpinnings. Recent

studies already went beyond this theoretical foundation, and by taking it for granted, they focus on new concepts like ‘elementary teachers’ nature of engineering views’ (e.g., Deniz et al., 2020). These studies also are gaining popularity in science education literature (e.g., Aydoğan & Çakıroğlu, 2021). However, even in these studies, the discursive choices of the nature of science epistemic community in elementary education can be observed. Especially the use of nominalizations to conform to the favored discursive choices of the audience or authority appears to be characteristic. Therefore, this research concluded that favoring the nominalization ‘view’ was characteristic of this discourse in many cases. However, in general, accommodating different discursive choices to conform to the preferences of the authority of the field or the audience of the text appears to be characteristic of the nature of science discourse in elementary science education literature.

The analysis of the vocabulary and linguistic features of the text revealed that through the use of nominalization and passive sentence structures, students were consistently positioned as passive participants in the science instruction. While participants, in other words, student teachers were portrayed as active participants having some control in their interaction with NOS aspects. At the same time, teachers and researchers were frequently positioned as active participants through active sentence structures. Also, scientists were portrayed as imperfect by emphasizing their human aspects. As the agencies participants (student teachers), students, instructor, and scientists were portrayed in different roles in the text, agencies like parents, family, community, society, etc., were not mentioned in the text. These observations were similar to the observed discursive choices on the nature of science epistemic community in science education. Therefore, it was concluded that there was no noteworthy difference at the text level in terms of agency and subject positions differentiating the discursive choices of the nature of science epistemic community in elementary science literature. Other than the text’s emphasis on the ‘student teachers.’ Therefore, subject positions promoted by the nature of science discourse in elementary science education were further investigated. Findings were reported in the next sections.

When the discursive choices of the nature of science epistemic community in science education and in elementary science education literature were considered in terms of the finding of the text analysis, it was concluded that discursive choices of the nature of science epistemic community in elementary science education literature were more dependent on the audience and authority. As a result, discrepancies among different sections of the text were common. Therefore, using different nominalizations to associate with specific epistemic communities or researchers or groups of researchers was a characteristic of this discourse that was investigated at the contextual level.

## ***6.2. Subject Positions of Nature of Science Discourse in Elementary Science Education***

The text analysis revealed that certain subject positions were present in the text. Teachers, participants, graduate participants, researchers, and instructor were portrayed as active participants in science instruction, while students were portrayed as passive participants. Also, researchers and instructor were portrayed as the authority responsible for improving teachers/student teachers' NOS views. Moreover, the text portrayed the scientists as not so perfect human beings. Since the discursive choice of the text changed in different sections and different nouns were used in these sections, findings were reported accordingly.

The analysis revealed that in the introduction, 'Improving Science Teachers' Views of NOS' section, active-passive sentence structures and nominalizations were used, suggesting a power difference between teachers and researchers. Even though teachers were portrayed to have control over their actions with the frequent use of active sentences, researchers were still portrayed as the authority. For example, on the same page of the text, teachers were presented as being able to choose whether to endorse the tentative nature of scientific knowledge, while researchers were presented as the ones that 'attempt to improve science teachers' conceptions of NOS' and also the ones who reviewed these attempts.

A significant proportion of teachers, for example, did not endorse the tentative nature of scientific knowledge. (p.296)

In their comprehensive review of the attempts undertaken to improve science teachers' conceptions of NOS, Abd-El-Khalick and Lederman (1998) noted that these attempts used one of two general approaches. (p.296)

This observation was also consistent with the findings regarding the discursive choices of the nature of science epistemic community in science education literature. Considering previous findings, the text portrayed teachers as active participants, contrasting students' passive roles. It also referred to the researchers' efforts to change teachers' conceptions as attempts, implying some difficulty in changing teachers' conceptions. For example, the portrayed relationship among these subject positions can be seen in one sentence.

Nonetheless, when the reviewed attempts, both implicit and explicit, were scrutinized in terms of the resultant science teachers' NOS understandings, Abd-El-Khalick and Lederman concluded that much is still desired in terms of fostering among science teachers conceptions of NOS that would enable them to convey to students more adequate views of the scientific endeavor. (p.297)

These examples also explained why Abd-El-Khalick and Lederman were observed as items in the VOSviewer co-occurrence maps. By referencing these two researchers directly in the text, the discursive choices of the text also position them as an authority. In science education and elementary science education literature the influence of these researchers is significant and the extent of this influence can also be seen in the VOSviewer citation maps generated to locate the epistemic communities of both science education and elementary science education literature (See, Chapter 4).

'Participant' was the most frequently observed agency in the text, and the VOSviewer co-occurrence map showed that it had the highest occurrence and cluster effect (Figure 6.1, Figure 6.1). Out of 49 items in the generated co-occurrence map with a threshold, 47 items had links to participants. Therefore, the emphasis put on the participants by the text was evident. In the text, 'participants' was used instead of 'undergraduate student teachers,' and 'graduate participants' was used instead of 'graduate student teachers.' In some occurrences, 'participants' was used for both groups. Therefore, the real emphasis was put on the student teachers or, in other words, pre-service teachers by the analyzed text. A similar tendency can also be observed in the literature. In the elementary science education literature, research on student teachers' or pre-service

teachers' nature of science views (e.g., Akerson et al., 2006, 2009a; Dickinson et al., 2000; Shim. Et al., 2010; Morrison et al., 2009), conception (e.g., Akerson & Abd-El-Khalick 2005; Park & Lee, 2009; Liu & Lederman, 2007), understanding (e.g., Lee & Shea, 2016; Bell et al., 2008; Garcia-Carmona, 2021) and beliefs (e.g., Yoon & Kim, 2016) are more common than research on in-service teachers' or elementary students' nature of science view/conception/understanding/belief (e.g., Ozkal et al., 2010; Hacieminoglu et al., 2015; Walls, 2012) or research on both students' and teachers' nature of science understanding (Lederman & Lederman, 2004, 2005).

In the 'Method,' 'Data Analysis,' and 'Results' sections, the use of the agencies 'participants,' 'graduate participants,' 'instructor,' and 'scientist' was more frequent. While 'participants' referred to 'student teachers,' 'instructor' referred to the first author of the text, in other words, one of the researchers. Therefore, the instructor-participant relationship refers to the researcher-student teacher relationship. The discursive choice of the text portrayed participants (student teachers) as active participants of the science instruction. For example, in the following quotes, participants were portrayed as capable of acquiring NOS understandings and articulating, elaborating, and applying them with some help.

This reflective component of the intervention aimed to help participants articulate and elaborate their acquired NOS understandings and apply those understandings in various contexts. (p.301)

More graduate participants, however, held adequate views of the empirical and tentative NOS, whereas more undergraduates held adequate conceptions of the creative and imaginative NOS. (p.305)

On the other hand, as the above examples regarding the participants showed, the text used different nominalizations with different agencies. However, this did not indicate any consistent use of nominalizations with certain agencies. On the contrary, this observation supported the previous assumption that nominalizations 'conception' and 'view' were used interchangeably by the text.

Nominalizations, passive-active sentence structures, and in some cases, object-subject positions in the sentence structures were used to portray the instructor to have control over participants. For example,

During the first 6 h in the course, the instructor engaged participants in 10 different activities that explicitly addressed the seven target aspects of NOS. (p.300)

At this stage, the instructor's role shifted from prompting discussion about NOS to facilitating the discussion, providing focus, and helping participants to come to some sort of closure. (p.302)

The first sentence was constructed to position the instructor as the subject of the sentence and participants as the object; since it was not participants who engaged with activities, it was the instructor who engaged participants with the activities. The second sentence was also portraying the instructor as having different roles and was implying that with the help of the instructor, participants could come to some sort of (intended) closure.

Due to the unique position of the student teachers, they were sometimes referred to as 'students' in the text. However, the instructor-student relationship portrayed in the text was similar to the instructor-participant (student-teacher) relationship, as it can be seen in the following quote.

The instructor asked the undergraduates whether this discussion was related in any way to earlier NOS discussions... These discussions might help to illustrate the importance of explicit prompts to get students to think about and reflect on different issues related to NOS. Without such prompts, these discussions, which got students involved in discourse about NOS, were not likely to have taken place. Students' involvement in such discussions, we believe, is crucial for providing them with opportunities to clarify their ideas about NOS for themselves in the first place, and for others in the second place. (p.302)

Moreover, the human side of the scientist was emphasized by the discursive choices of the text. Therefore, they were portrayed as not so perfect, which insinuated that scientists could make mistakes. For example,

These questions started students thinking about the distinction between the finished products of science as they appear in professional journals and the actual work that scientists engage in during their daily activities. (p.301)

In general, these participants recognized that scientists' prior knowledge, personal backgrounds, and viewpoints, as well as other human elements, influence the ways in which scientists interpret empirical evidence. (p.311)

Overall, the promoted subject positions and relationships among these positions suggested that teachers and student teachers were perceived as capable of improving their NOS views. Yet since teachers have control over the decisions made during science instruction, they may choose not to include NOS and keep their misconceptions. This is the challenge of the researchers who attempt to improve teachers' and student teachers' NOS view.

These findings were also consistent with the trends observed in the elementary science education literature. There is numerous research focusing on the improvement of elementary student teachers' NOS views ( Akerson et al., 2006; Akerson et al., 2007; Akerson et al., 2009a; Erdas-Kartal, 2018; Morrison et al., 2009), conceptions ( Abd-El-Khalick, & Akerson, 2009; Akerson et al. 2011; Abell et al., 2001), understanding (Cofre et al., 2014; Garcia-Carmona, 2021) in the literature. Noticeably, however, there is very little research on teachers' or student teachers' NOS beliefs in elementary science education literature. Moreover, in comparison to science education literature, research on in-service teachers' and students' NOS views/conception/understanding/beliefs are not as popular in elementary science education literature.

Thus, the analysis of the subject positions showed that the observed discursive choices of the nature of science epistemic community in both science education and elementary science education contexts were similar. The distinctive discursive choice of the nature of science epistemic community in elementary science education was the emphasis put on the student teachers (pre-service teachers) and the improvement of their NOS views. On the other hand, consistent with the previous findings in the science education context, researchers were portrayed as the authority, while teachers and student teachers were portrayed as active participants, and K12 students were portrayed as passive participants of science instruction.

### **6.3. *Nature of Science Discourse in Elementary Science Education***

According to Fairclough's triadic approach (2001), the contextual discursive choices were also analyzed to reveal the text-context interaction. The analysis revealed that discursive choices of nature of science epistemic community in both science education and elementary science education contexts overlaps significantly. On the other hand, studying the nature of science epistemic community's discursive choices in these two contexts enabled this research to partially differentiate the nature of science discourse in elementary science education and clarify some discursive choices that could not be explained with confidence in the science education context.

*Attempts to improve science teachers' NOS view/conception:* One of the observations in the analyzed texts was the use of the expression 'attempt to improve science teachers' NOS view/conception.' For example,

In their comprehensive review of the attempts undertaken to improve science teachers' conceptions of NOS, Abd-El-Khalick and Lederman (1998) noted that these attempts used one of two general approaches. (p.296)

Most of these attempts to improve science teachers' NOS views were undertaken in the context of preservice elementary or secondary science methods courses and inservice workshops/institutes. (p. 297)

A very similar expression was also used by the sampled text of the nature of the science epistemic community in science education. However, an explanation for this observation could not be reached in the analysis since 'attempt' was only used once in this text. Observing the same expression again in sampled text for elementary science education required further investigation. Therefore, this discursive choice was investigated in the relevant literature.

In the science education literature, this expression is commonly used by N. Lederman (Abd-El-Khalick & Lederman, 2000, Schwartz & Lederman, 2002; Lederman & Lederman, 2014). However, in elementary science education literature, this expression was used with reference to Lederman's works and presented as a rationale for investigating teachers' NOS view/conceptions/understanding since previous attempts did not result as desired (Hanuscin et al., 2006; Mesci, & Schwartz, 2017). In a way,

by using this expression and conforming to the discursive choices of the nature of science epistemic community, the text was associating itself with authority, in this case, with a specific researcher.

The expression “attempt to improve science teachers’ NOS view” was also used by the analyzed text with no reference; however, this was expected considering that N. Lederman was the third author of this text. This observation showed that on some occasions, the discursive choices of nature of science epistemic community in elementary education conform to the discursive choices of researchers or groups of researchers considered to be the authority to associate with them. If those researchers or groups of researchers are among the writers of a text, the discursive choices of the text are naturally determined by them. Therefore, within epistemic communities, some influential researchers are recognized as an authority, and these researchers’ discursive choices could determine the discursive choices of the community.

Nonetheless, this observation was noteworthy since a similar observation was made regarding article titles in the literature (see Chapter 6, 6.1.2 Critical Analysis of the Organization of the Text). The titles of Akerson’s recent works favored the nominalization ‘NOS view’ (e.g., Akerson et al., 2009a, 2009b, Akerson, & Donnelly, 2008; Akerson et al., 2006). However, Akerson and Abd-El-Khalick’s published works favored the use of both conception and view together or conception in general (e.g., Akerson, & Abd-El-Khalick’s, 2004; Abd-El-Khalick & Akerson, 2009). Therefore, this observation begs the question ‘Whether the discursive choices of the nature of science epistemic community in science/elementary science education conform to any researchers or other epistemic community’s discursive choices? Whether epistemic communities conform to each other’s discursive choices to associate or create more prominent communities?

*Target NOS aspects:* One of the discrepancies observed in the organization of the text was about the titles of the results section. In this section, preinstruction and postinstruction NOS views of the participants were presented with five secondary subtitles. While two of these secondary sub-titles had no reference to NOS directly, ‘Observation Versus Inference’ and ‘Functions of and Relationship between Scientific

Theories and Laws,’ the remaining three secondary sub-titles had explicit references to NOS, ‘Empirical and Tentative NOS,’ ‘Creative and Imaginative NOS,’ ‘Subjective and, Social and Cultural NOS.’ This discrepancy was significant because through this representation, titles grouped NOS views into two groups, views regarding “values and beliefs inherent to scientific knowledge” (Lederman, 2007) and views regarding some of the aspects of NOS. However, these five titles were referred to as target NOS aspects throughout the text.

In the text, writers claim that among the various agreed-upon aspects of NOS only

...seven of these aspects that we believe are accessible to K–12 students and relevant to their daily lives were adopted and emphasized (also see Abd-El-Khalick et al., 1998). These aspects are that scientific knowledge is tentative (subject to change), empirically based (based on and/or derived from observations of the natural world), subjective (theory laden), partly the product of human inference, imagination, and creativity (involves the invention of explanation), and socially and culturally embedded. Two additional important aspects are the distinction between observations and inferences, and the functions of and relationships between scientific theories and laws. (p.298)

As seen in the quote, the writers did not list ‘observations and inferences’ and ‘the functions of and relationships between scientific theories and laws’ among the seven accessible aspects. Yet, they referred to them as additional aspects. In the literature, observation-inference and theory-law differences were presented as the characteristics of scientific knowledge that students should be taught to understand nature of science (Lederman, 2007). Moreover, there are quite a few lists in the literature claim to be providing some reference points regarding the agreed-upon aspects of the nature of science (Abd-ElKhalick et al., 1998; Lederman et al., 2002; McComas et al., 2000) however, even among these lists some inconsistencies can be observed.

The use of the nominalization ‘target NOS aspects’ almost instantly solves this inconsistency problem by gathering all these aspects in one group. Throughout the text, there were many references to the target NOS aspects. For example,

The majority of participants held naive views of the target NOS aspects at the beginning of the study. (p. 295)

An open-ended questionnaire in conjunction with semistructured interviews was used to assess participants' views of the target aspects of NOS. (p. 299)

This initial activity-based explicit NOS instruction was intended to provide participants with a NOS framework by introducing and, in a sense, sensitizing them to the target NOS aspects. (p.300)

Many participants still held naive views of one or more of the target NOS aspects. (p.312)

As these examples show, the use of this nominalization sorts out all problems caused by the variance and the inconsistencies regarding the NOS aspects. It creates a hierarchy among the NOS aspects, suggesting that some of these aspects are accessible and targeted by science instruction and others are not. Therefore, it was not surprising that this nominalization was popular in the literature. In science education literature, the nominalization 'target NOS aspects' was commonly used by F. Abd-El-Khalick (e.g., Dogan & Abd-El-Khalick, 2008; Khishfe & Abd-El-Khalick, 2002; Abd-El-Khalick et al., 2008). However, in elementary science education literature especially in F. Abd-El-Khalick and V.L. Akerson's collaborative works, it was used as 'views of target NOS aspects' (e.g., Akerson & Abd-El-Khalick 2003; Abd-El-Khalick & Akerson, 2009). The popularity of this nominalization was well established in the field, since many other researchers used it as 'views of target NOS aspects' (e.g., Khishfe, 2008, 2012; Yacoubian & BouJaoude, 2010) or to refer to teachers' or students' view frequently in the text while using the nominalization target nature of science aspects (Cofre et al., 2019; Zion et al., 2020). Therefore, the characteristic emphasis on the "views" in discursive choices of nature of science epistemic community of elementary science education literature was naturally observed in other nominalizations like "views of target NOS aspects".

*Adequate view/ Adequate conception:* In the text, the use of the nominalization 'adequate views of NOS' was frequently observed. It was the second item, after 'view,' with the highest occurrence and cluster effect in the VOSviewer co-occurrence map generated with a threshold. The emphasis put on adequacy was clear in the text. For example,

More graduate participants, however, held adequate views of the empirical and tentative NOS, whereas more undergraduates held adequate conceptions of the creative and imaginative NOS. (p. 305)

This compartmentalized and fragmented nature of participants' views of NOS was not unexpected (Abd-ElKhalick, 1998) given that before this investigation, the majority of these participants were not given opportunities to think about and clarify their conceptions of science as an enterprise. (p.305)

Creative and Imaginative NOS. Most participants (76% of undergraduates and 84% of graduates) did not demonstrate adequate understandings of the role of human inference, imagination, and creativity in generating scientific claims (p.307).

These examples also demonstrated the interchangeable use of the nominalizations view, conception, and understanding.

Moreover, the table presented by the investigated text was named “Percentage of participants with adequate views of emphasized aspects of NOS” (p.305) clearly showed that the adequacy of the participants' views/conception of NOS aspects were reported in a binary way. Participants were considered either to have adequate views regarding a NOS aspect or not. By emphasizing adequacy and presenting it in a binary way the discursive choices of the text presented every aspect separately, overlooking the possibility that if these aspects were collectively evaluated there could be various ways and levels to be adequate. Therefore, this observation begs the questions ‘Can there be levels of adequacy? If an individual does not have an adequate view of only one of the NOS aspects, what happens? To assume that an individual has an adequate view of the nature of science how many aspects of NOS should be adequate?’

#### **6.4. Conclusion**

As a result, this research was able to find answers to the research questions regarding the nature of science epistemic community in elementary science education literature.

- What are the characteristics of discourses promoted by the epistemic community of elementary science education?
- Do the discursive choices of the epistemic community of elementary science education create power differences? If so...

- How do the discursive choices of the epistemic community of elementary science education create power differences?

Even though these answers are not at all comprehensive, they can contribute to the understanding of the role of epistemic communities' discursive choices in elementary science education literature.

The findings of the critical discourse analysis revealed that the discourse of the nature of science epistemic community of elementary science education literature could be identified by its emphasis on the nominalization 'view of nature of science'. Also, using different nominalizations to associate with epistemic communities or researchers or groups of researchers appears to be characteristic of this discourse as well. The nominalization 'view of nature of science' appears to be a competing discursive choice, an alternative to 'conception of nature of science' in elementary science education literature. Depending on the audience and the authority, one of these nominalizations is used by this discourse in different parts of the text. If the text aims to appeal to general science education literature 'conception of nature of science' is used, even if it causes inconsistencies, especially between the title/titles and body of the text.

The findings of the critical discourse analysis also revealed that at the sentence level, the discourse promoted by the nature of the science epistemic community in elementary science education portrayed the teachers, students, and researchers in hierarchical positions similar to the way they are portrayed in science education literature. However, as explained before, the discursive choices observed in the sampled text for the elementary science education context vary in different sections of the text. Therefore, promoted subject positions also vary in these sections. On the other hand, consistent with the previous findings in the science education context, throughout the text researchers were portrayed as the authority. Moreover, the text portrayed the scientists as not so perfect human beings. Most significantly, in the analysis, Abd-El-Khalick and Lederman were observed as items in the VOSviewer co-occurrence maps, based on this observation, the text appeared to position them as the authority. Considering the fact that they were co-authors of this text, the effect of self-

referencing was clear. Since the text was a research article, in the main body of the text ‘participant’ was the most frequently observed subject position. In the text, ‘participants’ was used instead of ‘undergraduate student teachers,’ and ‘graduate participants’ was used instead of ‘graduate student teachers.’ Therefore, the real emphasis was put on the student teachers or, in other words, pre-service teachers by the discursive choices of the analyzed text. Also, teachers and student teachers were portrayed as active participants, and students were portrayed as passive participants in science instruction.

At the text level, the aspects of nature of science were presented in a hierarchy by this discourse. By consistently using the nominalization “target NOS aspects”, the text was suggesting that some of the aspects of nature of science were accessible and targeted by science instruction and others are not. Similarly at the text level, the nominalization ‘adequate views of NOS’ was frequently observed in the text. It was the second item, after ‘view,’ with the highest occurrence and cluster effect in the VOSviewer co-occurrence map generated with a threshold. By emphasizing adequacy, the findings were presented in a binary way; adequate-inadequate.

## **CHAPTER 7**

### **CONCLUSION**

Educational researchers did not pay much attention to language use for a long time. Language use and speech events become a topic of interest to them considerably late. When the linguistic anthropologist started to show the role of language within a cultural context and the ways it presupposes certain social positions and creates social relations (Agha, 2006; Wortham, 2008), it became impossible for educational researchers to ignore the role of language use. As a result, discourse, or as it is defined, language in use, has gained considerable popularity in educational research. Discourse theory and research enabled educational researchers to investigate what was taking place in the classrooms discursively.

For the last few decades, research focusing on teacher-student interactions showed that the way they use scientific discourse and ask questions mediates the social context of the classroom (Roth, 1996; 2004). Teachers can make complex concepts like the nature of science or socio-scientific issues accessible to students through certain discursive choices (Lemke, 1990; van Zee & Minstrell, 1997; Walker & Zeidler, 2007) or prevent students from gaining access to scientific knowledge (Varelas et al., 2008). Furthermore, research on classroom discourse showed that discourse plays a significant role in science classrooms, especially in reasoning (Convertini, 2021; Kelly & Bazerman, 2003) and meaning-making (Franco & Munfold, 2021; Kelly, 2007; Wilmes & Siry, 2021). However, to assume that discourse in the educational context is limited to teacher-student interaction and classroom practice would be ignorant. The educational events taking place in learning environments and outside of these environments are discursive in nature. Recent studies of curriculum materials (Bazull, 2014; Sharma & Buxton, 2015) and policy documents (Hufnagel et al., 2018, Thomas. 2011) appear to support this perspective and expand the scope of discourse research in education. However, considering the role of discourse and the way it creates norms

and expectations within social groups and institutions, discourse studies should also focus on the macro-level interactions in educational contexts. Primarily, epistemic communities and their discursive choices should be studied since the norms and expectations set by these communities could be the main sources of what we observe in the classrooms, curriculums, and even educational policies regarding discourse.

Recognizing this need, the ultimate aim of this research was to expand the scope of discourse studies and explore the macro-level interactions through epistemic communities' discursive choices within the education context. Although there are philosophical and linguistic studies with similar perspectives in the literature investigating academic discourse (Angermuller, 2018; Anthony, 2001; Ball, 2009; Biber & Gray, 2013; Rossi & Brand, 2020), the limited number of studies in the field of science education has indicated a considerable gap in the literature. Therefore, some fundamental exploratory questions needed to be asked to address this significant gap. This research took on the challenge of exploring the epistemic communities' discursive choices and their role in promoting power difference in science education. Since there was no prior research on the topic to investigate the macro-level interactions, the research questions were investigated in two embedded contexts, science education, and elementary science education, to assure a comparative reference point. Consequently, investigating the discursive choices of epistemic communities in these two contexts together yielded more specific information by contrast. Moreover, investigating science education and elementary science education contexts together enabled this research to address all levels of context to attain theoretical or perspective triangulation (see Chapter 3, 3.8 Research Rigor).

Considering the nature of the research questions, this research aimed to answer exploratory, confirmatory, and inferential questions. The first research question was intended to explore the characteristics of the discourses promoted by the epistemic communities; "What are the characteristics of discourses promoted by the epistemic communities of science education/elementary science education?". The second research question was a confirmatory yes or no question; "Do the discursive choices of the epistemic communities of science education/elementary science education create power differences?". Finally, the third question was an inferential question that

could not be answered with certainty since any answer to this question would also be embedded in the power structures explored; “How do the discursive choices of the epistemic communities of science education/elementary science education create power differences?” However, findings regarding this question could help us portray and understand what is actually happening in the field to a degree and question the current status quo. Thus, from the start, the research questions, the research design, and the methodology were all intended to shed light on things we do not usually pay attention to or automatically take for granted in science education. Therefore, a critical perspective was adopted in this research, and the critical discourse analysis (CDA) methodology was utilized.

Moreover, keeping in mind that the methodology, CDA, is often criticized due to the lack of reflexivity and its ideological standpoint, the research was specially designed to address these issues. The research design intended to minimize the researcher effect by starting from an exploratory perspective instead of associating with a theoretical framework that could serve as an ideological standpoint. Also, to assure reflexivity, this research presented every decision made by the researcher. All the analysis steps were explained in detail to the reader, including the member checking processes with the VOSviewer program. Also, the inferential aspect of this research depended on the findings of the exploratory and confirmatory questions. Therefore, theoretically, the only ideological assumption established at the very beginning of this research was that ‘discourse creates power difference,’ which was repeatedly stated by many researchers (Fairclough, 2001; van Dijk, 2017).

The first challenge this research faced was to locate the epistemic communities in science and elementary science education literature. The prior research about epistemic communities in science education literature was limited. As a result of this gap in the literature, a bibliographic investigation was conducted to locate epistemic communities. According to Haas’s (1992) epistemic community framework, a co-citation analysis was conducted, and three epistemic communities were located in the relevant literature using VOSviewer co-citation maps. Moreover, to address the concerns that co-citation analysis often overlooks the body of the text while claiming that there are semantic similarities among texts based on co-citations, additional

analysis was conducted. VOSviewer co-occurrence maps were generated to assure that the texts located in the literature indeed have some semantic similarities. After these analyses, two epistemic communities were located and named within the science education literature: the nature of science epistemic community and the argumentation epistemic community. In contrast, only the nature of science epistemic community was located in elementary science education. There were clear indications of other epistemic communities in science and elementary science education literature. However, this research was able to distinguish only three of these epistemic communities with confidence. Moreover, while the nature of science epistemic community was also located in both science education literature and elementary science education literature, a corresponding community for the argumentation epistemic community was not located in elementary science education literature. Since there was no prior research regarding epistemic communities, the research was designed to investigate the discursive choice of epistemic communities in two embedded contexts to have a comparative reference point to support the findings. Therefore, further investigations regarding the Argumentation epistemic community could not be conducted.

After locating epistemic communities, one representative article for each located epistemic community was selected based on their link strength scores and consistent citation history. Lederman's (1992), and Akerson, Abd-El-Khalick, & Lederman's (2000) articles were purposefully sampled as representative texts for the nature of science community in science education and the nature of science community in elementary science education literature, respectively. To answer the research questions mentioned above, this research utilized Fairclough's (2001) triadic CDA approach and its guiding questions focusing on the discursive choices, especially linguistic features of the text. This framework allows researchers to use it in combination with other approaches and analyses. Therefore, Gee's (2004) guiding questions for identities (subject position) were incorporated into this framework to explore the subject positions. As linguistic features, subject positions provided crucial information regarding power structures to answer the second confirmatory research question.

Moreover, additional VOSviewer co-occurrence maps of each sampled article were incorporated into the analysis as a member checking tool to assure research rigor.

Addressing the first research question, “What are the characteristics of discourses promoted by the epistemic communities of science education/ elementary science education?” the critical discourse analysis of the sampled texts revealed that discourses promoted by these located epistemic communities have some distinctive characteristics. First of all, findings showed that the discourse of the nature of science epistemic community in science education could be identified by its emphasis on certain nominalization like students’ conception/ understanding/ view/ belief of the nature of science and teachers’ conception/ understanding/ view/ belief of nature of science. These nominalizations were used almost as terminologies in this discourse. However, they were often used interchangeably. Therefore, they cannot be considered established terminologies (Halliday & Martin, 1993).

Moreover, even though the discursive choices of the text put some emphasis on the nominalization of the ‘conception of nature of science,’ there was a substantial need for consistency to consider it as the terminology of this discourse. Considering there was no explanation for why these nominalizations were used interchangeably in the investigated text or the relevant literature, it begs the question; What is the reason behind using multiple nominalizations interchangeably? What purpose does it serve? Nevertheless, the findings of this research provided evidence to suggest that the nature of science epistemic community in science education struggles to provide an established terminology for the commonly used variable or distinguishing definitions for the variables used, which are represented with these nominalizations. Moreover, in a recent position paper, citing their prior research (Lederman & Lederman 2014), Norman and Judith Lederman (2019) claims that “nature of scientific knowledge (NOSK) is commonly referred to as “nature of science (NOS), but NOSK is more descriptive of what is originally meant by the phrase.” This stance of the most prominent figures of the nature of science (alternatively NOSK) framework in science education literature also indicates a terminological struggle. Furthermore, new nominalizations like ‘perception of nature of science,’ appears to be gaining popularity in science education literature (Erduran et al., 2020). While it is expected that the

inconsistency regarding the nominalizations to be resolved over time with the knowledge attained from relevant research, the variance is becoming characteristic of the discourse promoted by the nature of the science epistemic community in science education literature. Exploring the dynamics behind this observation is important because these nominalizations are not replacing each other; they are being used interchangeably and increasing in numbers. There are numerous researches using these nominalizations interchangeably or even together in the literature (e.g., Mesci & Schwartz, 2017; Lederman et al., 2002). Therefore, this observation also begs the question; What do we gain or lose by using these nominalizations interchangeably? and What purpose do these various nominalizations serve in the nature of science discourse?

The findings of the critical discourse analysis also revealed that the discourse of the nature of science epistemic community of elementary science education could be identified by its emphasis on the nominalization ‘view of nature of science’. Accordingly, there has been an observable increase in recent studies favoring the nominalization ‘view’ (e.g., Cofré et al., 2019; Dorsah, 2020; Schellinger et al., 2019). This observation could be caused partially by the increasing popularity of the ‘Views of Nature of Science Questionnaire’ (Lederman et al., 2002) and later Views of Scientific Inquiry: The VOSI Questionnaire (Schwartz et al., 2008) in elementary science education research (e.g., Edgerly et al., 2022; Mesci & Schwartz, 2017). Also, using different nominalizations to associate with epistemic communities or researchers or groups of researchers appears to be characteristic of this discourse as well. Instead of settling on one consistent terminology, the nominalization ‘view of nature of science’ became a competing discursive choice, an alternative to ‘conception of nature of science’ in elementary science education literature. Depending on the audience and the authority, different nominalization is used by this discourse in different parts of the text, even if it causes inconsistencies, especially between the title/titles and body of the text. Considering the fact that the titles of the journal articles are expected to convey the topic effectively and be clear, accurate, and precise (Hartley, 2008) and, at the same time, draw readers’ attention and provide enough information about the content to allow readers to decide whether to continue reading (Shahidipour, &

Alibabae, 2017; Yitzhaki, 1994), this observation begs the question; ‘If the nominalizations used in the title/titles and body of the text are inconsistent, what would be the consequence?’’ Also, prior research suggests that high citation rates are related to specific title characteristics particular to a field and as judged by certain title words (Jacques & Sebire, 2010). Therefore, additional questions come to mind “Would the inconsistent use of nominalizations in the title/titles and the body of the text reduce the informative value of the title for the sake of its citation rate?”, “What do we gain or lose by using the nominalizations inconsistently in the titles and the body of the text?”.

The other two research questions; “Do the discursive choices of the epistemic communities of science/elementary science education create power differences?” If so... How do the discursive choices of the epistemic communities of science/elementary education create power differences?” will be addressed below together to keep the readers’ attention on one issue at a time. The critical discourse analysis of the sampled texts revealed that the discursive choices of the located epistemic communities promoted characteristic power differences. First, the discursive choices of the sampled text for the science education literature created power differences between teachers and students either by using passive versus active sentence structures or positioning ‘students’ as products and ‘teachers’ as the main actors of the educational processes. Moreover, ‘researchers’ mostly used with active voice and were portrayed as having idealized positive characteristics. Throughout the text, researchers were portrayed as the sources of authority. Thus, the discourse promoted by the nature of the science epistemic community in science education portrayed students as passive participants, teachers as active participants in science inquiry, and researchers as the authority of science education. On the other hand, discursive choices observed in the text did not refer to groups like parents, family, community, society, etc., and give any roles to them. In science education literature, research on teachers’ and students’ nature of science conception/ understanding/ view/ belief (Clough, 2018; Matthews; 2017) supports the aforementioned hierarchical roles. In comparison, there is almost no research readily accessible in the literature investigating parents’, families’, or community’s involvement in the nature of science education or their nature of science conception/ understanding/ view/ belief.

Considering that subject positions help explain how text produces accounts of the world (Sabaratnam, 2020), the discourse promoted by the nature of the science epistemic community in science education appears to be limiting its world to a teacher-oriented classroom environment, overlooking the other stakeholders of the science education outside of the classroom, and students' power and control over their own learning. Therefore, these findings beg the questions, 'Can specific groups have a common socially constructed conception/ understanding/ view/ belief of the nature of science?' and "What are the consequences of portraying students as passive participants?"

At the text level, a central role was given to 'adequate conception/understanding of nature science' as an objective by this discourse. As an objective, nature of science was positioned as essential, lasting, and repeating with the use of adjectives by the sampled text. Some discursive choice of the nature of science epistemic community, for example, using the adjectives like perennial and prominent in reference to nature of science was noticeable in the text since these adjectives were only used in reference to the nature of science when it was presented as an objective. Most of the texts associated with the nature of science epistemic community located within this research and reviewed articles in the relevant literature had reference to either a research, a position, or a policy paper stating this objective (e.g., Abd-El-Khalick & Lederman, 2000, American Association for the Advancement of Science, 1989; Hazen & Trefil, 1991; Kimbal, 1967, 1968; Klopfer, 1969; Lederman, 1992, 2007, 2014; National Science Teacher Association, 2013; Rutherford & Ahlgren, 1990). Even the researchers questioning the nature of science framework and the effects of the absence of a definition in the science education literature stated this objective in their work (e.g., Alsop & Gardner, 2017; Hodson & Wong, 2001, Stanley & Brickhouse, 2001). As an objective, "development of adequate student conception of nature of science" appears to be well established in science education literature; it has almost become a common-sense assumption. Common sense assumptions are implicit, and they are rarely questioned. However, they control our actions and the way we perceive and interpret others' actions (Fairelough, 2001). Therefore, this observation begs the question, "Can this common-sense assumption, 'development of adequate student

conception of nature of science is the prominent objective of science education' be easily challenged by new researchers?" Moreover, the analyzed text appears to emphasize and use this objective in place of a definition of nature of science. Many science education researchers acknowledge that there is not an agreed-upon definition of the nature of science in science education literature. However, these researchers also suggest that the lack of definition can be overlooked since there is some agreement on the general aspects of nature of science, and these agreed-upon aspects can be studied (e.g., Akerson et al., 2000; Çetinkaya- Aydin & Çakıroğlu, 2017; Lederman et al. 2014). This consensus approach is widely accepted in science education literature. On the other hand, some researchers propose a more substantial change of perspective. There are some attempts in the literature to change the notion of the nature of science by introducing it with a different focus and name, "features of science," which emphasizes the epistemological, historical, psychological, social, technological, and economic elements of science (Matthews 2012). Other researchers also criticize and expand the consensus approach and propose a new framework, 'the Family Resemblance Approach (FRA)' (Irzik & Nola, 2014; Dagher & Erduran, 2016). This framework incorporates the domain-general and domain-specific aspects of science, and 'describes components of science in terms of categories subsumed under epistemic, cognitive, and social systems used' (Erduran & Dagher, 2014, p.19). Therefore, these efforts in the field raise additional questions, 'What are the reasons behind the lack of an agreed-upon definition of nature of science in science education literature?', 'How do/ Would the definition of science and the definition of nature of science differ, if there was an agreed-upon definition nature of science?' and 'Could alternative frameworks provide substantial solutions to the challenges the lack of definition caused?'

At the contextual level, the discursive choices of the nature of science epistemic community in science education established an association between the agreed-upon aspects of the nature of science and aspects of scientific knowledge. By doing so, these choices position the aspects of nature of science almost equivalent to aspects of scientific knowledge. Since these aspects ultimately constitute scientific knowledge which has the ultimate authority position in science education literature, in association,

the aspects of nature of science also gain a position of power. This position of the agreed-upon aspects of nature of science can easily be observed in international science education standards (Commas & Olson, 1998; Olson, 2018). Over the years, this consensus view of nature of science has become considerably influential not only in curriculums but also in students' evaluations (Allchin, 2017; Clough & Olson, 2008; Erduran & Dagher, 2014). Moreover, while in the literature, "there is considerable disagreement on what version of the nature of science ought to be taught" (Stanley & Brickhouse, 2001, p.47), the rising popularity of the nature of science aspects adopted by science curriculums around the world has been constant for the last few decades (Olson, 2000). Therefore, this observation also begs the question, "Why are the aspects of nature of science so popular in curriculums, while there are some unresolved fundamental discussions regarding them in the science education literature?"

Moreover, the association constructed between the nature of science and scientific knowledge with the discursive choices was more direct and logic-based than other representations of the nature of science observed in the text. The effect of this association can also be seen in science education literature. Scientific knowledge or aspects of scientific knowledge are consistently associated with the nature of science conception/ understanding/ view/ belief. Through these associations, the nature of science epistemic community promotes these agreed-upon aspects of the nature of science in the literature. There are quite a few lists of the agreed-upon aspects of the nature of science in the literature (Abd-ElKhalick et al., 1998; Lederman et al., 2002; McComas et al., 2000); however, even among these lists, some inconsistencies can be observed.

These lists of the nature of science aspects based on the consensus view are also criticized for separating the nature of knowledge from the processes of scientific inquiry (Alsop & Gardner, 2017). Researchers like Alsop and Gardner (2017) suggest that these lists of nature of science aspects could vary based on different theoretical approaches. Furthermore, introducing the different voices (Allchin, 2017; Alsop & Gardner, 2017; Dagher & Erduran, 2017; Hodson & Wong, 2017) contributing to the plurality in nature of science debates, Bazzul (2017, p.70) lists the wide range of relevant views/practices/uses of science that are excluded by the consensus view of

nature of science. Therefore, while the discursive choices of the nature of science epistemic community support the common-sense assumption that nature of science and nature of scientific knowledge are similar (or sometimes the same thing), in the literature, this assumption is still criticized and debated. Going back to the recent statement of Lederman and Lederman (2019) about the “nature of scientific knowledge (NOSK) is commonly referred to as “nature of science (NOS), but NOSK is more descriptive of what is originally meant by the phrase,” this statement also supports what is observed in the findings of this research and begs the questions, ‘Why NOS is more commonly used in the science education literature than NOSK?’ and ‘Are aspects of nature of science consists of more than the aspects of scientific knowledge or vice versa?’.

The findings of the critical discourse analysis also revealed that at the sentence level, the discourse promoted by the nature of the science epistemic community in elementary science education literature portrayed the teachers, students, and researchers in hierarchical positions similar to the way they are portrayed in science education literature. However, as explained before, the discursive choices observed in the sampled text for the elementary science education context vary in different text sections. Therefore, promoted subject positions also vary in these sections. On the other hand, consistent with the previous findings in the science education context, researchers were portrayed as the authority throughout the text. Moreover, the text portrayed the scientists as not-so-perfect human beings. Most significantly, in the analysis, Abd-El-Khalick and Lederman were observed as items in the VOSviewer co-occurrence maps. Based on this observation, the text appeared to position them as the authority. Considering they were co-authors of this text, the effect of self-referencing was apparent. This observation raises the question, “What is the effect of self-referencing on science/elementary science education literature’s power structures?”

Since the analyzed text was a research article, ‘participants’ was the most frequently observed subject position in the text’s main body. ‘Participants’ was used instead of ‘undergraduate student teachers,’ and ‘graduate participants’ was used instead of ‘graduate student teachers’ by the text. Therefore, the real emphasis was put on the student teachers or, in other words, pre-service teachers by the discursive choices of

the analyzed text. Also, teachers and student teachers were portrayed as active participants, and students were portrayed as passive participants in science instruction. A similar tendency can also be observed in the literature. In the elementary science education literature, research on student teachers' or pre-service teachers' nature of science views (e.g., Akerson et al., 2006, 2009a; Dickinson et al., 2000; Shim. et al., 2010; Morrison et al., 2009), conception (e.g., Akerson & Abd-El-Khalick 2005; Park & Lee, 2009; Liu & Lederman, 2007), understanding (e.g., Lee & Shea, 2016; Bell et al., 2011; Garcia-Carmona, 2021) and beliefs (e.g., Yoon & Kim, 2016) are particularly common compared to research on in-service teachers' or elementary students' nature of science view/conception/understanding/belief (e.g., Ozkal et al., 2010; Hacieminoglu et al., 2015; Walls, 2012) or research on both students' and teachers' nature of science understanding (Lederman & Lederman, 2004, 2005). Therefore, this observation begs the questions "Why does research on nature of science in elementary science education literature focus more on pre-service teachers?" and "Does grade level affect researchers' target populations and sampled groups in the literature on nature of science?"

At the textual level, in the investigated text, the aspects of nature of science were presented in different positions by this discourse. By consistently using the nominalization "target NOS aspects," the text suggested that some of the aspects of nature of science were accessible and targeted by science instruction and others were not. This discursive choice gave these "target NOS aspects" more value and importance than others. This nominalization was popular in the literature as well. In science education literature, the nominalization 'target NOS aspects' was commonly used by F. Abd-El-Khalick (e.g., Dogan & Abd-El-Khalick, 2008; Khishfe & Abd-El-Khalick, 2002; Abd-El-Khalick et al., 2008). However, in elementary science education literature, especially in F. Abd-El-Khalick and V.L. Akerson's collaborative works, it was used as 'views of target NOS aspects' (e.g., Akerson & Abd-El-Khalick 2003; Abd-El-Khalick & Akerson, 2009). The popularity of this nominalization was well established in the field. In the literature, many researchers used it as 'views of target NOS aspects' (e.g., Khishfe, 2008, 2012; Yacoubian & BouJaoude, 2010). Even when they do not use this nominalization in general, some researchers refer to

teachers' or students' view frequently in the text while using the nominalization understanding/conception of the target nature of science aspects (Cofre et al., 2019; Kaya et al., 2019; Zion et al., 2020). Therefore, the characteristic emphasis on the "views" in discursive choices of nature of science epistemic community of elementary science education literature was naturally observed in derivative nominalizations like "views of target NOS aspects."

Similarly, at the text level, the nominalization 'adequate views of NOS' was frequently observed in the text. It was the second item, after 'view,' with the highest occurrence and cluster effect in the VOSviewer co-occurrence map generated with a threshold. By emphasizing adequacy, in the analyzed text, the findings were presented in a binary way; adequate-inadequate. This observation raises the question, "Who has the ultimate authority to decide "what is adequate" in terms of nature of science conception/understanding/view?". In the literature, only a few years after the publication of the analyzed text Lederman et al. (2002) also stated similar concerns, criticizing the Test of Understanding Science (TOUS) (Klopfer & Cooley, 1961) and the approaches, labeling participants' views as adequate or inadequate and assigning them a numerical value. They also argued that standardized tests fall short to help us understand participants' NOS views. Therefore, to address this problem, Lederman et al. (2002) developed the Views of Nature of Science Questionnaire (VNOS). However, the binary (adequate-inadequate) representation of the nature of science conception/understanding/view/ stays strong in the literature. Also, instead of standardized forced-choice instruments, open-ended instruments like VNOS (Lederman et al. 2002) are gaining popularity. Therefore, the same question, "Who has the ultimate authority to decide "what is adequate" in terms of nature of science conception/understanding/view?" gains more importance.

From a much more general perspective, the findings of this research showed that there are various epistemic communities in education literature, and only a few of them are located in science and elementary science education literature by this research. Similar to research fields, these communities have complex and embedded relationships. For example, the elementary science education field can be considered embedded in the science education field. However, both fields are also significantly connected to the

teacher education field and many other fields. Therefore, it would be best to look at these communities located in these contexts as constructs without clear borders. Like discourses, these communities can split, meld together, change or dissolve and replace one another; therefore, a complete account of these communities cannot be reached. Based on the close connection between discourse and epistemic communities, if we apply Gee's (2004) perspective on discourse to epistemic communities, striving to understand "how and why an epistemic community works the way it does" carries more importance than simply describing it. For this reason, this research's primary focus was on the power differences created by the discursive choices of epistemic communities in science and elementary science contexts. Also, this research showed that individual researchers or groups of researchers could be a member of more than one epistemic community. The discursive choices of the researchers or group of researchers are influenced by the discourses promoted by the epistemic communities and at the same time, these researchers and groups of researchers have some influence over the promoted discourse through their own discursive choices. The findings also show that there are many ways to create power differences with discursive choices. The power differences are not limited to roles, like teachers or students, in the discourse certain goals or terminologies can be brought into positions of power by discursive choices. Finally, the investigation of the epistemic communities' discursive choices and the way these choices create power differences raise many questions which are somehow being overlooked due to our common-sense assumptions or non-critical perspective. Answering these questions could provide valuable information to the field and be a significant endeavor for future researchers. Therefore, this research aims to point out by being an example that critical paradigm can be utilized for emancipatory goals that are not particularly related to the struggles of the oppressed but more subtle power structures that are not easily recognized by researchers. Also, critical perspective and research can be used to raise awareness and ask questions about the current status quo by simply revealing what is obvious but overlooked. Critical analysis of the prior research and works of different research communities could help us validate that we accomplished what we claimed in any field. Validity within the field could also be assured with this critical perspective.

As for the contribution of this research to the literature, the research's exploratory nature allowed it to detect various gaps in the literature. First of all, the findings of this research showed that epistemic communities are naturally formed within the education field and have a substantial influence. Therefore, educational researchers should pay more attention to epistemic communities, especially in science education. This research was able to locate only three of the epistemic communities in the literature. However, there were indications of some other epistemic communities which could not be located within the scope of this research with confidence. Considering the impact these communities have in the field, the ways these communities form and function could be a topic of interest for future research. Also, the findings of this research showed that the role of discourse in science education is not limited to curriculum, policy papers, course materials, or classroom talk. Discourses promoted by epistemic communities have a significant role in science education. Therefore, education literature could benefit from additional research on epistemic communities, other social groups, and institutions' discursive choices.

The critiques of CDA research repeatedly warn us about the pitfalls of this approach. The increasing popularity and importance of CDA research cannot be overlooked in education. However, handling CDA research requires extensive knowledge of discourse analysis and critical research. Unfortunately, not many researchers in the field of education have the means to gain this extensive knowledge. On the other hand, the methodological flexibility of CDA research enables researchers to implement different methods in their research design. Therefore, using additional tools to triangulate and challenge the interpreted data could be beneficial for inexperienced researchers. In this research, the VOSviewer data mapping program was used as an unbiased reference point to challenge the interpretations, and its contribution to the clarity and quality of the CDA was significant. VOSviewer program was also used for the sampling procedure and enabled this research to locate the epistemic communities and purposefully sample the representative articles from over 40 thousand articles and 1.2 million citations. Since some thresholds (minimum 25 co-citations) were used to both locate the most influential texts in the literature and keep the extent of the research manageable for one researcher, only a few epistemic communities were located within

the scope of this research. However, if these thresholds were changed and more extensive data sets were analyzed, more epistemic communities can be located in science and elementary science education literature. Besides VOSviewer, numerous bibliographic and text analysis programs are rapidly becoming available for researchers. Even though currently there are some language and format restrictions, these programs have proven useful.

Researchers in science education find themselves in a role that connects natural sciences and social sciences. It is a unique role because both fields could benefit from each other, no matter how dissimilar they appear. This research showed that even though the epistemic communities framework developed in international relations literature, it can easily be used by educational researchers. Also, epistemic communities have an essential role in educational research. Discourse plays a tremendous role in this respect. As the finding of this research suggests, discursive choices of epistemic communities have a substantial influence in science and elementary science education and should be paid attention to. This conclusion can easily be generalized to all fields of education. This research calls for attention to the fact that, as researchers, the knowledge that we produce and how we produce and present it through our discursive choices affect the future of any field. No matter how insignificant they appear, our discursive choices will have some consequences and impact the works of the next generation of researchers. Whether it is the established terminology or norms of communication, as researchers, we all have been enculturated by conforming to the discursive choices of the previously established epistemic communities to gain membership. As new terminologies and norms of communications are created by our generation, the next generation of researchers will go through the same process to gain membership in the discourses created by us. Even when they criticize us or explore their unique paths, first, the next generation of researchers must overcome the power hierarchies created by our discursive choices. This research showed that epistemic communities' discursive choices could act as gatekeepers. Therefore, researchers should not take this responsibility lightly and pay attention to the consequences of their discursive choices.

Alternatively, the discursive choices could also become keys to gaining membership in epistemic communities. By conforming to the discursive choices and adopting the terminologies and norms of communications promoted by epistemic communities, new researchers could find opportunities to take place and be recognized in the literature and even influence the discursive choices of these communities. However, the intentions and awareness behind such acts should be clear and quality oriented to assure real progress in the field. Being too conformist in our discursive choices carry the risk of repetition in the field, and being too radical could also carries some risks, such as being easily dismissed by the field and missing the opportunities to benefit from the accumulated knowledge. In my humble opinion, emphasizing research utilizing critical perspectives in any field could be helpful for both novice researchers and experts in the field to reflect on the effect and extent of their discursive choices and the reasons behind them.

In his book ‘Stuff of Thought,’ Steven Pinker (2008), one of the prominent languages and cognitive science researchers’ gives an example of how the choice of one word, ‘event,’ in an insurance document and the different interpretations of its meaning could worth three and a half-billion dollars. This mentioned document says in case of a destructive event, the insurance company will pay three and a half-billion dollars to the owner of the World Trade Center. Yet, the insurance company and the lawyers have different opinions on whether to consider what happened in 9/11, two hijacked airplanes crashing into the towers of the World Trade Center, as a single event or two separate events. This example shows that even with the choice of using a certain word, the meaning that we intend to convey can be interpreted differently, which could have a consequence that cannot be predicted in advance. Our discursive choices as science education researchers do not appear to have any monetary value at first glance, but even that is debatable. However, one view that we could all agree on is that our discursive choices matter. Therefore, these choices need to be made consciously. Their effect should be investigated and criticized constantly by all the stakeholders in our field to ensure the quality of the knowledge produced by our efforts. In the end, if we do not pay attention to our discursive choices, we may easily lose our way in power struggles.

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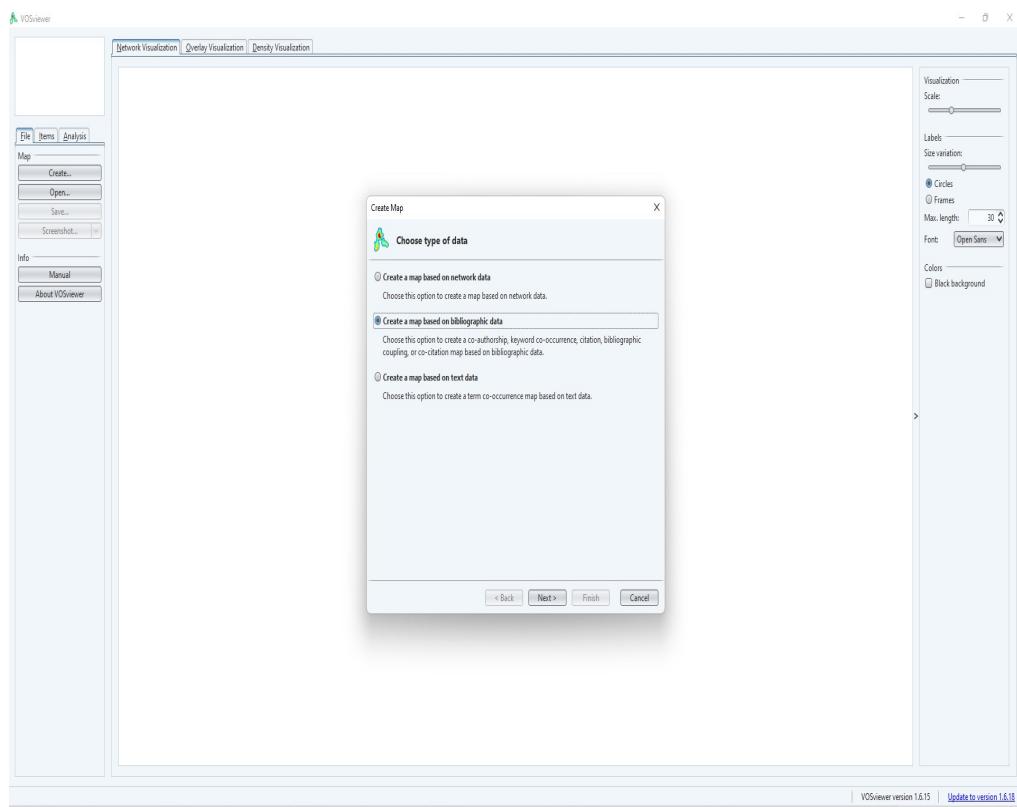
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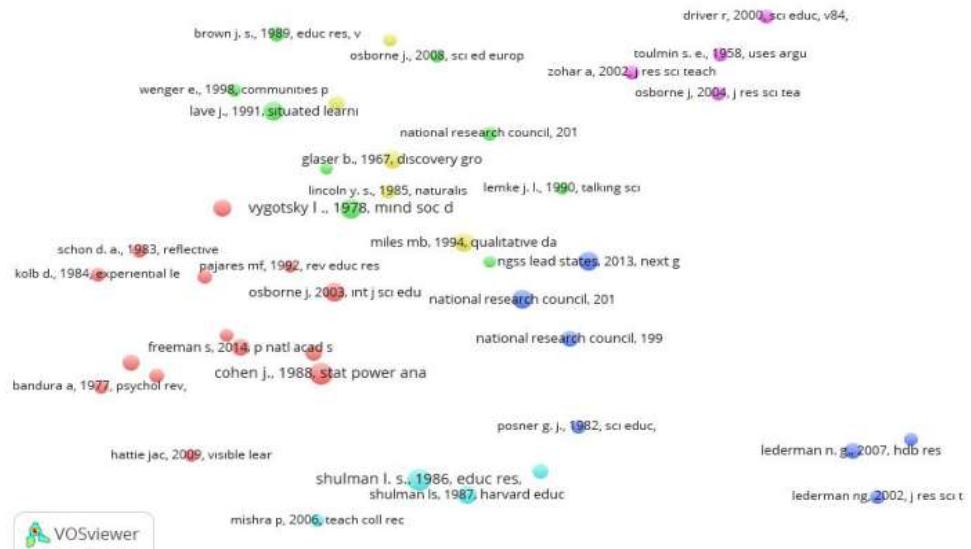
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## APPENDICES

### A. VOSviewer CO-CITATION MAPS



Map 1.



Citation Frequencies of Map 1

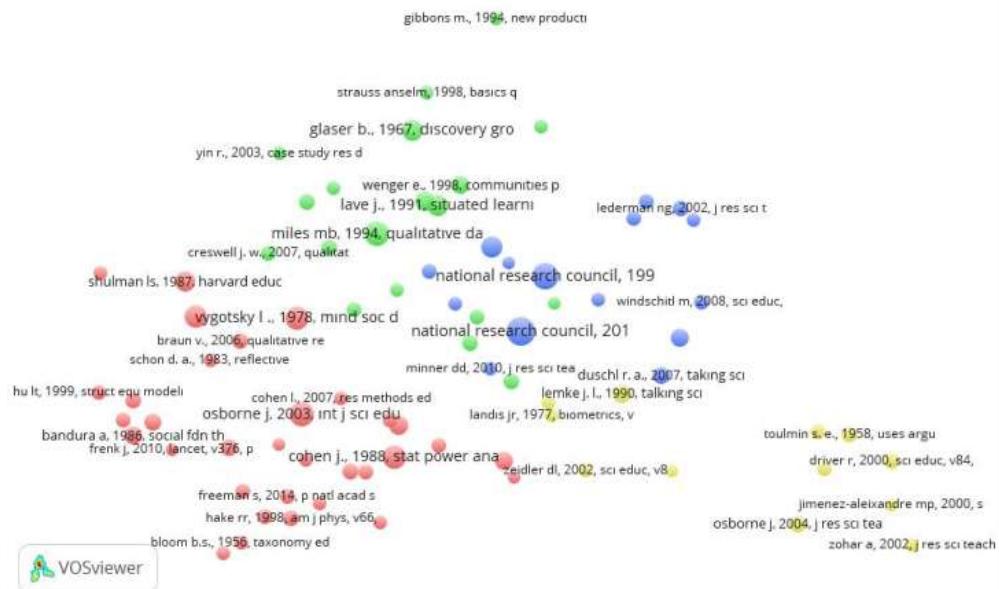
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<input checked="" type="checkbox"/>	lave j., 1991, situated learning le	58	105
<input checked="" type="checkbox"/>	miles mb, 1994, qualitative data ana	57	101
<input checked="" type="checkbox"/>	toulmin s. e., 1958, uses argument	30	99
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<input checked="" type="checkbox"/>	driver r., 2000, sci educ, v84, p287, doi 10.1002/(sici)...	33	85

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Map 2.



Citation Frequencies of Map 2

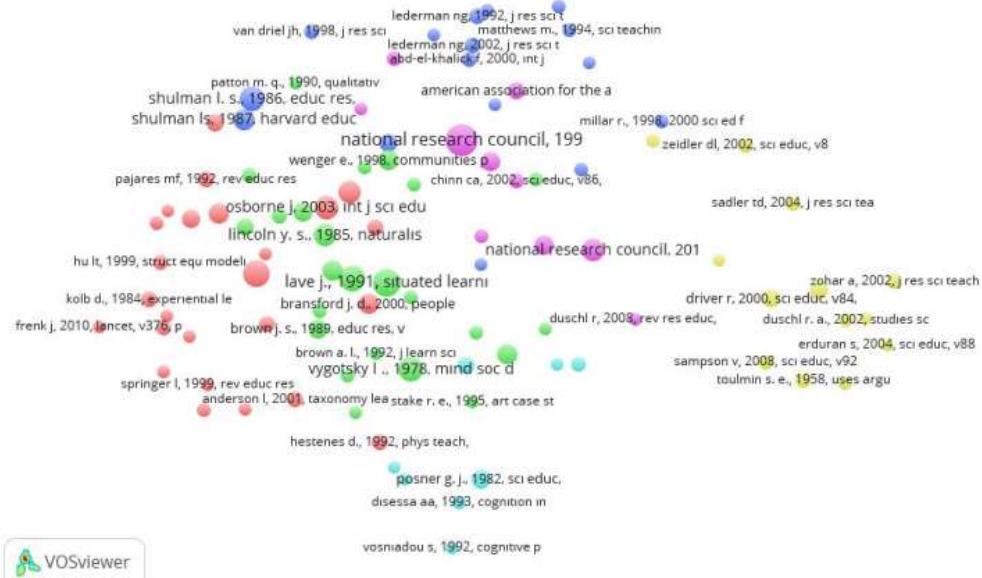
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Map 3.



Citation Frequencies of Map 3

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Map 4.



Citation Frequencies of Map 4

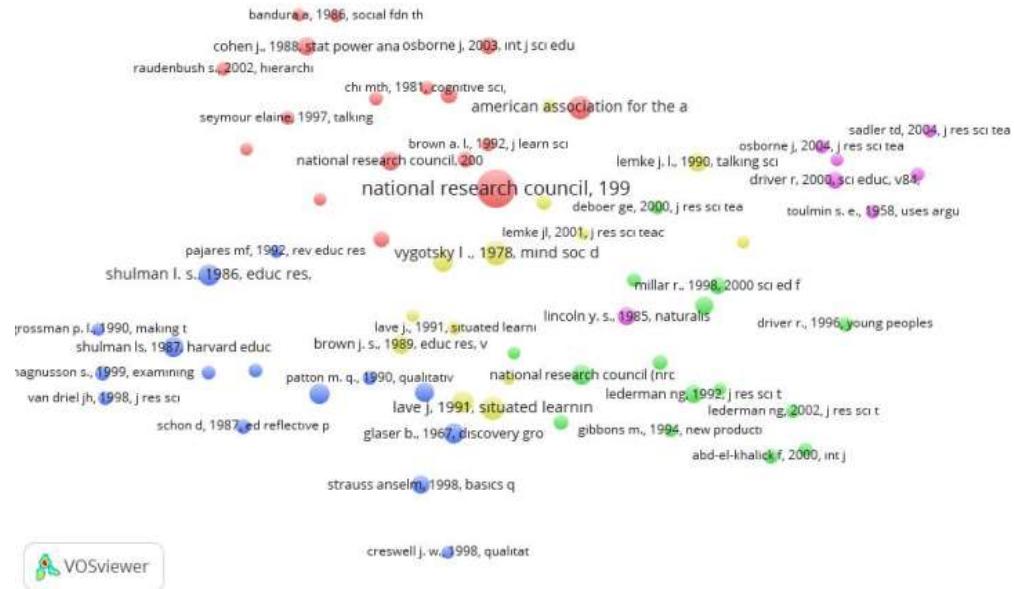
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<input checked="" type="checkbox"/>	national research council (nrc), 1996, nat sci ed sta...	80	272
<input checked="" type="checkbox"/>	driver r., 1996, young peoples images	46	266
<input checked="" type="checkbox"/>	posner g.j., 1982, sci educ, v66, p211, doi 10.1002...	78	259
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Map 5.



Citation Frequencies of Map 5

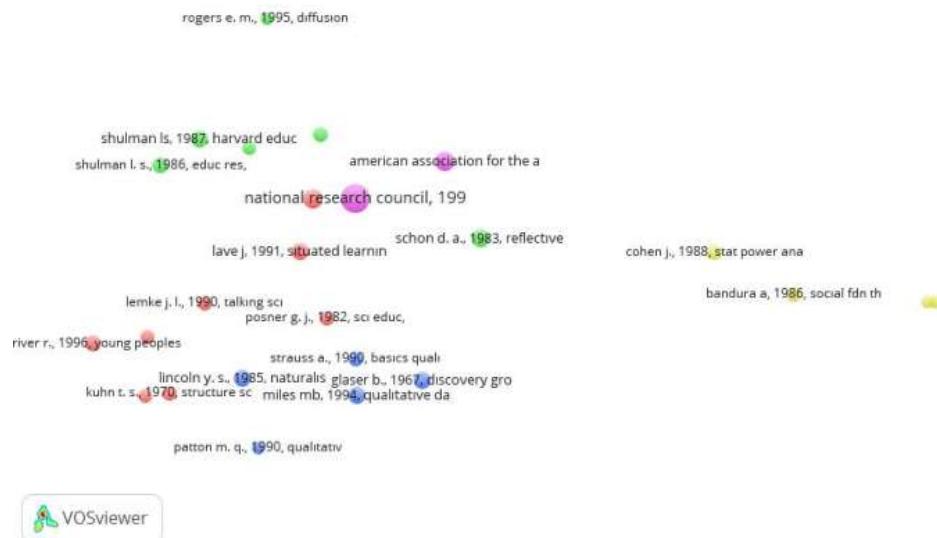
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<input checked="" type="checkbox"/>	wenger e, 1998, communities practice	69	181
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Map 6.



Citation Frequencies of Map 6

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Map 7.



Citation Frequencies of Map 7

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<input checked="" type="checkbox"/>	kuhn t. s., 1970, structure sci revolu	53	98
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<input checked="" type="checkbox"/>	glaser b., 1967, discovery grounded t	58	89
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<input checked="" type="checkbox"/>	schon d, 1987, ed reflective practi	54	80
<input checked="" type="checkbox"/>	...	--	--

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Map 8.

schon d. a., 1983, reflective kuhn t. s., 1970, structure sci revolu  
eylon bs, 1988, rev educ res, 1981, what res says sci te, v3  
harms n. c., 1981, what res



Citation Frequencies of Map 8

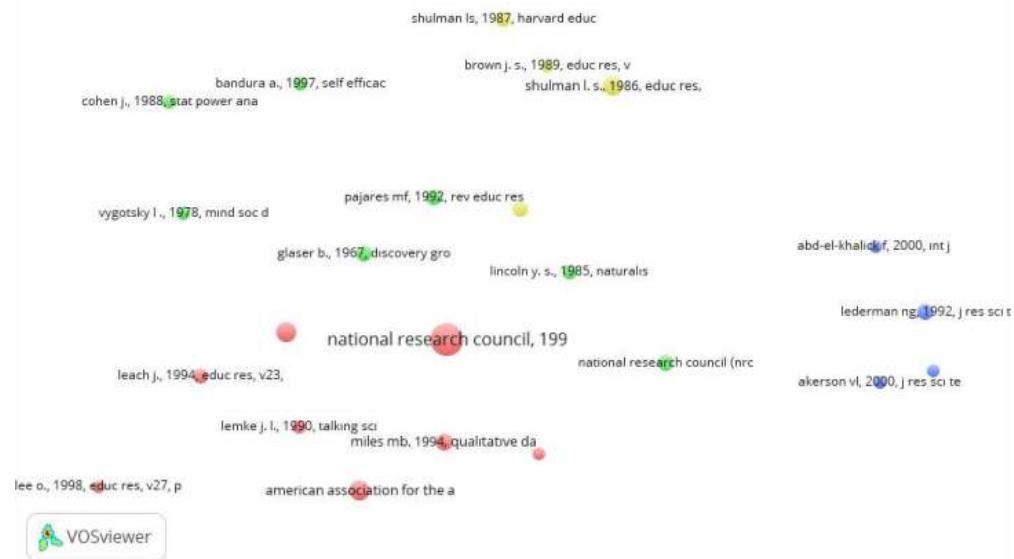
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<input checked="" type="checkbox"/>	kuhn t, 1962, structure sci revolu	27	6
<input checked="" type="checkbox"/>	harms n. c., 1981, what res says sci te, v3	27	1

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Map 9. Elementary Science Education Articles



Citation Frequencies of Elementary Science Education Articles

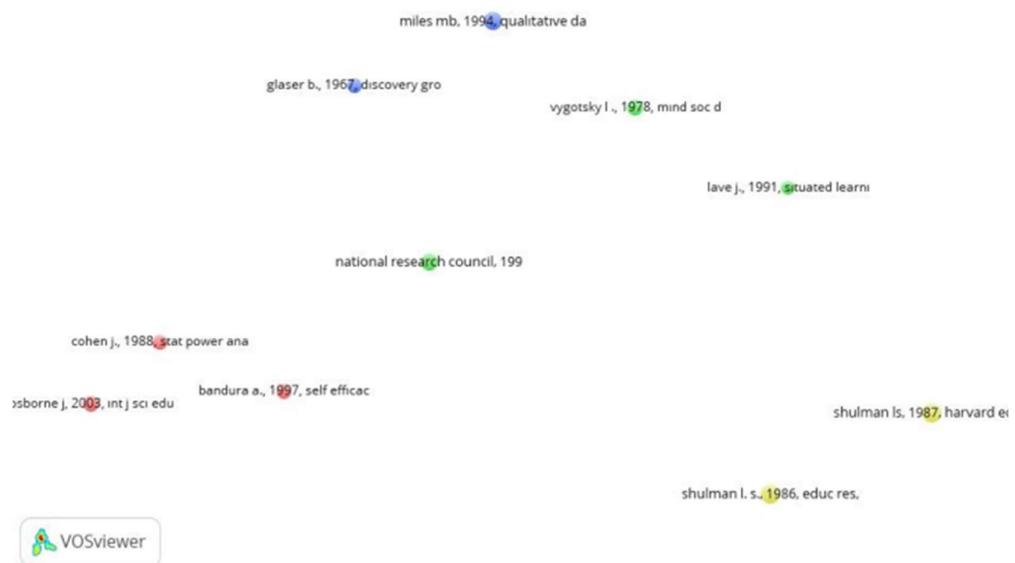
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<input checked="" type="checkbox"/>	abd-el-khalick f, 2000, int j sci educ, v22, p665, doi...	28	102
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<input checked="" type="checkbox"/>	lincoln y. s., 1985, naturalistic inquiry	37	90
<input checked="" type="checkbox"/>	posner g. j., 1982, sci educ, v66, p211, doi 10.1002...	43	90
<input checked="" type="checkbox"/>	glaser b., 1967, discovery grounded t	40	85

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Map 10. Primary Science Education Articles



Citation Frequencies of Primary Science Education Articles

**Create Map**

**Verify selected cited references**

Selected	Cited reference	Citations	Total link strength
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<input checked="" type="checkbox"/>	bandura a, 1997, self efficacy exerci	30	12
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<input checked="" type="checkbox"/>	cohen j., 1988, stat power anal beha	29	11
<input checked="" type="checkbox"/>	lave j., 1991, situated learning le	26	9

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Map 11. Early Science Education Articles



Citation Frequencies of Early Science Education Articles

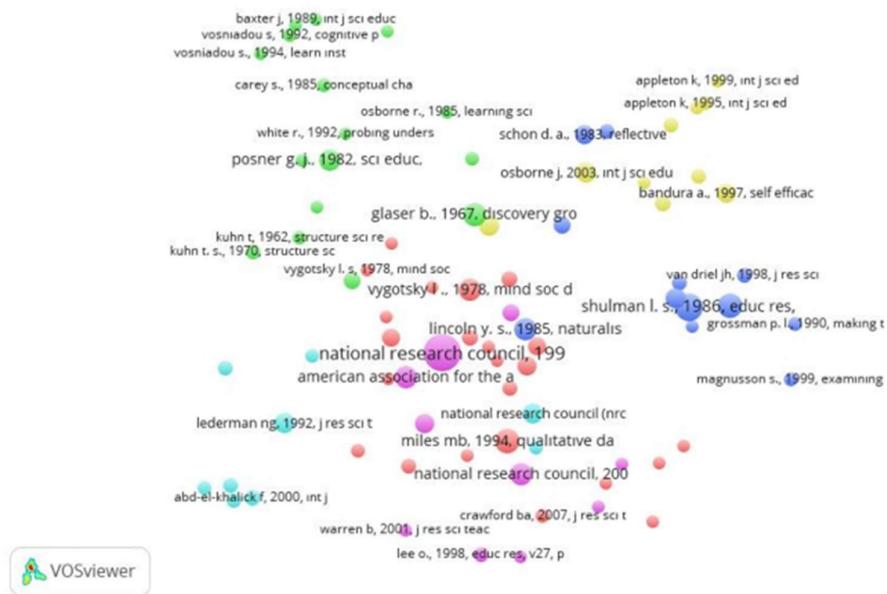
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Verify selected cited references

Selected	Cited reference	Citations	Total link strength
<input checked="" type="checkbox"/>	national research council, 1996, nat sci ed stand	40	11
<input checked="" type="checkbox"/>	vygotsky l., 1978, mind soc dev higher	28	6
<input checked="" type="checkbox"/>	shulman l. s., 1986, educ res, v15, p4, doi 10.3102/0...	25	4
<input checked="" type="checkbox"/>	glaser b., 1967, discovery grounded t	26	3

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Map 12. Elementary/Primary/Early Science Education Articles



Citation Frequencies of Elementary/Primary/Early Science Education Articles

Create Map

Verify selected cited references

Selected	Cited reference	Citations	Total link strength
<input checked="" type="checkbox"/>	national research council, 1996, nat sci ed stand	217	891
<input checked="" type="checkbox"/>	national research council, 2000, inq nat sci ed stand	79	422
<input checked="" type="checkbox"/>	shulman l. s., 1986, educ res, v15, p4, doi 10.3102/...	121	411
<input checked="" type="checkbox"/>	american association for the advancement of scie...	80	333
<input checked="" type="checkbox"/>	shulman ls, 1987, harvard educ rev, v57, p1	96	332
<input checked="" type="checkbox"/>	miles mb, 1994, qualitative data ana	99	294
<input checked="" type="checkbox"/>	lederman ng, 1992, j res sci teach, v29, p331, doi 1...	63	291
<input checked="" type="checkbox"/>	lincoln y. s., 1985, naturalistic inquiry	77	276
<input checked="" type="checkbox"/>	pajares mf, 1992, rev educ res, v62, p307, doi 10.31...	64	259
<input checked="" type="checkbox"/>	posner g. j., 1982, sci educ, v66, p211, doi 10.1002/...	71	253
<input checked="" type="checkbox"/>	lemke j. l., 1990, talking sci language	60	228
<input checked="" type="checkbox"/>	glaser b., 1967, discovery grounded t	85	225
<input checked="" type="checkbox"/>	abd-el-khalick f, 2000, int j sci educ, v22, p665, doi...	41	216
<input checked="" type="checkbox"/>	brown j. s., 1989, educ res, v18, p32, doi 10.3102/0...	54	208

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## B. VOSviewer CO-OCCURRENCE MAPS

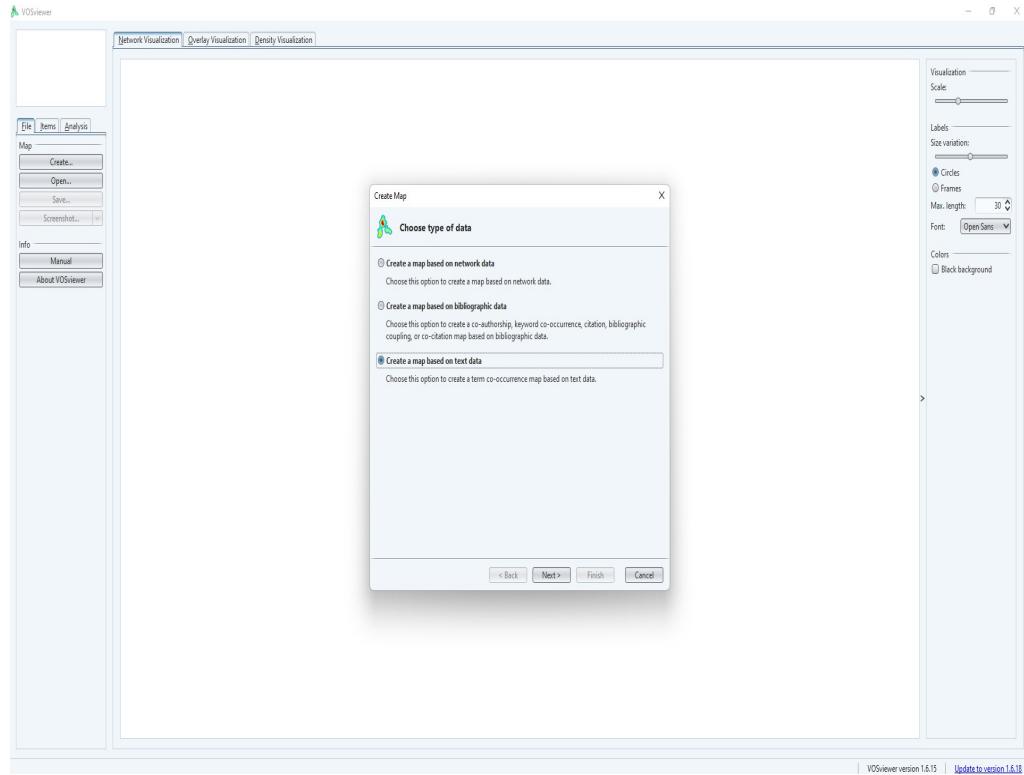


Figure 4.1 Co-occurrence Map of the Science Education Articles Based on Text Data

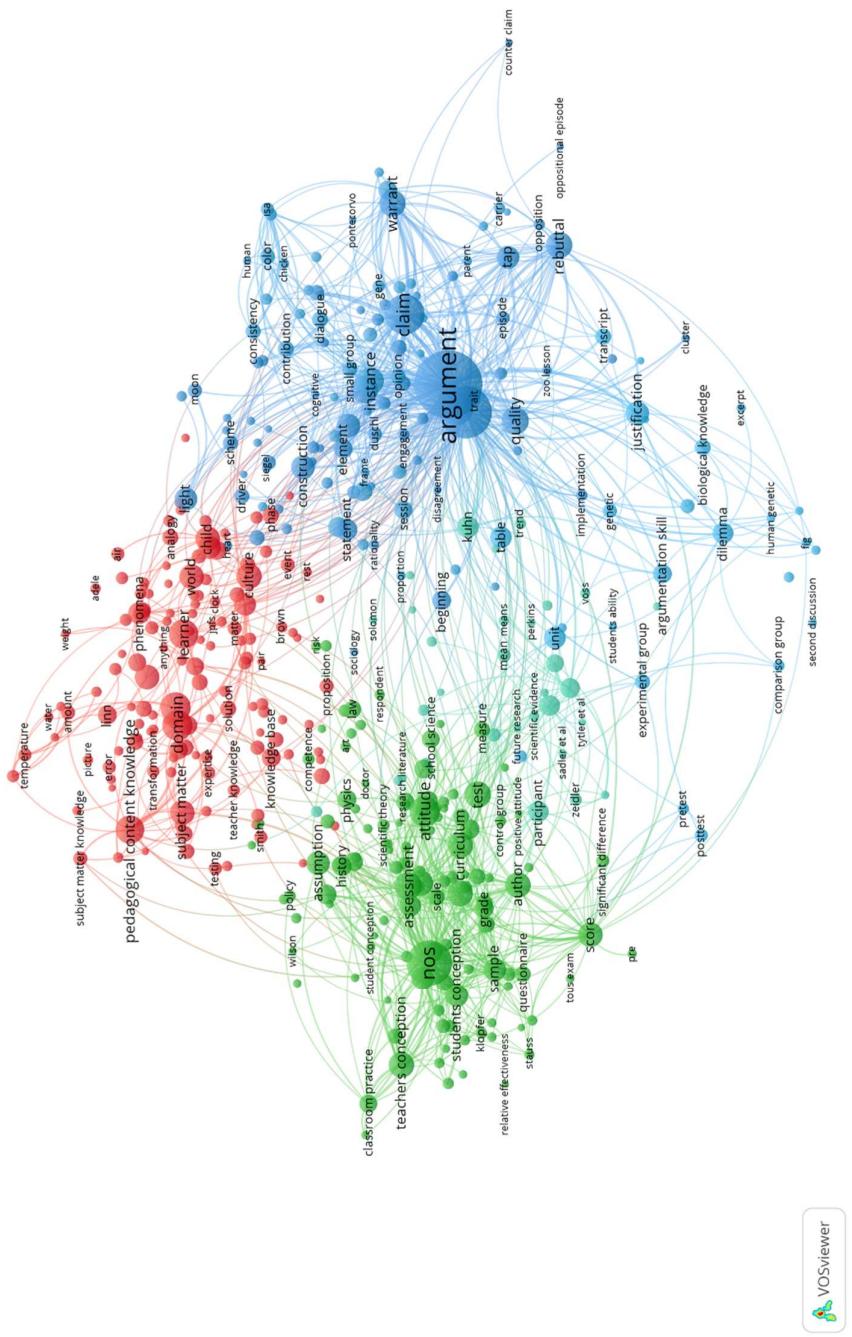


Figure 4.2 Co-occurrence Map of the Elementary Science Education Articles Based on Text Data

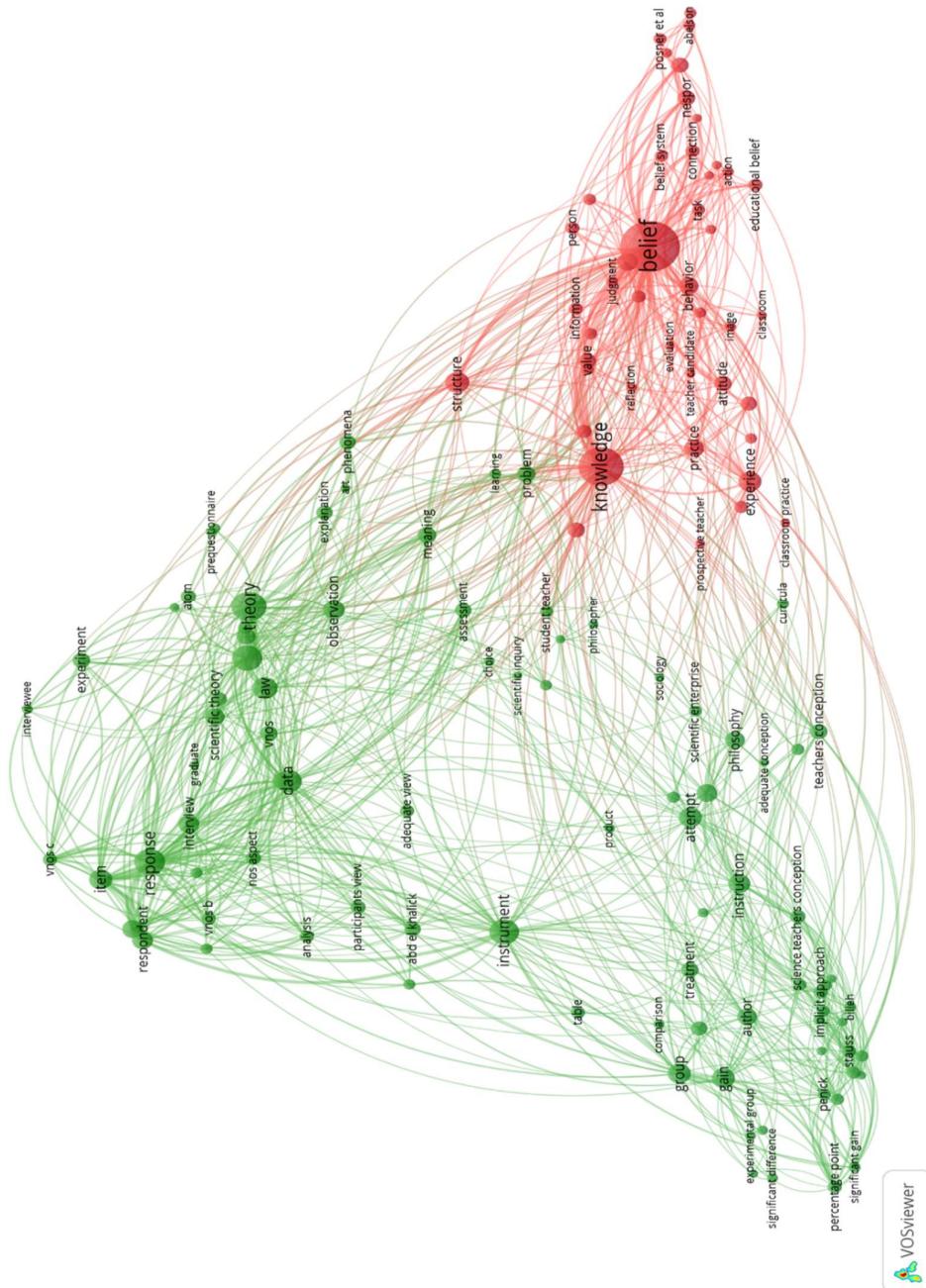


Figure 4.3 Co-occurrence Map of the Located NOS Articles in Science Education Literature

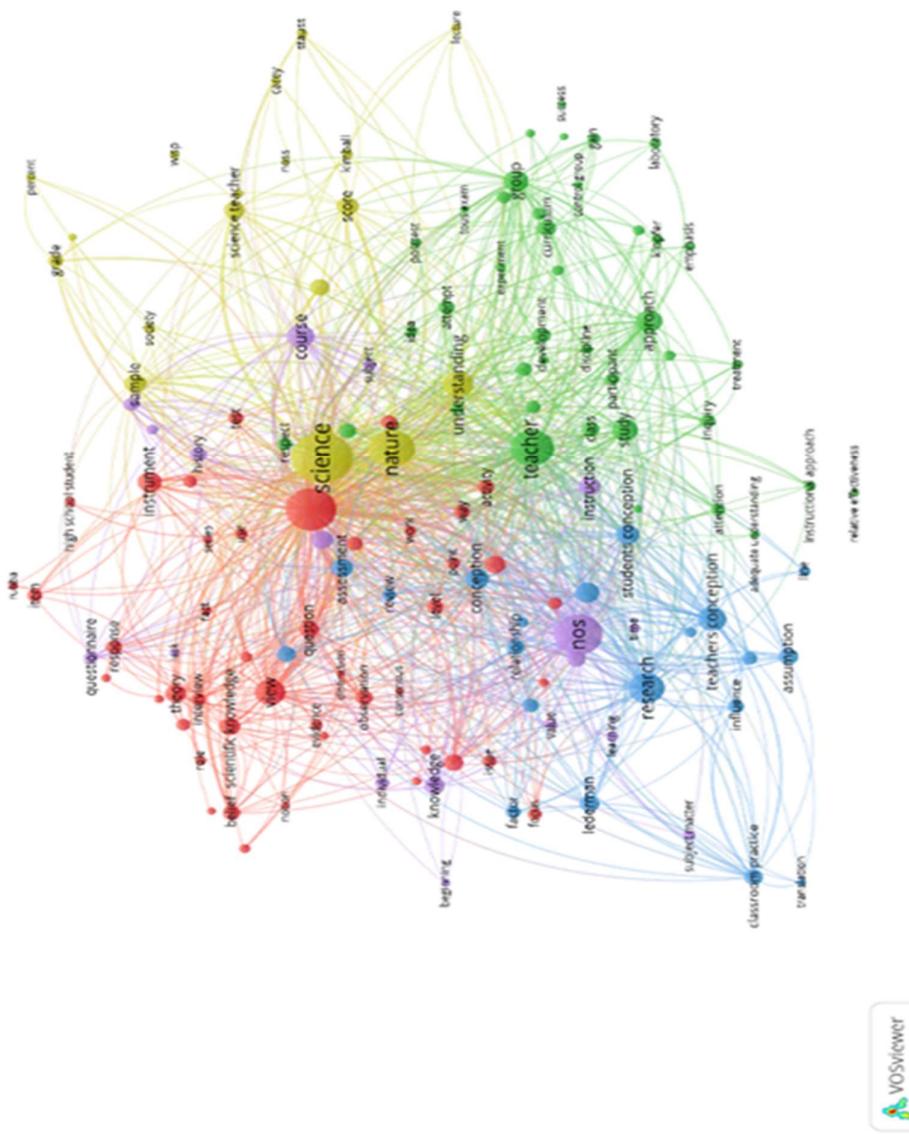


Figure 4.4 Co-occurrence Map of the Located NOS Articles in Elementary Science Education Literature

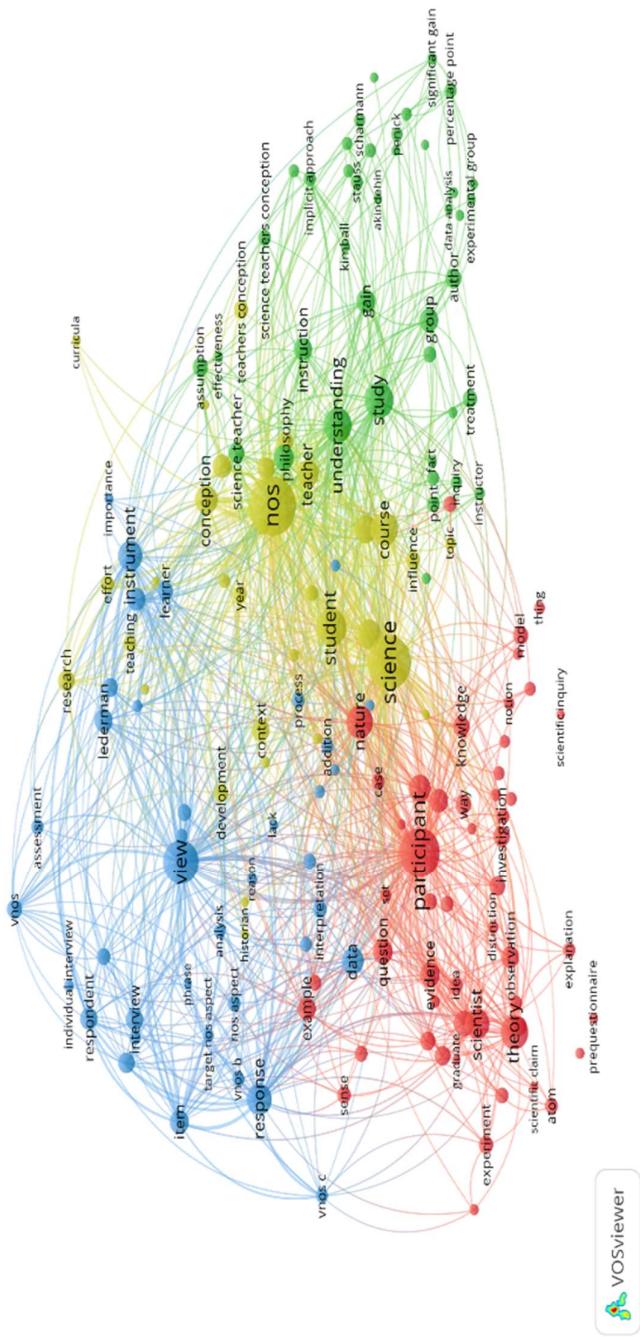


Figure 4.5 Co-occurrence Map of the 21 Located Articles Based on Text Data

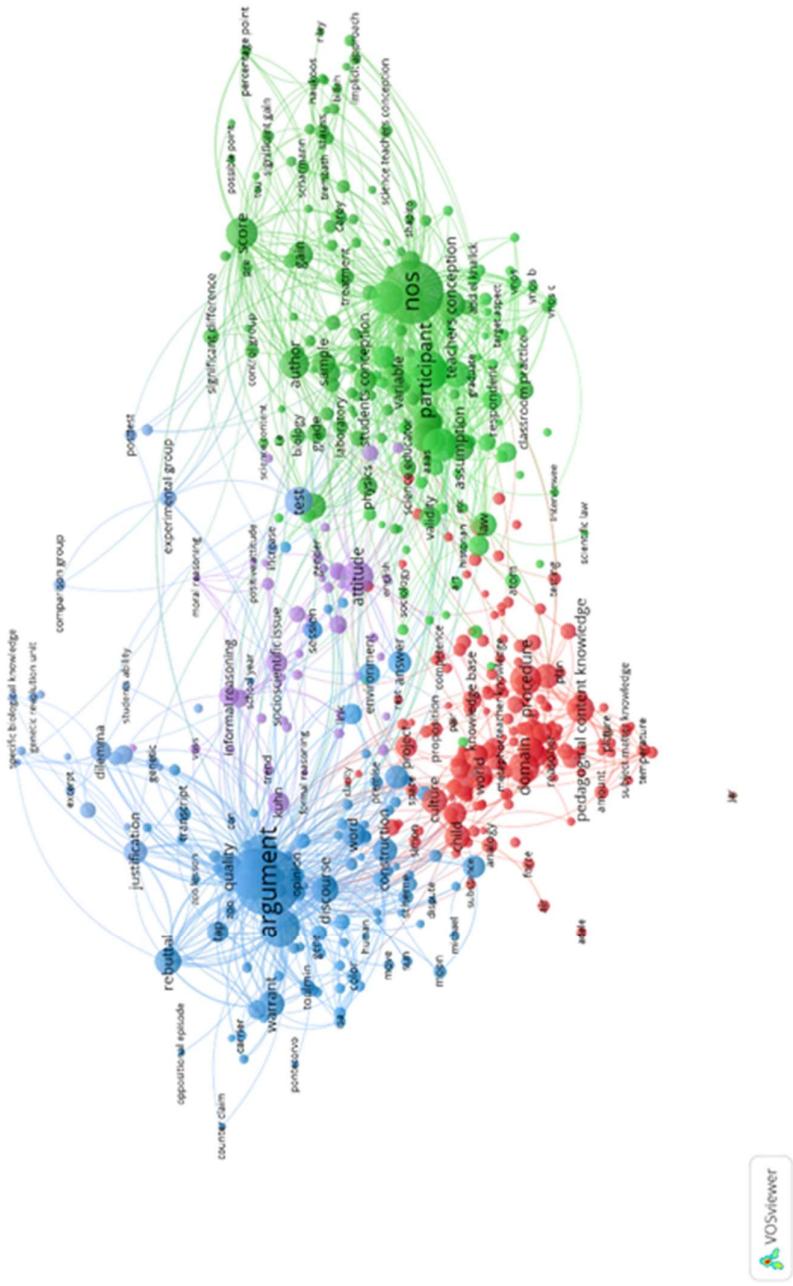


Figure 5.1 Co-occurrence Map of the Items in the Sampled Article for Nature of Science Epistemic Community in Science Education Based on Text Data without Threshold.

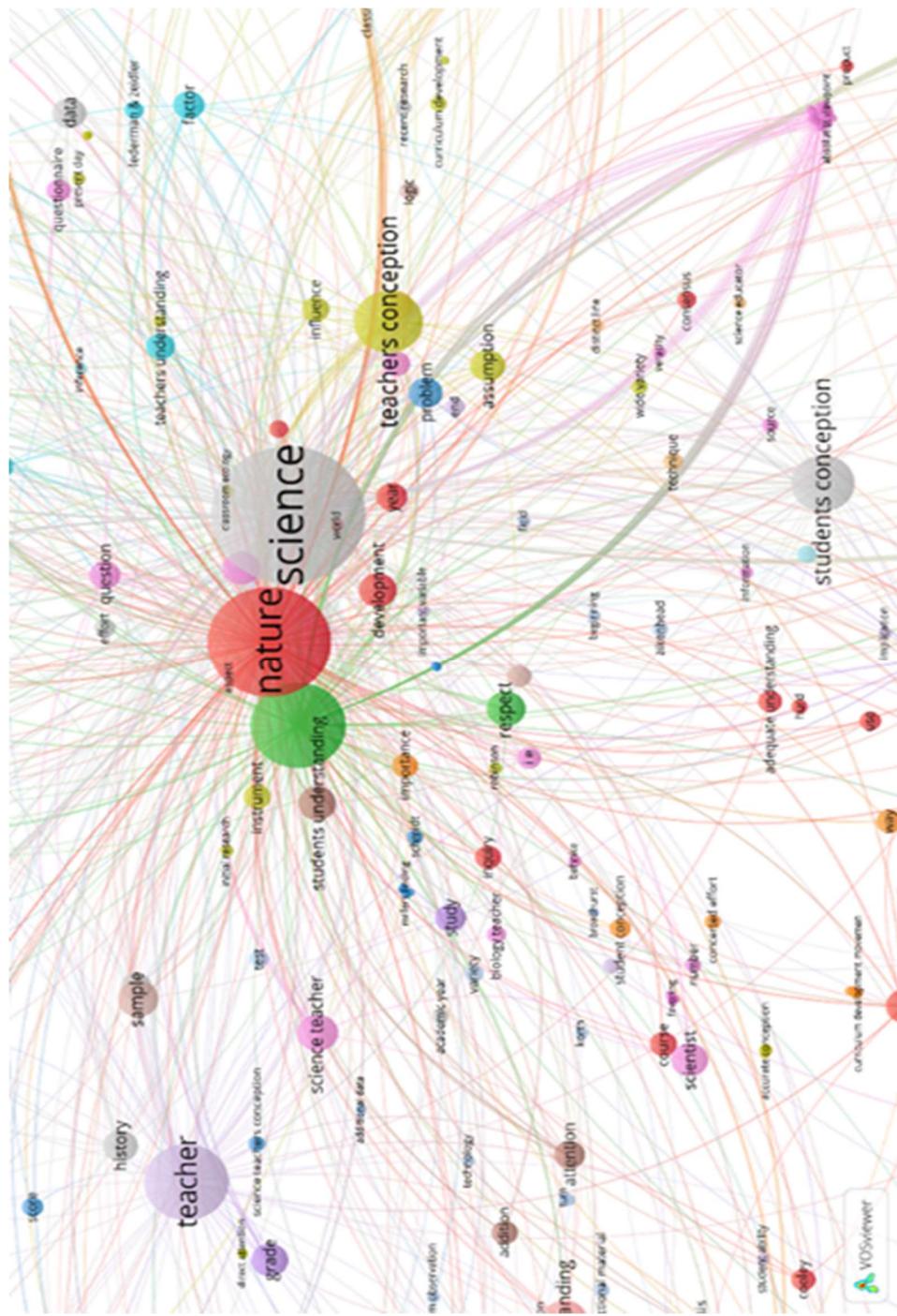


Figure 5.2 Co-occurrence Map of the Items in the Sampled Article for Nature of Science Epistemic Community in Science Education Based on Text Data with Threshold.

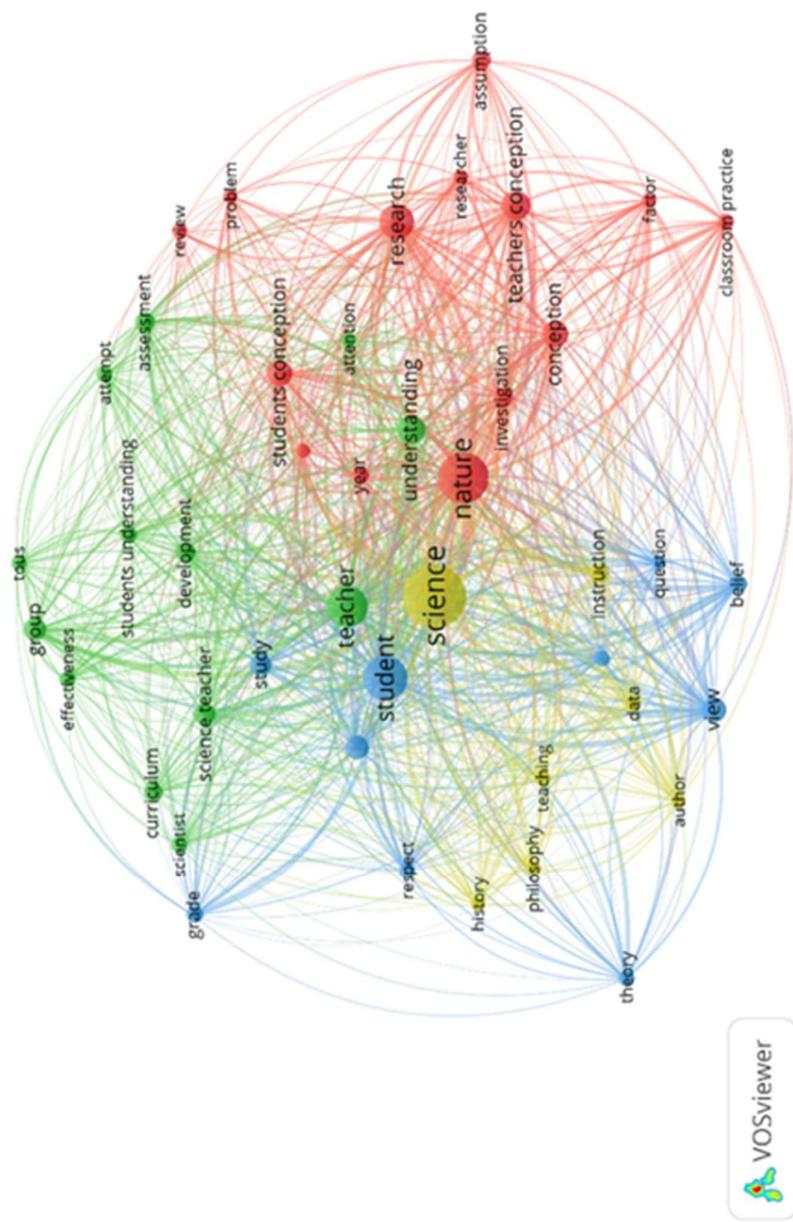


Figure 6.1 Co-occurrence Map of the Items in the Sampled Article for Nature of Science Epistemic Community in Elementary Science Education Based on Text Data without Threshold.

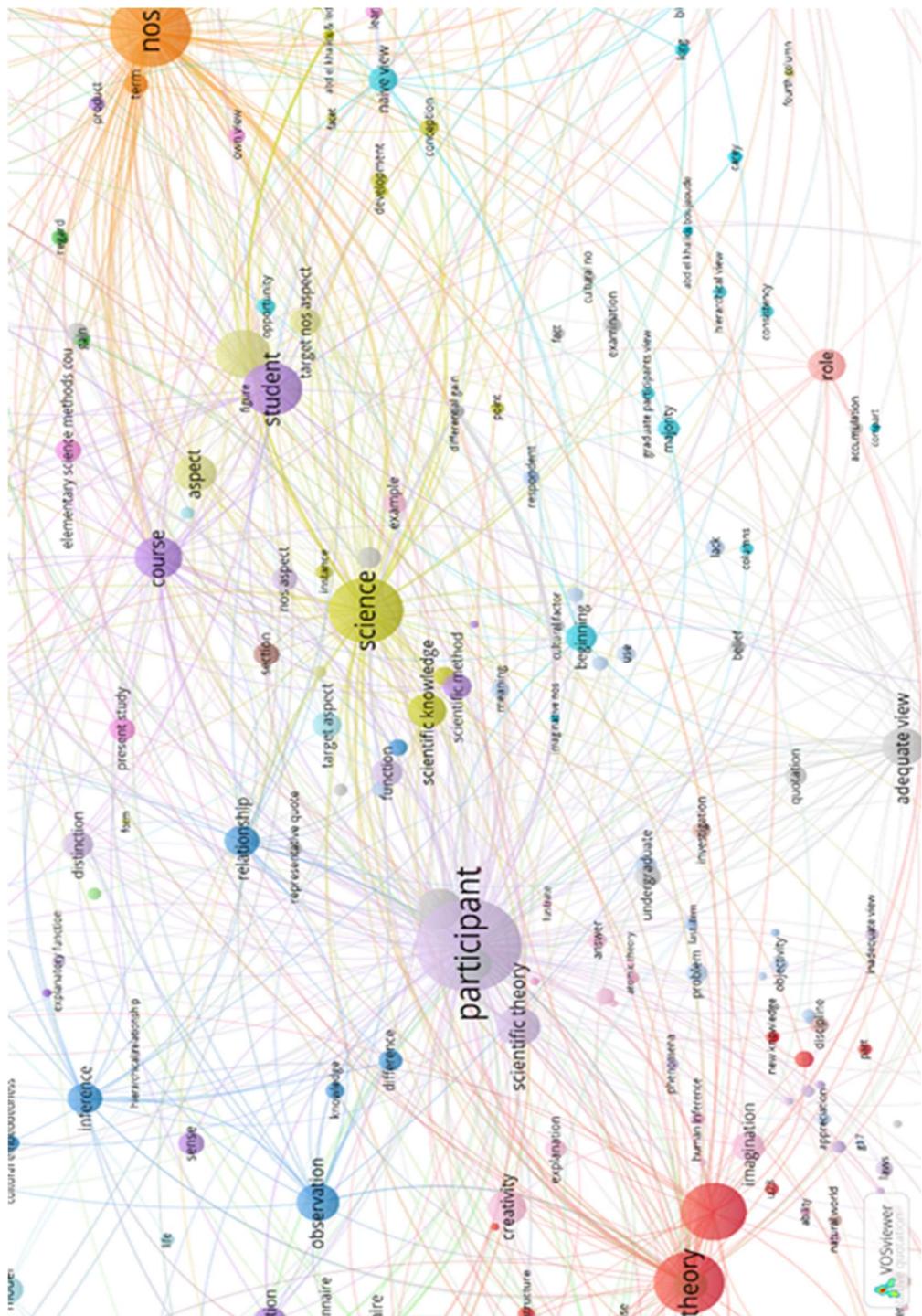
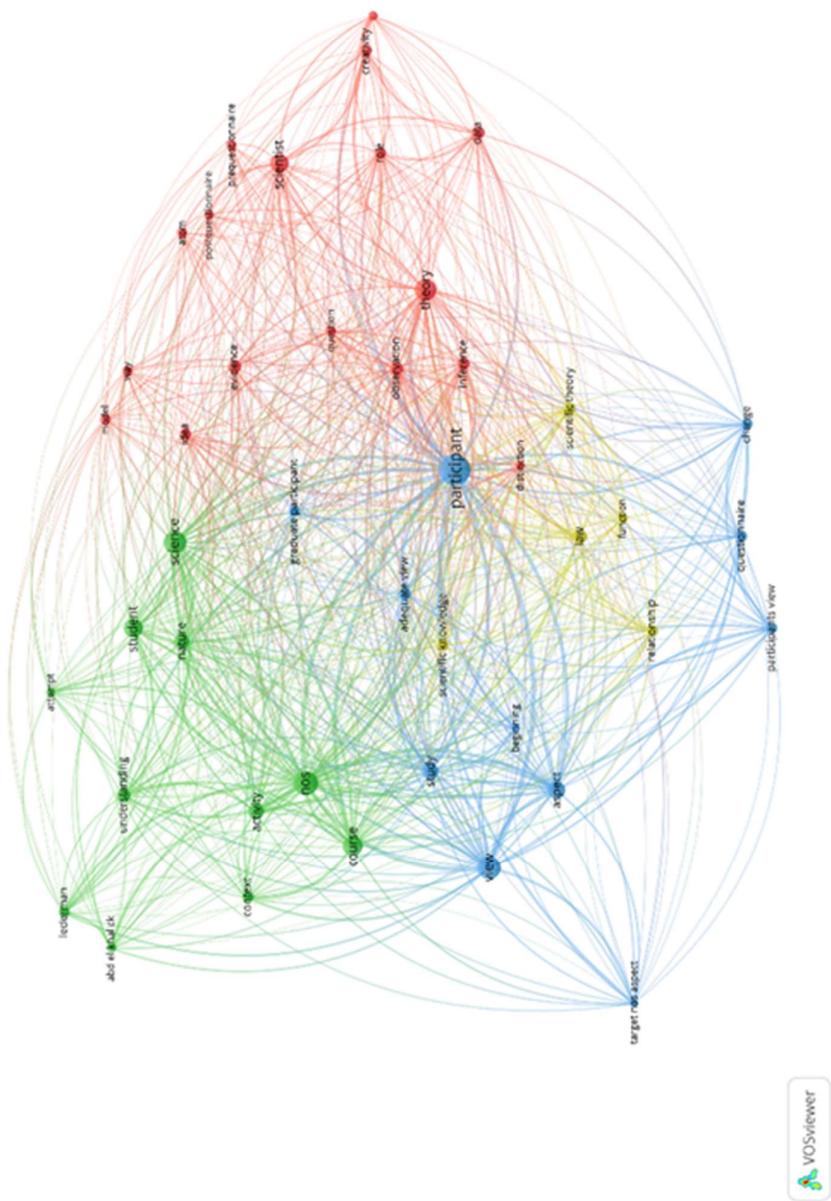


Figure 6.2 Co-occurrence Map of the Items in the Sampled Article for Nature of Science Epistemic Community in Elementary Science Education Based on Text Data with Threshold.



## **C. CURRICULUM VITAE**

### **Areas of Research Interest**

Discourse in Science and Elementary Science Education  
K-4 Teacher Education  
Cooperative Learning  
Critical Discourse Analysis  
Alternative Research Methodologies

### **Educational Background**

PhD.	2022	Elementary Education
		Middle East Technical University
MA.	2004	Elementary Education
		University of Colorado Boulder
B.S.	2000	Chemistry Education
		Dokuz Eylul University

### **Employment Background**

Kütahya Dumlupınar University    2010- Continued  
Research and Teaching Assistant  
Assist. Erasmus Coordinator  
Elementary Education Department Foreign Students Coordinator  
Member of Quality Standards Committee

## **Peer-Reviewed Conferences**

Akillioglu, F. C. & Avci, C. (2022, September). *Early Childhood Pre-service Teachers' Conceptions of Children's Play*. European Conference on Educational Research, (ECER PLUS Online 2022)

Akillioglu, F. C., Avci, C. &; Kılıç, M. (2021, September). *Comparing teacher Educators'; and pre-service teachers'; evaluations of inquiry activities*. EECERA Annual Conference, Online Festival.

Akillioglu, F. C. & Avci, C. (2018, May). *Effects of perceived feedback on early childhood pre-service teachers' lesson planning*. V. International Eurasian Educational Research Congress, (EJER 2018) Antalya, Turkey.

Akillioglu, F. C. (2017, August). *Multimodal Critical Discourse Analysis of Pre-Service Science Teachers' Visual Representations of Nature of Science*. Criticality in Education (Research): Definitions, Discourses, and Controversies. Helsinki, Finland

Akillioglu, F. C. & Avci, C. (2017, May). *Okul öncesi öğretmen adaylarının matematik öğretim süreçlerinin örnek olay yöntemi ile incelenmesi*. IVth International Eurasian Educational Research Congress, (EJER 2017) Denizli, Türkiye.

Kose M. & Akillioglu F. C. (2017, May). *Pre-service science teachers' concerns about their future careers*. IVth International Eurasian Educational Research Congress, (EJER 2017) Denizli, Türkiye

Avci, C. & Akillioglu, F. C. (2016, September). *Okul öncesi öğretmen adaylarının video analize dayalı bireysel ve grup yansımıma becerilerinin incelenmesi*. IV. International Instructional Technologies and Teacher Education Symposium. Elazığ, Türkiye.

Aydın, G. Ç., Evren, E., Atakan, İ., Şen, M., Yılmaz, B., Pirgon, E., Yeşilyurt E., Akıllıoğlu F.Ç., & Ebren, E. (2016). *Delphi technique as a graduate course activity: Elementary science teachers' TPACK competencies*. SHS Web of Conferences (Vol. 26, p. 01135). EDP Sciences.

Akillioglu, F. C. & Aydogan, C. (2015, September). *Current quality issues in Turkish science education research. A comparative study of Turkish science education research published nationally and internationally*. European Conference on Educational Research. (ECER 2015) Budapest, Hungary.

Akillioglu F. C. (2014, April). *Using Critical Theory in Science Education*. International Symposium on Education and Psychology. (ISEP, 2014) Nagoya, Japan

Akillioglu F. C. Bahar-Guner H. O., Gulsen-Turgut I. (2013, April). *Cross Referencing Turkish MoNE Teacher Competencies in Science, Math and EFL Fields*. International Conference on Innovation and Challenges in Education (CICE, 2013), Kütahya, Turkey.

Akillioglu F. C. (2013, April). *Methodological Applications of Critical Discourse Analysis in Science Education*. International Conference on Innovation and Challenges in Education (CICE, 2013), Kütahya, Turkey.

Akillioglu F. C. (2013, May). *A Critical Discourse Analysis of Turkish MONE Science and Technology Teachers Competency Standards*. International Symposium, New Issues on Teacher Education (ISNITE, 2013), Ankara, Turkey.

Akillioglu, F. C. (2013, July). *Phenomenology in Science Education*. 10th International Conference on Hands on Science Educating for Science and Through Science (pp.141). (HSCI, 2013) Košice, Slovakia.

Akillioglu, F.C. (2011, September), Visual Literacy in Science Education: Critical Discourse Analysis of Hidden Curriculum Embedded in Text. (IVLA, 2011). Galloway, NJ., USA.

Aydogan C., Sagsoz G., Akillioglu F. C. (2011, April). Yaratıcı Drama Liderinin Uygulamadaki Davranış Örütüsü İle Drama Uygulama Yeterliliği Arasındaki İlişki. Uluslararası Eğitimde Yaratıcı Drama Sempozyumu (İstanbul, Turkey)

Kern, A. L., Moore, T. J., & Akillioglu, F. C. (2007, October). Cooperative learning: Developing an observation instrument for student interactions. 37th Annual Frontiers in Education Conference-Global Engineering: Knowledge Without Borders, Opportunities Without Passports (pp. T1D-1). (IEEE Computer Society, 2007). Milwaukee, WI., USA.

Akillioglu, F. C., & Upadhyay, B. (2006, January). Hmong Teachers' Perception of Science Teaching: A Case Study of Two Female Pre-Service Elementary Hmong Teachers. The Association of Science Teacher Education, (ASTA, 2006), Portland, OR., USA.

### **Book Chapters**

Akillioglu, F. C. (basimda). Matematiksel Söylem. M Kılıç & C. Avcı (Eds.), Erken çocuklukta matematik eğitimi. Eğiten.

Köse, M. & Akillioglu, F. C. (2017). Öğrenme Öğretme Kuramları-Modelleri-Yaklaşımları. S. Dal & M. Köse (Eds.), Öğretim İlkeleri ve Yöntemleri Etkinlik ve Ders Planı Örnekleriyle Zenginleştirilmiş. Anı Yayıncılık.

Köse, M. & Akillioglu, F. C. (2017). Fen Bilimlerinin Temel Kavramları. N.Y. Duban (Ed.), İlkokulda Temel Fen Bilimleri. Vize Yayıncılık.

Aydoğan, C. (2015). *Mükemmellik Geleneği Üzerine Yapılanma*. H. Z. İnan & T. İnan (Eds.), Erken çocukluk eğitiminde etkili uygulamalar (ss. 308-339). Nobel Akademik Yayıncılık Eğitim Danışmanlık Tic. Ltd. Şti. (Çeviri Effective Practices in Early Childhood Education: Building a Foundation, S. Bredekamp, 2013, Pearson.)

### **Projects**

ERASMUS + KA2 ISSA Project “Improving Solutions for Student Absenteeism”  
(Project no: 2016-1 -TR01 -K201 -034947) (Instructor)

ERASMUS +KA2 DigiSEL Project “Digitally Improving Social and Emotional Skills of Primary School Teachers” (Project no: 2020-1-TR01-KA226-SCH-098576)  
(Instructor)

Technological Research Council of Turkey (TÜBİTAK) 4004 Project, “A Journey to the Nature of Science with Gifted Students at the place History of Civilization Changed” (Project no: 119B953) (Instructor)

ONE MORE HOPE FOR THEM, Other public institutions (except Higher Education Institutions), Advisor: N. Bayindir, Advisor: F. C. Akillioğlu, 05/01/2012 - 05/06/2012

### **Courses Taught (Teaching Assistant)**

Laboratory Applications in Science I

Laboratory Applications in Science II

School Experience

Practice Teaching in Elementary Education

Practice Teaching in Early Childhood Education

## **D. TURKISH SUMMARY / TÜRKÇE ÖZET**

Fen öğrenimi, giderek daha fazla söylemsel yönü ile kavramsallaştırılmaktadır. Fen eğitiminin öğrencilerin bilimsel söylemi nasıl kullanacakları hakkında bilgi edinip, eğitim etkinliklerine katılma yeteneğini desteleyen yönü de bu şekilde daha fazla öne çıkmaktadır. Çeyrek yüzyıldır araştırmacılar, akademik ortamlarda desteklenen bilimsel söylemin güç kültürünü pekiştirdiğini (Delpit, 1995; Aikenhead, 2001; Ogbu, 2004) ve fen eğitiminin bireyin özellikle söylemsel yetkinliğin sağladığı ‘sosyal imkanlara’ (Gee, 1999; 2006) erişip erişemeyeceğini belirlediğini vurgulamaktadırlar. Bunun sonucu olarak, fen eğitimi bağlamında söylem çalışmaları giderek artmaktadır. Fen eğitiminde söylem çalışmaları öncelikli olarak sınıf diyaloglarına (Hanrahan, 2005, Kelly, 2007; Moje, 1997), eğitim politikalarına (Hufnagel, Kelly & Henderson, 2018, Thomas. 2011) veya müfredat ve ilgili materyallere (Bazull, 2014; Sharma & Buxton, 2015), odaklanmakta ve fen eğitimi epistemik toplulukları tarafından desteklenen söylemleri kaynağında araştırmaya öncelik vermemektedir. Fen eğitimi araştırmacıları epistemik topluluklar oluşturur ve söylemsel seçimleri aracılığıyla fen eğitiminde desteklenen söylemlerin özelliklerini belirleyen bir etkiye sahiptirler. Bilimsel toplulukları araştıran çok sayıda çalışma vardır. Özellikle bilimsel literatürün betimleyici ve nicel özelliklerine odaklanan scientometrik çalışmaların tanınırlık kazanması (Fernández-Cano ve Bueno, 1999; Konur, 2012) ve eğitim araştırma topluluğu içinde oluşan ilişki ağlarına artan ilgi (Tang, vd., 2021; Tuire ve Tuire & Erno, 2001) açıktır. Ancak, bu etkili toplulukların söylemsel seçimlerini ve bu seçimlerin güç farkı yaratıp yaratmadığını ve fen eğitiminde güç kültürünü pekiştirip pekiştirmedigini araştıran sınırlı sayıda araştırma bulunmaktadır.

Alanyazında gözlemlenen ihtiyacı dikkate alarak, bu araştırma söylem çalışmalarının kapsamını genişletmeyi ve eğitim bağlamında epistemik toplulukların söylemsel seçimleri aracılığıyla makro düzeydeki etkileşimleri keşfetmeyi amaçlamıştır. Alanyazında, akademik söylemi inceleyen benzer bakış açılarına sahip felsefi ve dilbilimsel çalışmalar olmasına rağmen (Angermuller, 2018; Anthony, 2001; Ball, 2009; Biber & Gray, 2013; Rossi & Brand, 2020; Fairclough 2001, van Dijk, 2017) fen

eğitimi alanında yapılan çalışmaların sınırlı sayıda olması alanyazındaki bu boşluğun dikkate değer büyülüklükte olduğunu işaret etmektedir. Bu nedenle, söz konusu boşluğu gidermek için bazı temel araştırma sorularının sorulması gerekmektedir. Bu araştırma, epistemik toplulukların söylemsel seçimlerini ve fen eğitiminde güç farklılıklarını teşvik etmedeki rollerini keşfetmeyi amaçlayarak bu olası temel sorular içinde bir odak noktası belirlemiştir. Fen eğitimi bağlamında makro düzeydeki etkileşimleri araştırmak için konuya ilgili önceden yapılmış araştırmalardan yararlanma imkânı olmadığından, karşılaştırmalı bir referans noktası sağlamak için araştırma soruları fen eğitimi ve ilköğretim fen eğitimi olmak üzere iki gömülü bağlamda araştırılmıştır. Sonuç olarak, bu iki bağlamda epistemik toplulukların söylemsel tercihlerini birlikte araştırmak daha detaylı bilgiye ulaşılmasını sağlamıştır. Ayrıca, fen eğitimi ve ilköğretim fen eğitimi bağlarının birlikte araştırılması, bu araştırmanın teorik ya da perspektif üçgenlemesini (*theory or perspective triangulation*) sağlamak için kullanılan söyleme ait tüm bağlam seviyelerini ele almayı (Wodak, 2011) kolaylaştırmıştır.

Araştırma sorularının doğası göz önüne alındığında, bu araştırma keşfedici, doğrulayıcı ve çıkarımsal sorulara cevap vermeyi amaçlamıştır. İlk araştırma sorusu, epistemik topluluklar tarafından desteklenen söylemlerin özelliklerini keşfetmeyi amaçlamıştır; “Fen eğitimi/ilköğretim fen eğitimi epistemik toplulukları tarafından desteklenen söylemlerin özellikleri nelerdir?”. İkinci araştırma sorusu doğrulayıcı bir evet veya hayır sorusudur; “Fen eğitimi/ilköğretim fen eğitimi epistemik topluluklarının söylemsel seçimleri güç farklılıklarını yaratır mı?”. Son olarak, üçüncü soru, yorumu dayalı çıkarımsal bir sorudur, çünkü bu soruya verilecek herhangi bir yanıt, incelenen güç yapılarını doğal olarak içermekte ve bu yapılara bağlı olmak durumundadır; “Fen eğitimi/ilköğretim fen eğitimi epistemik topluluklarının söylemsel seçimleri nasıl güç farklılıklarını yaratır?” Ancak bu soruya ilişkin bulgular, sahada gerçekte neler olup bittiğini bir dereceye kadar betimlememize, anlamamıza ve mevcut statükoyu sorgulamamıza yardımcı olma imkanına sahiptir. Bu nedenle, bu çalışmanın başından itibaren, araştırma soruları, araştırma tasarımları ve yöntemi ile ilgili yapılan tüm seçimler, fen eğitiminde genellikle dikkat etmediğimiz veya otomatik olarak kabul ettiğimiz durumlara ışık tutmayı amaçlamıştır. Bu amaç göz önünde

bulundurularak bu araştırmada eleştirel bir bakış açısı benimsenmiş ve eleştirel söylem analizi (Critical Discourse Analysis, CDA) yönteminden yararlanılmıştır.

Eleştirel söylem analizinin sıkılıkla bu yöntemi kullanan çalışmaların düşünümsellik (reflexivity) eksikliği ve yöntem olarak genellikle ideolojik bir bakış açısı ile ilişkilendirilmesi nedeniyle eleştirildiği akılda tutularak (Rogers, 2005; Verschueren, 2001; Widdowson, 1998, 2005), araştırma bu sorunları ele almak için özel olarak tasarlanmıştır. Araştırma tasarımindan, bu çalışmayı ideolojik bir bakış açısı olarak hizmet edebilecek teorik bir çerçeve ile ilişkilendirmek yerine, keşfedici bir bakış açısı benimsenmiş ve araştırmacı etkisini en aza indirmek amaçlanmıştır. Ayrıca, düşünümselliği sağlamak için bu araştırmada, araştırmacı tarafından verilen her karar okuyucunun takip edebileceği şekilde sunulmuştur. Araştırma yöntemi olarak kullanılan Fairclough'un (2001) eleştirel söylem analizi ve bu yöntemi desteklemek için kullanılan Gee'nin (2004) söylem analizi ve VOSviewer programı ile yapılan veri kontrolü (veri teyidi) süreçleri de dahil olmak üzere tüm analiz adımları okuyucuya detaylı olarak anlatılmıştır. Ayrıca, bu araştırmmanın çıkarımsal yönü, keşfedici ve doğrulayıcı soruların bulgularına bağlı olarak ortaya konmuştur. Bu nedenle, teorik olarak, bu araştırmmanın en başında kabul edilen tek ideolojik varsayımdır, birçok araştırmacı tarafından defalarca dile getirilen “söylemin güç farkı yarattığı” varsayımdır (Fairclough, 2001; van Dijk, 2017).

Bu araştırmmanın karşılaştığı ilk zorluk, fen ve ilköğretim fen eğitimi alanyazının epistemik toplulukların yerini belirlemekti. Fen eğitimi alanyazının epistemik topluluklarla ilgili araştırmaların sınırlı olması ve bu toplulukların alanyazındaki yerlerinin ve oluşumlarının önceki çalışmalarca belirlenmemiş olması nedeni ile epistemik toplulukların fen eğitimi alanyazındaki yerini belirlemek için bibliyografik bir araştırma yapılmıştır. Haas'ın (1992) epistemik topluluk tanımı çerçevesine göre ortak alıntı analizi yapılmış ve VOSviewer ortak alıntı haritaları kullanılarak ilgili alanyazında üç epistemik topluluk tespit edilmiştir. Ayrıca, ortak alıntı analizinin bir sınırlılığı olarak karşımıza çıkan, metnin içeriğine bakılmadan ortak alıntılarla dayalı olarak metinler arasında anlamsal benzerlikler olduğu varsayımdan kaçınmak için ek bir analiz yapılmıştır. Alanyazında VOSviewer ortak

alıntı haritaları ile belirlenen metinlerin gerçekten de bazı anlamsal benzerliklere sahip olduğundan emin olmak için VOSviewer programının farklı bir analiz özelliği kullanılarak bu metinlerin isim ve isim tamlamalarının ortak görülmeye haritaları oluşturulmuştur. Böylece epistemik toplulukların söylemsel seçimlerini işaret eden bu metinlerdeki anlamsal benzerlikler belirlenmiştir. Bu analizlerle fen eğitimi alanyazının iki epistemik topluluk belirlenmiş ve isimlendirilmiştir: bilimin doğası epistemik topluluğu ve argümantasyon epistemik topluluğu. Buna karşılık, ilköğretim fen eğitimi alanyazının sadece bilimin doğası epistemik topluluğu belirlenmiştir. Fen ve ilköğretim fen eğitimi alanyazının diğer epistemik toplulukların bulunduğu gösterir açık belirtiler vardır. Ancak bu araştırma, bu epistemik topluluklardan yalnızca üçünü diğerlerinden ayırt edebilmiştir. Ayrıca, bilimin doğası epistemik topluluğu hem fen eğitimi hem de ilköğretim fen eğitimi alanyazının yer alırken, argümantasyon epistemik topluluğuna karşılık gelen bir topluluk ilköğretim fen eğitimi alanyazının belirlenmemiştir. Epistemik topluluklarla ilgili fen eğitimi bağlamında önceden yapılmış bir araştırma olmadığından, bu araştırma, bulgularını desteklemek ve karşılaştırmalı bir referans noktasına sahip olmak için iki gömülü bağlamda epistemik toplulukların söylemsel seçimlerini araştırmak üzere tasarlanmıştır. İlköğretim fen eğitimi alan yazısında sadece bilimin doğası epistemik topluluğu ile ilgili bulgulara ulaşılması nedeniyle argümantasyon epistemik topluluğu ile ilgili daha fazla inceleme yapılamamıştır.

Epistemik topluluklar alanyazında belirlendikten sonra, VOSviewer programı tarafından üretilen ortak alıntı haritalarında gözlemlenen bağlantı gücü puanlarına ve tutarlı alıntı geçmişine dayalı olarak, belirlenen her bir epistemik topluluk için bir temsili makale seçilmiştir. Lederman'in (1992) ve Akerson, Abd-El-Khalick ve Lederman'in (2000) makaleleri, sırasıyla fen eğitiminde bilimin doğası epistemik topluluğu ve ilköğretim fen eğitiminde bilimin doğası epistemik topluluğu için temsili metinler olarak amaçlı olarak örneklenmiştir. Daha önce ifade edilen araştırma sorularını yanıtlamak için, bu araştırma Fairclough'un (2001) üçlü CDA yaklaşımını benimsemiştir. Bu çerçeve, araştırmacıların onu diğer yaklaşımalar ve analizlerle birlikte kullanmasına izin vermektedir. Bu nedenle, özne konumlarını (subject positions) diğer bir ifade ile metinde oluşturulan kimlikleri (identities) keşfetmek için

Gee'nin (2004) önerdiği yönlendirici sorular bu çerçeveye dahil edilmiştir. Dilsel özellikler olarak, özne konumları, ikinci doğrulayıcı araştırma sorusunu yanıtlamak için güç yapılarına ilişkin önemli bilgiler sağlamıştır. Ayrıca, örneklenen her makalenin ek VOSviewer (metinlerin isim ve isim tamlamalarının) ortak görülmeye haritaları oluşturulmuş, araştımanın standartlarını sağlamak için bir veri kontrol aracı olarak analize dahil edilmiştir.

İlk araştırma sorusunu “Fen eğitimi/ilköğretim fen eğitiminin epistemik toplulukları tarafından desteklenen söylemlerin özellikleri nelerdir?” ele aldığımızda, örneklenen metinlerin eleştirel söylem analizi, bu belirlenmiş epistemik topluluklar tarafından desteklenen söylemlerin bazı ayırt edici özelliklere sahip olduğunu ortaya çıkarmıştır. Öncelikle, bulgular, fen eğitiminde bilimin doğası epistemik topluluğu tarafından desteklenen söylemin, öğrencilerin bilimin doğasını kavrayışı/anlayışı/görüşü/inancı ve öğretmenlerin bilimin doğasını kavrayışı/anlayışı/görüşü/inancı gibi belli adlaştırmalara yaptığı vurgu ile tanımlanabileceğini göstermiştir. Bu adlaştırmalar, bu söylemde adeta birer terminoloji olarak kullanılmıştır. Ancak çoğu zaman birbirinin yerine kullanıldıkları için yerleşik terminolojiler olarak karşımıza çıkmamaktadır (Halliday ve Martin, 1993).

Ayrıca, metnin söylemsel tercihleri, "bilimin doğası kavrayışı" adlaştırmasına vurgu yapsa da bu adlaştırmayı söz konusu söylemin terminolojisi olarak kabul etmek için yeterli bir tutarlılık göstermemektedir. İncelenen metinde veya ilgili literatürde farklı adlaştırmaların neden birbirinin yerine kullanıldığına dair bir açıklama olmadığı düşünüldüğünde, şu sorular akla gelmektedir; ‘Birden çok adlaştımanın birbirinin yerine kullanılmasının arkasındaki sebep nedir?’ ‘Bu kullanım şekli hangi amaca hizmet etmektedir?’ Bununla birlikte, bu araştımanın bulguları, fen eğitiminde bilimin doğası epistemik topluluğunun, bu adlaştırmalarla temsil edilen, yaygın olarak kullanılan bir değişken için yerleşik bir terminoloji veya kullanılan değişkenler için ayırt edici tanımlar sağlama mücadelesi verdiği dair kanıtlar sağlamıştır. Ayrıca, Norman ve Judith Lederman (2019), önceki araştırmalarına atıfta bulunarak (Lederman & Lederman 2014), yakın tarihli bir pozisyon makalesinde, “bilimsel bilginin doğasına (NOSK) yaygın olarak “bilimin doğası (NOS)” olarak atıfta

bulunulmaktadır, ancak bilimsel bilginin doğası (NOSK), bu ifadenin orijinal olarak ne anlamına geldiğini daha açıklayıcıdır.” ifadesini kullanmışlardır. Bilimin doğası (alternatif olarak bilimsel bilginin doğası) çerçevesinin fen eğitimi literatüründe öne çıkan isimlerinin bu duruşu da bu alandaki bir terminolojik tutarsızlığı ve mücadeleyi işaret etmektedir. Dahası, ‘bilimin doğası algısı’ gibi yeni adlaştırmaların fen eğitimi literatüründe popülerlik kazandığı görülmektedir (Erduran vd., 2020; Shutherford & Dannick, 2002). Adlaştırmalara ilişkin tutarsızlığın ilgili araştırmalardan elde edilen bilgilerle zaman içinde çözülmesi beklenirken, adlaştırmalardaki çeşitlilik, fen eğitimi literatüründe bilimin doğası epistemik topluluğunun desteklediği söylemin karakteristik bir özelliği haline gelmiş görülmektedir. Bu gözlemin arkasındaki dinamikleri keşfetmek önemlidir çünkü bu adlaştırmalar birbirinin yerini kalıcı şekilde almamaktadır, birbirinin yerine değiştirilebilir şekilde kullanılmakta ve sayıları artmaktadır. Literatürde bu adlaştırmaları birbirinin yerine ve hatta birlikte kullanan çok sayıda araştırma bulunmaktadır (örn., Mesci ve Schwartz, 2016; Lederman vd., 2002). Dolayısıyla bu gözlem şu soruları da beraberinde getirmektedir; “Bu adlaştırmaları birbirinin yerine kullanarak ne kazanırız ya da kaybederiz? ve “Bu çeşitli adlaştırmalar bilimin doğası söyleminde hangi amaca hizmet ediyor?”

Eleştirel söylem analizinin bulguları ayrıca, ilköğretim fen eğitimi bilimin doğası epistemik topluluğunun desteklediği söylemin, “bilimin doğası görüşü” adlaştırmasına yaptığı vurguya tanımlanabileceğini de ortaya koymuştur. Ayrıca “görüş” adlaştırmasını kullanmayı tercih eden çalışmalarda son yıllarda gözlemlenebilir bir artış olmuştur (örn., Schellinger vd., 2019; Kinskey, 2020). Bu gözlem, kısmen ‘Bilimin Doğası Görüşleri Anketi’nin (Views of Nature of Science, Lederman et al., 2002) ve daha sonraki ‘Bilimsel Sorgulama Görüşleri Anketi’nin (Views of Scientific Inquiry: The VOSI Questionnaire, Schwartz et al., 2008) ilköğretim fen eğitimi araştırmalarında artan popüleritesinden kaynaklanabilir (örn., Edgerly et al., 2022; Mesci & Schwartz, 2017). Ayrıca, epistemik topluluklar veya araştırmacılar veya araştırmacı grupları ile bağdaştırmak için farklı adlaştırmalar kullanmak da bu söylemin özelliği gibi görülmektedir. Tutarlı bir terminolojiyi kullanmak yerine, “bilimin doğası görüşü” adlaştırması, ilköğretim fen eğitimi literatüründe “bilimin doğası anlayışına” bir alternatif, rekabet halindeki bir söylemsel seçim haline gelmiş

görünmektedir. Okuyucu kitlesine ve otoriteye bağlı olarak, özellikle metnin başlığı/başlıklarını ve gövdesi arasında tutarsızlıklara yol açsa da bu söylem tarafından metnin farklı bölümlerinde farklı adlaştırmalar kullanılmaktadır. Dergi makalelerinin başlıklarının okuyucuların okumaya devam edip etmeyeceğine karar vermesini sağlamak için konuyu etkili bir şekilde iletmesi, açık, doğru ve kesin olması (Hartley, 2008) ve aynı zamanda okuyucunun dikkatini çekmesi ve içerik hakkında yeterli bilgiyi sağlamasının beklentiği gerçeği göz önünde bulundurulduğunda (Shahidipour ve Alibabae, 2017; Yitzhaki, 1994), bu gözlem şu soruyu akla getirmektedir; “Metnin başlığında/başlıklarında ve gövdesinde kullanılan adlaştırmalar tutarsız ise bunun sonucu ne olur?” Ayrıca, önceki araştırmalar, yüksek atıf oranlarının bir alana özgü belirli başlık özellikleriyle ilişkili olduğunu ve belirli başlık sözcükleri tarafından değerlendirildiğini ileri sürmektedir (Jacques ve Sebire, 2010). Bu nedenle, “Başlık/başlıklar ve metnin gövdesindeki adlaştırmaların tutarsız kullanımını, atıf oranını adına başlığın bilgi değerini azaltır mı?”, “Adlaştırmaları metnin başlıklarında ve gövdesinde tutarsız bir şekilde kullanırsak ne kazanızız ya da ne kaybederiz” gibi sorular akla gelmektedir.

Diğer iki araştırma sorusu; “Fen eğitimi/ilköğretim fen eğitimi epistemik topluluklarının söylemsel seçimleri güç farklılıklarını yaratır mı?” Eğer güç farklılıklarını yaratıyorlarsa... Fen eğitimi/ilköğretim fen eğitimi epistemik topluluklarının söylemsel tercihleri nasıl güç farklılıklarını yaratır?” sorulariydi. Örneklenen metinlerin eleştirel analizi, alanyazında belirlenmiş epistemik toplulukların söylemsel seçimlerinin karakteristik güç farklılıklarını desteklediğini ortaya çıkarmıştır. İlk olarak, fen eğitimi literatürü için örneklenen metnin söylemsel seçimleri, etken ve edilgen cümle yapılarını kullanarak ya da “öğrencileri” ürün ve “öğretmenleri” eğitim süreçlerinin ana aktörleri olarak konumlandırarak öğretmenler ve öğrenciler arasında güç farklılıklarını yaratmıştır. Ayrıca 'araştırmacılar' çoğunlukla etken cümle yapısı ile kullanılmış ve idealize edilmiş olumlu özelliklere sahip olarak tasvir edilmiştir. Metin boyunca araştırmacılar otorite kaynakları olarak tasvir edilmiştir. Böylece, fen eğitiminde bilimin doğası epistemik topluluğu tarafından desteklenen söylem, öğrencileri pasif katılımcılar, öğretmenleri fen eğitimi sürecinin aktif katılımcılar ve araştırmacıları da fen eğitiminin otoritesi olarak tasvir etmiştir. Öte yandan metinde

gözlemlenen söylemsel seçimler anne baba, aile, topluluk, toplum vb. gruplara atıfta bulunmamakta ve onlara herhangi bir rol yüklememektedir. Fen eğitimi literatüründe, öğretmenlerin ve öğrencilerin bilimin doğası kavrayışı/anlayışı/görüşü/inançları üzerine yapılan araştırmalar (Clough, 2018; Matthews; 2017) yukarıda bahsedilen hiyerarşik rolleri desteklemektedir. Buna karşılık, literatürde ebeveynlerin, ailelerin veya toplumun bilimin doğası kavrayışlarını/anlayışlarını/görüşlerini/inançlarını inceleyen araştırmalar neredeyse yok deneyecek kadar az sayıdadır. Özne konumlandırmalarının (metin içinde yer alan kimliklerin) metnin kurguladığı dünyayı nasıl tasvir ettiğini açıklamaya yardımcı olduğu düşünüldüğünde (Sabaratnam, 2020), fen eğitiminde bilim doğası epistemik topluluğunu tarafından desteklenen söylem, kurguladığı dünyasını öğretmen odaklı bir sınıf ortamıyla sınırlandırıyor ve fen eğitiminin sınıf dışındaki paydaşlarını ve öğrencilerin kendi öğrenmeleri üzerindeki gücü ve kontrolünü gözden kaçırıyor gibi görülmektedir. Bu nedenle, araştırma bulguları, "Belirli gruplar bilimin doğasına ilişkin sosyal olarak inşa edilmiş ortak bir kavrayışa/ anlayışa/ görüşe/inançlara sahip olabilir mi?" ve "Öğrencileri pasif katılımcılar olarak tasvir etmenin sonuçları nelerdir?" sorularını gündeme getirmiştir.

Analiz sonuçları metin düzeyinde, fen eğitimi bağlamı için örneklenen metinde kullanılan söylem tarafından bir amaç olarak "yeterli bilimin doğası kavrayışı/anlayışına" merkezi bir rol verilmiştir. Bir amaç olarak bilimin doğası, örneklenen metin tarafından sıfatların kullanımıyla vazgeçilmez, kalıcı ve tekrarlayıcı olarak nitelenip konumlandırılmıştır. Bilimin doğası epistemik topluluğunun bazı söylemsel seçimleri, örneğin, metinde bilimin doğasına atıfta bulunan daimî ve onde gelen gibi sıfatların kullanılması bu sıfatların yalnızca bilimin doğasını nitelmek için kullanılmasından dolayı dikkat çekmektedir. Bu araştırma kapsamında fen eğitimi alanyazında belirlenmiş bilimin doğası epistemik topluluğunu temsile eden ve ilgili alanyazında gözden geçirilmiş makale metinlerinin çoğu, "yeterli bilimin doğası kavrayışı/anlayışına" ifadesini kullanarak bir araştırma, bir makale ya da bir politika belgesine atıfta bulunmuştur (örn., Abd-El-Khalick & Lederman, 2000, American Association for the Advancement of Science, 1989; Hazen & Trefil, 1991; Kimbal, 1967, 1968; Klopfer, 1969; Lederman, 1992, 2007, 2014; National Science Teacher Association, 2013; Rutherford & Ahlgren, 1990). Bilimin doğası teorik çerçevesini ve

fen eğitimi alanyazınında tam bir tanımın olmamasının etkilerini sorgulayan araştırmacılar bile çalışmalarında bu amacı dile getirmişlerdir (örn., Alsop ve Gardner, 2017; Hodson ve Wong, 2001; Stanley ve Brickhouse, 2001). Bir amaç olarak, “bilimin doğasına ilişkin yeterli öğrenci anlayışının geliştirilmesi”, fen eğitimi literatüründe neredeyse bir sağduyu varsayımları haline gelmiş ve yerleşmiş görünmektedir. Sağduyu varsayımları örtüktür ve nadiren sorgulanır. Ancak, eylemlerimizi ve başkalarının eylemlerini algılama ve yorumlama şeklimizi kontrol ederler (Fairclough, 2001). Bu nedenle, bu gözlem şu soruyu akla getirmektedir: "Bu 'bilimin doğasına ilişkin yeterli öğrenci kavrayışının geliştirilmesi, bilim eğitiminin onde gelen hedefidir' sağduyu varsayımlı, yeni araştırmacılar tarafından kolayca sorgulanabilir mi? Ayrıca, analiz edilen metin, bilimin doğasının bir tanımı yerine bu amaci vurguluyor ve kullanıyor gibi görünmektedir. Birçok fen eğitimi araştırmacısı, fen eğitimi literatüründe bilimin doğasının üzerinde anlaşmaya varılmış bir tanımı olmadığını kabul etmektedir. Bununla birlikte, bu araştırmacılar, bilimin doğasının genel yönleri üzerinde bazı fikir birlikleri olduğu için tanım eksikliğinin göz ardı edilebileceğini ve üzerinde anlaşmaya varılan bu yönlerin çalışılabileceğini öne sürmektedirler (örn., Akerson vd., 2000; Çetinkaya-Aydın). & Çakıroğlu, 2017; Lederman vd. 2014). Bu fikir birliği yaklaşımı fen eğitimi literatüründe yaygın olarak kabul edilmektedir. Öte yandan, bazı araştırmacılar daha temel bir bakış açısı değişikliği önermektedir. Literatürde, bilimin doğası kavramını farklı bir odak ve adla, “bilimin özellikleri”, tanıtarak, bilimin epistemolojik, tarihsel, psikolojik, sosyal, teknolojik ve ekonomik unsurlarını vurgulayarak bilimin doğası kavramını değiştirmeye yönelik bazı girişimler vardır. (Matthews 2012). Diğer araştırmacılar da fikir birliği yaklaşımını eleştirmektedir ya da geliştirilmesi gerektiğini savunmaktadır. Örneğin fikir birliği yaklaşımının eleştirilen yönlerini ele alarak geliştirilen “Aile Benzerliği Yaklaşımı (FRA)” adlı yeni bir teorik çerçeve bunlardan biridir (Irzik ve Nola, 2014; Dagher ve Erduran, 2016). Bu teorik çerçeve bilimin genel ve alana özgü yönlerini içerir ve “bilimin bileşenlerini kullanılan onu epistemik, bilişsel ve sosyal sistemler altında toplanan kategoriler açısından tanımlar” (Erduran & Dagher, 2014, s.19). Bu nedenle, bu alandaki çabalar, “Fen eğitimi literatüründe üzerinde uzlaşılmış bir bilimin doğası tanımının olmamasının arkasındaki nedenler nelerdir?”, “Alternatif

teorik çerçeveler tanım eksikliğinin neden olduğu zorluklara tatmin edici çözümler sağlayabilir mi?" gibi ek soruları gündeme getirmektedir.

Bağlamsal düzeyde, fen eğitiminde bilimin doğası epistemik topluluğunun söylemsel seçimleri, bilimin doğasının üzerinde anlaşmaya varılan yönleri ile bilimsel bilginin yönleri arasında bir ilişki kurmuştur. Dolayısıyla, bu seçimler, bilimin doğasının özelliklerini neredeyse bilimsel bilginin yönlerine özdeş olarak konumlandırmıştır. Bu yönler fen eğitimi alanyazında nihai otorite konumuna sahip olan bilimsel bilgiyi oluşturduğundan, kurulan bu ilişki ile, bilimin doğasının yönleri de bir güç konumu kazanmıştır. Bilimin doğasının üzerinde anlaşmaya varılan yönlerinin bu konumu, uluslararası fen eğitimi standartlarında kolaylıkla gözlemlenebilir (Commas & Olson, 1998; Olson, 2018). Bilimin doğasına ilişkin bu ortak görüş, yıllar içinde sadece müfredatlarda değil, öğrencilerin değerlendirmelerinde de oldukça etkili olmuştur (Allchin, 2017; Clough & Olson, 2008; Erduran & Dagher, 2014). Ayrıca, alanyazında "bilimin doğasının hangi versiyonunun öğretilmesi gerektiği konusunda önemli bir anlaşmazlık olmasına" (Stanley & Brickhouse, 2001, s.47), rağmen fen müfredatları tarafından benimsenen bilimin doğasının artan popüleritesi dünya çapında Elli yılı aşkın süredir sabittir (Olson, 2000). Sonuç olarak bu gözlem, "Bilim eğitimi literatüründe bunlarla ilgili çözülmemiş bazı temel tartışmalar varken, bilimin doğasının yönleri müfredatlarda neden bu kadar popüler?" sorusunu akla getirmektedir.

Ayrıca, bilimin doğası ve bilimsel bilgi ile söylemsel seçimler arasında kurulan ilişki, metinde gözlemlenen bilimin doğasının diğer temsillerinden daha doğrudan ve mantığa dayalı görülmektedir. Bu birlikteliğin etkisi fen eğitimi alanyazında da görülmektedir. Bilimsel bilgi veya bilimsel bilginin yönleri, bilimin doğası kavrayışı/anlayışı/görüşü/inancı ile tutarlı bir şekilde ilişkilidir. Bu birleşme aracılığıyla, bilimin doğası epistemik topluluğu, alanyazında bilimin doğasının üzerinde anlaşmaya varılmış yönlerini desteklemektedir. Literatürde bilimin doğasının üzerinde anlaşmaya varılmış yönleriyle ilgili çok sayıda liste vardır (Abd-ElKhalick vd., 1998; Lederman vd., 2002; McComas vd., 2000), ancak bu listeler arasında bile, bazı tutarsızlıklar gözlemlenebilir.

Fikir birliği görüşüne dayanan bu bilimin doğası yönleri listeleri, bilginin doğasını bilimsel araştırma süreçlerinden ayırdığı için de eleştirilmektedir (Alsop ve Gardner, 2017). Alsop ve Gardner (2017) gibi araştırmacılar, bu bilimin doğası yönleri listelerinin farklı teorik yaklaşılara göre değiştibileceğini öne sürmektedirler. Ayrıca bilimin doğası tartışmalarında çoğulculuğa katkıda bulunan farklı sesleri (Allchin, 2017; Alsop & Gardner, 2017; Dagher & Erduran, 2017; Hodson & Wong, 2017) tanıtan Bazzul (2017, s.70) bilimin doğasına ilişkin fikirbirliği görüşü tarafından dışlanan bu konu ile ilgili çok çeşitli görüşleri/uygulamaları/kullanımları listelemiştir. Sonuç olarak, bilimin doğası epistemik topluluğunun söylemsel tercihleri, bilimin doğası ile bilimsel bilginin doğasının benzer (veya bazen aynı şey) olduğu şeklindeki sağduyuya dayalı varsayımini desteklerken, literatürde bu varsayıım hala eleştirilmekte ve tartışılmaktadır. Lederman ve Lederman'ın (2019) "bilimsel bilginin doğası (NOSK) genel olarak bilimin doğası (NOS) olarak anılır, ancak bilimsel bilginin doğası NOSK, bu ifadenin orijinal olarak ne anlama geldiğini daha açıklayıcıdır" şeklindeki savına geri donecek olursak, Lederman'ın bu ifadesi bu araştırmada gözlemlenen bulguları desteklemekte ve "Fen eğitimi alanyazının neden bilimin doğası (NOS) ifadesi bilimsel bilginin doğası (NOSK) ifadesinde daha yaygın olarak kullanılmaktadır?" ve Bilimin doğasının özellikleri, bilimsel bilginin yönlerinden daha fazlasını mı içeriyor yoksa tam tersi mi?" sorularını açığa çıkarmaktadır.

Eleştirel söylem analizinin bulguları ayrıca, cümle düzeyinde, ilköğretim fen eğitimi alan yazısında bilimin doğası epistemik topluluğu tarafından desteklenen söylemin, öğretmenleri, öğrencileri ve araştırmacıları, fen eğitimi alanyazısında tasvir edildiklerine benzer bir hiyerarşik yapıda tasvir ettiğini ortaya koymuştur. Ancak, daha önce açıklandığı gibi, ilköğretim fen eğitimi bağlamı için örneklenen metinde gözlemlenen söylemsel seçimler farklı metin bölümlerinde farklılık göstermektedir. Bu nedenle, desteklenen özne konumları da bu bölümlerde farklılık göstermektedir. Öte yandan, fen eğitimi bağlamında önceki bulgularla tutarlı olarak, araştırmacılar metin boyunca otorite olarak tasvir edilmiştir. Dahası, metin bilim adamlarını mükemmel olmayan insanlar olarak tasvir etmektedir. En dikkate değer olarak da analizde Abd-El-Khalick ve Lederman, VOSviewer birlikte gözlenme haritalarında öğeler olarak bu haritalarda yer almışlardır. Bu gözleme dayanarak, metin onları

otorite olarak konumlandırıyor gibi görülmektedir. Bu metnin ortak yazarları oldukları düşünüldüğünde; kendi çalışmalarını referans göstermelerinin etkisi belirgindir. Bu gözlem, “Araştırmacıların kendi çalışmalarına atıfta bulunmalarının fen/ilköğretim literatürünün güç yapılarına etkisi nedir?” sorusunu gündeme getirmektedir.

İncelenen metin bir araştırma makalesi olduğundan, metnin ana gövdesinde en sık gözlenen özne konumu “katılımcılar” olmuştur. Metinde “lisans öğrenci öğretmen” yerine “katılımcılar”, “lisansüstü öğrenci öğretmen” yerine “mezun katılımcılar” kullanılmıştır. Bu nedenle asıl vurgu, çözümlenen metnin söylemsel seçimleriyle öğrenci öğretmenlere ya da başka bir deyişle hizmet öncesi öğretmenlere yapılmıştır. Ayrıca, öğretmenler ve öğrenci öğretmenler fen öğretiminde aktif katılımcılar olarak, öğrenciler ise pasif katılımcılar olarak tasvir edilmiştir. Benzer bir eğilim literatürde de görülmektedir. İlköğretim fen eğitimi alanyazınında, öğrenci öğretmenlerin veya hizmet öncesi öğretmenlerin bilimin doğası görüşleri (örn., Akerson vd., 2006, 2009a; Dickinson vd., 2000; Shim. vd., 2010; Morrison vd., 2009), kavrayışları (örn., Akerson ve Abd-El-Khalick 2005; Park ve Lee, 2009; Liu ve Lederman, 2007), anlayışları (örn., Lee ve Shea, 2016; Bell vd., 2011; Garcia-Carmona, 2021) ve inançları (ör., Yoon & Kim, 2016) üzerine araştırmaların, hizmet içi öğretmenlerin veya ilköğretim öğrencilerinin bilimin doğası görüşü/kavram/anlama/inançları (ör., Özkal et al. , 2010; Hacieminoglu vd., 2015; Walls, 2012) üzerine çalışmalarda veya hem öğrencilerin hem de öğretmenlerin bilimin doğası anlayışı üzerine araştırmalarдан (ör., Lederman & Lederman, 2004, 2005) daha yaygın olduğu gözlemlenmektedir. Dolayısıyla bu gözlem, “İlköğretim fen eğitimi literatüründe bilimin doğasına ilişkin araştırmalar neden daha çok öğretmen adaylarına odaklanmaktadır?” ve “Sınıf düzeyi bilimin doğası literatüründe araştırmacıların hedef kitlelerini ve örneklem gruplarını etkiler mi?” sorularını akla getirmektedir.

Metin düzeyinde, bilimin doğasının yönleri bu söylem tarafından farklı konumlarda sunulmuştur. Metin, tutarlı bir şekilde “hedef bilimin doğası yönleri” adlaştırmasını kullanarak, bilimin doğasının bazı yönlerinin erişilebilir olduğunu ve bilim eğitimi tarafından hedef alındığını, diğerlerinin ise erişilebilir olmadığını öne sürmektedir. Bu

söylemsel seçim, bu “hedef bilimin doğası yönlerine” diğerlerinden daha fazla değer ve önem verildiğini işaret etmektedir. Bu adlaştırma literatürde de sıkılıkla kullanılmaktadır. Fen eğitimi alanyazının, F. Abd-El-Khalick tarafından 'hedef bilimin doğası yönleri' adlaştırması yaygın olarak kullanılmıştır (örn., Doğan ve Abd-El-Khalick, 2008; Khishfe ve Abd-El-Khalick, 2002; Abd-El- Khalick vd.., 2008). Ancak ilköğretim fen eğitimi alanyazının özellikle F. Abd-El-Khalick ve V.L. Akerson'in ortak çalışmalarında, 'hedef bilimin doğası yönleri görüşleri' olarak kullanılmıştır (örn., Akerson & Abd-El-Khalick 2003; Abd-El-Khalick & Akerson, 2009). Bu adlaştırma fen eğitimi alanında yerleşik bir kullanım sahip görülmektedir. Alanyazında birçok araştırmacı bu adlaştırmayı “hedef bilimin doğası yönlerine ilişkin görüşler” olarak kullanmıştır (ör., Khishfe, 2008, 2012; Yacoubian & BouJaoude, 2010). Genel olarak bu adlaştırmayı kullanmasalar bile bazı araştırmacılar, hedef bilimin doğasına ilişkin kavrayışlar/anlayışlar adlaştırmasını kullanmayı tercih etmelerine rağmen metin içinde öğretmen veya öğrenci görüşlerine sıkılıkla atıfta bulunmaktadır (Cofre vd.., 2019; Kaya vd., 2019; Zion vd., 2020). Bu nedenle, ilköğretim fen eğitimi literatüründe bilimin doğası epistemik topluluğunun söylemsel seçimlerindeki “görüşler” üzerindeki karakteristik vurgu, doğal olarak “hedef bilimin doğası yönlerine ilişkin görüşler” gibi türev adlaştırmalarda gözlemlenmiştir.

Benzer şekilde metin düzeyinde, “yeterli bilimin doğası görüşleri” adlaştırması metin içinde sıkılıkla gözlemlenmiştir. Bu adlaştırma bir eşik görülmeye sıklığı ile oluşturulan VOSviewer birlikte görülmeye haritasında en yüksek görülmeye sıklığı ve küme etkisine sahip "görüş" adlaştırmasının ardından sıkılıkla gözlemlenen ikinci öğeydi. Yeterlilik incelenen metinde tutarlı olarak vurgulanarak ikili (binary) bir şekilde sunulmuştur; yeterli-yetersiz. Bu gözlem, “Bilimin doğası kavrayışı/anlayışı/görüşü açısından “neyin yeterli” olduğuna karar verme konusunda nihai yetkiye sahip olan kimdir?” sorusunu gündeme getirmektedir. Alanyazında, analiz edilen metnin yayınlanmasından sadece birkaç yıl sonra Lederman vd. (2002) de benzer kaygıları dile getirerek Bilimi Anlama Testi (Test of Understanding Science, TOUS; Klopfer & Cooley, 1961) ve katılımcılarını yeterli veya yetersiz olarak etiketleyen ve onlara sayısal bir değer atayan yaklaşımıları eleştirmiştir. Ayrıca standart testlerin, katılımcıların bilimin doğası görüşlerini anlamamıza yardımcı olmak için yetersiz

kaldığını savunmuşlardır. Bu nedenle, bu sorunu çözmek için Lederman vd... (2002) Bilimin Doğası Anketi'ni (Views of Nature of Science) geliştirmiştir. Ancak bilimin doğası kavrayışının/anlayışının/görüşünün ikili (yeterli-yetersiz) temsili alınyazında güçlü bir şekilde yer almaya devam etmektedir. Ayrıca, standartlaştırılmış zorunlu-seçenekli ölçme araçları yerine VNOS (Lederman ve ark. 2002) gibi açık uçlu araçlar da giderek popülerlik kazanmaktadır. Dolayısıyla aynı soru “Bilimin doğası kavrayışı/anlayışı/görüşü açısından “neyin yeterli” olduğuna karar verme konusunda nihai yetki kimdedir?” daha da önem kazanmaktadır.

Daha genel bir bakış açısından ele alacak olursak, bu araştırmmanın bulguları, eğitim literatüründe çeşitli epistemik toplulukların olduğunu ve bu araştırma ile fen ve ilköğretim fen eğitimi literatüründe sadece birkaçının belirlendiğini göstermiştir. Araştırma alanları arasındaki ilişkilere benzer şekilde, bu toplulukların arasında da karmaşık ve yerleşik ilişkiler vardır. Örneğin, ilköğretim fen eğitimi alanı doğal olarak fen eğitimi alanına gömülü olarak kabul edilebilir, ancak her iki alan da öğretmen eğitimi alanı ve daha birçok alanla önemli ölçüde bağlantılıdır. Bu nedenle, bu alanlar bağlamında belirlenen epistemik topluluklara net sınırları olmayan yapılar olarak bakmak en iyisi olacaktır. Söylemler gibi bu topluluklar da bölünebilir, kaynaşabilir, değişebilir veya dağılabilir ve birbirlerinin yerine geçebilir, bu nedenle bu toplulukların tam bir tanımına ulaşılamaz. Söylem ve epistemik topluluklar arasındaki yakın bağlantıya dayanarak, Gee'nin (2004) söylem hakkındaki bakış açısını epistemik topluluklara uyarlaysak, ‘bir epistemik topluluğun nasıl ve neden belli bir şekilde çalıştığını anlamaya çalışmak, onu basitçe tanımlamaktan daha işlevseldir.’ Bu nedenle, bu araştırmmanın öncelikli odak noktası, epistemik toplulukların söylemsel tercihlerinin fen ve ilköğretim fen eğitimi bağamlarında yarattığı güç farklılıklarını olmuştur. Ayrıca, bu araştırma bireysel araştırmacıların veya araştırmacı gruplarının, birden fazla epistemik topluluğun üyesi olabileceğini göstermiştir. Araştırmacıların veya bir grup araştırmacının söylemsel seçimleri, epistemik topluluklar tarafından desteklenen söylemlerden etkilenir ve aynı zamanda bu araştırmacılar ve araştırmacı grupları, kendi söylemsel seçimleri aracılığıyla desteklenen söylem üzerinde belli bir etkiye sahiptir. Bulgular ayrıca, söylemsel seçimlerle güç farklılıklarını yaratmanın birçok yolu olduğunu göstermektedir. Güç farklılıklarının, söylemdeki öğretmenler

veya öğrenciler gibi rollerle sınırlı olmadığı ve belirli hedefler veya terminolojilerinde söylemsel seçimlerle güçlü konumlara getirilebildiği araştırma bulguları tarafından desteklenmektedir. Son olarak, bu araştırma epistemik toplulukların söylemsel seçimlerine ve bu seçimlerin nasıl güç farkı yarattığını inceleyerek, sağduyuya dayalı varsayımlarımız veya eleştirel olmayan bakış açımız nedeniyle bir şekilde gözden kaçan birçok soruyu göz önüne sermektedir. Bu soruları yanıtlamak gelecekteki araştırmacılar için önemli bir çaba olabilir ve alana değerli bilgiler sağlayabilir. Bu nedenle, bu araştırma, eleştirel paradigmın, özellikle ezilenlerin mücadeleleriyle ilgili olmayan, ancak kolayca fark edilmeyen ya da kabul görmeyen daha detaylı güç yapılarıyla ilgili özgürleştirici hedefler için kullanılabilceğini bir örnek olarak göstermeyi amaçlamıştır. Ayrıca, sadece bariz olan ancak gözden kaçanları ortaya çıkararak, eleştirel bakış açısı ve eleştirel araştırmalar farkındalığı artırmak ve mevcut statüko hakkında sorular sormak için kullanılabilir. Önceki araştırmaların ve farklı araştırmacı topluluklarının çalışmalarının eleştirel analizi, herhangi bir alanda iddia ettiğimiz şeyi başardığımızı doğrulamamıza yardımcı olabilir. Alan içinde geçerlilik de bu eleştirel bakış açısıyla sağlanabilir.

Bu araştırmmanın alanyazına katkısına gelince, araştırmmanın keşifsel doğası, alanyazındaki çeşitli boşlukları tespit etmesine olanak sağlamıştır. Her şeyden önce, bu araştırmmanın bulguları, epistemik toplulukların eğitim alanında doğal olarak olduğunu ve önemli bir etkiye sahip olduğunu göstermiştir. Bu nedenle eğitim araştırmacıları, özellikle fen eğitiminde epistemik topluluklara daha fazla önem vermelidir. Bu araştırma, alanyazındaki epistemik topluluklardan sadece üçünü belirleyebilmiştir. Ancak, bu araştırma kapsamındaki sınırlılıklar nedeni ile belirlenememiş başka epistemik toplulukların alanyazında bulunduğuunu belirten bulgular vardır. Epistemik toplulukların sahadaki etkisi göz önüne alındığında, bu toplulukların oluşma ve işlev görme biçimleri gelecekteki araştırmalar için ilgi çekici bir konu olabilir. Ayrıca, bu araştırmmanın bulguları, fen eğitiminde söylemin rolünün müfredat, politika belgeleri, ders materyalleri veya sınıf konuşmalarıyla sınırlı olmadığını göstermiştir. Epistemik topluluklar tarafından desteklenen söylemlerin fen eğitiminde önemli bir yeri vardır. Bu nedenle eğitim literatürü, epistemik topluluklar,

diğer sosyal gruplar ve kurumların söylemsel tercihleri üzerine ek araştırmalardan yararlanabilir.

Eleştirel söylem analizini eleştiren çalışmalar, bizi bu analiz yaklaşımın tuzakları konusunda uyarmaktadır. Eğitimde eleştirel söylem analizi araştırmalarının artan popüleritesi ve önemi göz ardı edilemez. Öte yandan, eleştirel söylem analizi araştırmasını ele almak, kapsamlı söylem analizi ve eleştirel araştırma bilgisi gerektirmektedir. Ne yazık ki, eğitim alanında çalışan pek çok araştırmacı bu kapsamlı bilgiyi edinme olanağına sahip değildir. Eleştirel söylem analizi araştırmasının metodolojik esnekliği, araştırmacıların araştırma tasarımlarında farklı yöntemler uygulamasını sağlar. Bu nedenle, yorumlanan verileri üçgenleme ve sorgulamak için ek araçlar kullanmak, deneyimsiz araştırmacılar için faydalı olabilir. Bu araştırmada, araştırmacı tarafından yapılan yorumlara sorgulamak için tarafsız bir referans noktası olarak VOSviewer veri haritalama programı kullanıldı ve bu programın eleştirel söylem analizinin netliğine ve kalitesine katkısı önemliydi. Bu araştırmada örneklemin belirlenmesinde de VOSviewer programı kullanıldı ve epistemik toplulukları alanyazında belirlemek ve 40 binden fazla makale ve 1,2 milyon alıntıdan temsili makaleleri amaçlı olarak örneklemek bu program sayesine mümkün oldu. Hem literatürdeki en etkili metinleri bulmak hem de araştırmmanın kapsamını bir araştırmacı için yönetilebilir tutmak için bazı eşikler (en az 25 ortak alıntı) kullanıldığından, bu araştırma kapsamında sadece birkaç epistemik topluluk yer aldı. Ancak bu eşikler değiştirilirse ve daha kapsamlı veri setleri analiz edilirse, fen ve ilköğretim fen eğitimi alanyazının daha fazla epistemik topluluk yapılacak araştırmalar sayesinde alanyazında belirlenebilir. VOSviewer'in yanı sıra, araştırmacılar için çok sayıda bibliyografik ve metin analiz programı hızla kullanıma sunuluyor. Şu anda bazı dil ve biçim kısıtlamaları olsa da bu programların yararı alanyazındaki bulgularla ve bu çalışma ile kanıtlanmıştır bulunmaktadır.

Fen eğitiminde araştırmacılar kendilerini doğa bilimleri ile sosyal bilimleri birbirine bağlayan bir rolde bulurlar. Bu eşsiz bir roldür çünkü ne kadar farklı görünürlерse görünsünler her iki alan da birbirinden faydalananabilir. Bu araştırma, epistemik topluluklar çerçevesinin uluslararası ilişkiler literatüründe geliştirilmiş olmasına

rağmen eğitim araştırmacıları tarafından rahatlıkla kullanılabileceğini göstermiştir. Ayrıca, epistemik toplulukların eğitim araştırmalarında önemli bir rolü vardır. Bu açıdan söylemin rolü büyüktür. Bu araştırmmanın bulgularının da desteklediği gibi, epistemik toplulukların söylemsel seçimlerinin fen ve ilköğretim fen eğitiminde önemli bir etkisi vardır ve bu etkilere dikkat edilmelidir. Bu bulgu, eğitimin tüm alanlarına kolaylıkla genellenebilir. Bu araştırma, araştırmacılar olarak ürettiğimiz bilginin ve bu bilgiyi söylemsel seçimlerimizle nasıl ürettiğimiz ve sunduğumuzun herhangi bir alanın geleceğini etkilediğine dikkat çekmektedir. Ne kadar ömensiz görünüşünler de söylemsel seçimlerimizin bazı sonuçları olacak ve gelecek nesil araştırmacıların çalışmalarını etkileyecektir. İster yerleşik terminoloji ister iletişim normları olsun, araştırmacılar olarak hepimiz, üyelik kazanmak için daha önce kurulmuş epistemik toplulukların söylemsel tercihlerine uyarak kültürlandıktır ve önceden belirlenmiş bu terminoloji ve normları kullanmayı benimsedik. Bizim kuşağımız tarafından yeni terminolojileri ve iletişim normları oluşturulurken, yeni kuşak araştırmacılar da bizim yarattığımız söylemlere üyelik kazanmak için aynı süreçten geçeceklər. Bizi eleştirdiklerinde veya kendi benzersiz yollarını keşfettiklerinde bile, yeni nesil araştırmacılar ilk önce, söylemsel seçimlerimizin yarattığı güç hiyerarşilerinin üstesinden gelmek durumunda kalacaklar. Bu araştırma, epistemik toplulukların söylemsel seçimlerinin topluluk üyeliği ile ilgili karar verici mekanizmalar olarak hareket edebileceğini gösterdi. Bu nedenle, araştırmacılar bu sorumluluğu hafife almamalı ve söylemsel seçimlerinin sonuçlarına dikkat etmelidir. Alternatif olarak, söylemsel seçimler de epistemik topluluklara üyelik kazanmanın anahtarı haline gelebilir. Yeni araştırmacılar, epistemik topluluklar tarafından desteklenen söylemsel seçimlere uyarak ve iletişim terminolojilerini ve normlarını benimseyerek, literatürde yer alma ve tanınma ve hatta toplulukların söylemsel seçimlerini etkileme fırsatları bulabilirler. Ancak, bu tür eylemlerin arkasındaki niyetler ve farkındalık, alanda gerçek ilerlemeyi sağlamak için açık ve kalite odaklı olmalıdır. Söylemsel seçimlerimizde fazla konformist olmak, alanda kendini tekrarlama riskini taşır ve radikal olmak, alan tarafından kolayca reddedilmek ve önceden edinilen bilgilerden yararlanma fırsatlarını kaçırıkmak gibi bazı riskler de taşıyabilir. Mütevazı görüşüme göre, herhangi bir alanda eleştirel bakış açılarını kullanan araştırmacıları vurgulamak hem yeni araştırmacılara hem de alanın

uzmanlarına, söylemsel seçimlerinin etkisi ve kapsamı ve bunların arkasındaki nedenler üzerinde düşünmeleri için yardımcı olabilir.

Önde gelen diller ve bilişsel bilim araştırmacılarından biri olan Steven Pinker (2008), 'The Stuff of Thought' adlı kitabında, bir sigorta belgesindeki bir kelime seçimi olan 'olay'ın ve bu kelimenin anlamının farklı yorumlarının nasıl üç büyük milyar dolar değerinde olabileceğine bir örnek verir. Söz konusu belge, yıkıcı bir 'olay' olması durumunda sigorta şirketinin Dünya Ticaret Merkezi sahibine üç büyük milyar dolar ödeyecekini söylemektedir. Ancak, 11 Eylül'de yaşananları, kaçırılan iki uçağın Dünya Ticaret Merkezi'nin kulelerine çarpmasını tek bir olay olarak mı yoksa iki ayrı olay olarak mı değerlendirmek gerektiği konusunda sigorta şirketi ve avukatların görüşleri farklılık göstermektedir. Bu örnek, belirli bir kelimeyi kullanma seçimiyle bile, iletmek istediğimiz anlamın farklı yorumlanabileceğini ve bunun önceden tahmin edilemeyen bir sonuca yol açabileceğini göstermektedir. Fen eğitimi araştırmacıları olarak söylemsel seçimlerimizin ilk bakışta herhangi bir parasal değeri yok gibi görünmektedir, ancak bu bile tartışmalı bir varsayımdır. Bununla birlikte, hepimizin hemfikir olabileceği bir görüş, söylemsel seçimlerimizin önemli olduğunu söylemektedir. Çabalarımızın ürettiği bilginin kalitesini sağlamak için etkileri, alanımızdaki tüm paydaşlar tarafından sürekli olarak araştırılmalı ve eleştirilmelidir. Nihayetinde, söylemsel seçimlerimize dikkat etmezsek, güç mücadelelerinde yolumuzu kolayca kaybedebiliriz.

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