THE ROLE OF ARGUMENTATION THEORY IN SCIENTIFIC REASONING AND SCIENCE EDUCATION

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

BY

GÜLDEN ALAZ MERİÇ

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF MASTER OF ARTS
IN
THE DEPARTMENT OF PHILOSOPHY

SEPTEMBER 2019

Approval of the Graduate School of Social Sciences

Assoc. Prof. Dr. Sadettin Kirazcı
Director (Acting)

I certify that this thesis satisfies all the requirements as a thesis for the degree of Master of Arts.

Prof. Dr. Şeref Halil Turan
Head of Department

This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Arts.

Assoc. Prof. Dr. Aziz Fevzi Zambak
Supervisor

Examining Committee Members

Prof. Dr. David Grünberg	(METU, PHIL)	
Assoc. Prof. Dr. Aziz Fevzi Zambak	(METU, PHIL)	
Assoc. Prof. Dr. Mehmet Ali Dombaycı	(Gazi Uni., FG)	

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Last name : GÜLDEN ALAZ MERİÇ

Signature :

ABSTRACT

THE ROLE OF ARGUMENTATION THEORY IN SCIENTIFIC REASONING AND SCIENCE EDUCATION

Meriç, Gülden Alaz
M.A., Department of Philosophy
Supervisor: Assoc. Prof. Dr. Aziz Fevzi Zambak
September 2019, 99 pages

This thesis analyzes Argumentation Theory within the context of science education. Within this thesis's purpose, foundations of Argumentation Theory together with the theory's main elements are also explained. The role of Argumentation Theory is approached in two aspects, namely the philosophical aspect and the educational aspect. In the philosophical aspect, it is questioned whether some reformations in Argumentation Theory is needed for adapting it for science education. In the educational aspect, it is explained that how we can use Argumentation Theory as a tool for a new type of science education. Throughout the thesis, it is defended that argumentation-based science education is beneficial for students in terms of learning scientific content, remembering what is learnt in longer periods with comparison to the traditional way of learning that is not argumentative, and learning how to argue.

Keywords: Argumentation Theory, Science Education, Informal Logic

ÖZ

ARGÜMANTASYON TEORİSİ'NİN BİLİMSEL AKIL YÜRÜTMEDEKİ VE FEN BİLİMLERİ EĞİTİMİNDEKİ ROLÜ

Meriç, Gülden Alaz
Yüksek Lisans, Felsefe Bölümü
Tez Yöneticisi: Doç. Dr. Aziz Fevzi Zambak
Eylül 2019, 99 sayfa

Bu tez Argümantasyon Teorisi'ni fen bilimleri eğitimi bağlamında analiz etmektedir. Tezin amacı içerisinde Argümantasyon Teorisi'nin temelleri ve ana unsurları da açıklanmaktadır. Argümantasyon Teorisi'nin rolüne, felsefi ve eğitim bilimsel olmak üzere iki açıdan yaklaşılmaktadır. Felsefi açıda Argümantasyon Teorisi'nin fen bilimleri eğitimine uyarlarken yeniliklere ihtiyaç olup olmadığı sorgulanmaktadır. Eğitim bilimsel açıda ise Argümantasyon Teorisi'nin yeni bir fen bilimleri eğitiminde bir araç olarak nasıl kullanılabileceği açıklanmıştır. Tez boyunca argümantasyon temelli fen bilimleri eğitiminin öğrencilerin fen bilimleri dersinin içeriğini öğrenmeleri, öğrendiklerini argümantasyon temelli olmayan bir eğitime kıyasla daha uzun süre hatırlamaları ve nasıl tartışmaları gerektiğini öğrenmeleri konusunda fayda sağladığı savunulmaktadır.

Anahtar Kelimeler: Argümantasyon Teorisi, Fen Bilimleri Eğitimi, Enformel Mantık

To my precious grandmother, Saadet Akyüz, who always encourages me whenever I feel insecure, listens to me whenever I tell something, and is always there for me whenever I need.

ACKNOWLEDGMENTS

I would first like to express my sincere thanks to my supervisor Assoc. Prof. Dr. Aziz Fevzi Zambak for supporting me during my master education. I will never forget his never-ending patience, motivation, and guidance during this period of my life. I would especially like to thank him for reminding me that everything is under control whenever I feel exhausted because of trying to write my thesis while coping with the difficulties of my life, especially in my workplace.

I would also like to thank my dear parents who always encouraged me for my choices, even I dropped out Faculty of Veterinary Medicine seven years ago. I know I made them worry but now I can feel their proud.

Last year, I started to work as a high school philosophy teacher at a private school, and I conducted the philosophy club. Here, I met five amazing, open-minded children: Ayşe Hale Bulut, Nehir Güler, Saide Defne Kantemir, Selen Güneş Köse, and Ahmet Levent Zengin. I would like to thank for their cheerfulness, kindness, and emotional support.

To my best friends Aygen Ecevit, Gökçe Topuz, Müveddet Esra Ulaş, and Gizem Ezgi Varol, I would like to express my gratitude for their deep understanding. They never judged me even I couldn’t call them or see them for long periods. I always knew that they understood me and I always felt blessing.

And my fluffy, lovely, and cute cats, Zeytin, Karamel, Bülent, and Seyhan... I would like to send my apologies for not being able to play with them especially in the last three months. It was difficult to resist their cuteness while I was studying.

Finally, I would also like to thank my fiancé, İlyas Can Hergül for his love, connection, and being my soul mate. He always makes me laugh and fall in love every day.

PREFACE

Argumentation, a reason guided and social activity, is an effective tool for representing the ideas, thoughts and knowledge in a structured manner and it has been a significant issue wherever an act of communication occurs. Its effectiveness is a result of its controllability, its standardized structure, and its objectivity: all those features enable us to approach this theory in a formal way. Thanks to this formalism it is the most significant tool for construction, representation, and transfer of the ideas, thoughts, and knowledge. Within its development, it has been understood that communication is a complicated act so is the argumentation, and at that point, the significance of the context came to light.

In this thesis, argumentation in the context of education is examined. The topic is narrowed down to the relation of argumentation and science education for several reasons. Firstly, science is one of the most difficult subjects for students since it is full of concepts, their relations and problems. It is a challenging activity both for the students and for the teacher because it involves all classroom into the learning process: this means that here the teacher is not just an information-giver in front of a group of silent, passive students. Instead, the teacher has a crucial role to check whether the information flow is all right. In this situation "persuasion" is not the only important part negotiation is also important. Secondly, science is an area which includes proven theories and even within this certainty, it is open to change because science is a dynamic and social area. These two features, being dynamic and social, correspond to the nature of argumentation. Thirdly, science necessitates a careful reasoning. Therefore, as a structured and formalized activity, argumentation is very closely related with scientific thinking.

Within this purpose, Argumentation Theory will be examined in two main aspects namely philosophical and educational. In the philosophical aspect of Argumentation

Theory I will question whether we need some reformations in Argumentation Theory for adapting it for science education. In the educational aspect I will inquire that how we can use Argumentation Theory as a tool for a new type of science education.

Since this tool provides a standardization, there is a type of logic peculiar to Argumentation Theory: informal logic. Argumentation Theory shows that the models within the formal logic is insufficient in terms of learning stages in a social environment. Learning includes certain stages such as reasoning and understanding. I claim that formal logic the models and the methods of formal logic are not sufficient for covering the reasoning and understanding stages of learning. Moreover together with learning, argumentative intuition which is a peculiar feature of human mind should also be taken into the consideration. To reveal this intuition, a philosophical approach is needed. Therefore Argumentation Theory should be more than formal logical techniques.

Unfortunately, science is thought in a way in which students are not active and social. They listen to their teachers, take notes, and are measured and evaluated by the exams which can be solved by learning the formulas and definitions by heart. Questioning what is given or constructing and expressing their ideas in front of the others are ignored in this context, despite the fact that these are the most important activities of scientists.

It is well known that science has sub branches such as physics, chemistry, and biology and this sub branches have their own sub branches. But in this thesis, all natural sciences are taken together and it is tried to present a standardized method to approach scientific topics. What should be taught to the students according to their levels is a topic that must be focused by scholars of the educational sciences. But how a curriculum of science lectures should be designed argumentatively is the problem of philosophy scholars.

The role of argumentation in scientific reasoning and applying argumentative way of science education is an interdisciplinary research area and this thesis aims to show the philosophical foundations of the relation between argumentation and science education. Within this purpose, this thesis has five main chapters.

In the first chapter, Argumentation Theory within its general parts are introduced, together with the different types of argumentation and the history of the theory. The basic definitions are given in the first chapter in order for the reader to follow the subject with a clear mind. Different types of argumentation are also given in order to explain what makes an argument in a certain context different. That is to say, why there is a need for classifying arguments as "such-and-such arguments". The history of the theory is beneficial for the reader to see how the Argumentation Theory evolved throughout the years. Within its history, it is shown that how the logic that is peculiar to Argumentation Theory is developed. This type of logic is informal logic which is more than the validity and the structure of the arguments. Meaning and expressions are very important parts of the informal logic.

In the second chapter, the main theme of this thesis, scientific argumentation which is just mentioned in the first chapter is explained in detail. One of the most important objective of this chapter is to show how argumentative way of teaching and learning correspond to the nature of science, which is social, dynamic, innovative and open to change. This chapter also introduces the contemporary claims on argumentation in science classrooms together with the methods that are adopted by the educational scientists to produce strong arguments. It is significant to present the theories and methods from the related literature in order to show how this issue is focused on and how it is open to development. The other substantial goal of this chapter is to present the difference between the traditional, teacher-lead education and the argumentative education in order to clarify how the traditional way of education goes against the nature of science: the traditional way of education passivates the students by not encouraging them to question what is given them and by compelling them learning everything by heart. In this chapter, the philosophical foundations of argumentation, including the methods on how to detect arguments is also explained in detail.

The third chapter is designated for one of the positive outcomes of Argumentation Theory: critical thinking. As it is mentioned and will be explained in detail in the first chapter, science is a social activity but at the same time it is reflexive which means that during scientific argumentation the learners question and react to the others (social part), and contemplate on their own thoughts (reflexive part). Although critical thinking is given as a separate lecture in some schools, in the third chapter it is underlined that in an argumentative way of education, critical thinking skills develop automatically.

The fourth chapter is to present the argumentative practices which are theorized in the second chapter. In this chapter there is a field study that is conducted by the educational scientists and this study is very beneficial to show the role of Argumentation Theory in scientific reasoning. In this chapter, how this enlightening study is improved with a philosophical approach is detailed. The fourth chapter is the place where the two main aspects, the philosophical and the educational, is taken into consideration together by indicating how these aspects interact.

The last chapter is the conclusion in which what has been stated in the thesis is summarized, and the conclusory remarks such as the future of this theme is presented. As an ever-developing research field, Argumentation Theory enables the researchers to concentrate on different topics. A philosophical touch to this theme which has long been focused by the faculty of education will hopefully reveal a more durable theory of argumentation in the educational context and its practice in the science education will ensure more permanent scientific knowledge.

TABLE OF CONTENTS

CHAPTER 1

INTRODUCTION

This chapter explores the foundations of Argumentation Theory. For this purpose, characteristics of argumentation, such as its key components and aims, will be analyzed. Although the study of argumentation can be said to be a new and developing field that is the focus of scholars of various disciplines, such as philosophy, linguistics, the social sciences, logic, and the cognitive sciences, its roots can be traced back to the ancient Greeks. So, in this chapter, the history of argumentation will be covered. As the types of argumentation can vary by the context, these types will be briefly explained. The core subject of this thesis, scientific argumentation, will also be introduced here, together with its relation to the domain of philosophy, in the context of education**.**

1.1) Defining Argumentation

Before defining argumentation, it would be beneficial to define argument, the main constituent of Argumentation Theory. Here, it is crucial to decide which sense of the term *argument* should be used. The first sense of argument is the way it is used by logicians: it is a set of propositions which consists of one or more premises, used to ground a claim, and a conclusion which is reached through the premises (Walton, 1990). This is the formal sense of argument, whose most important aspect is consequential validity: whether the given propositions reasonably lead to the conclusion. The other sense, however, is not understood only as the premise-conclusion relation; rather, argument here refers to the claims made by people when discussing, discovering knowledge, and creating social truths in various contexts (Rowland 1987, and Binkley 1995). Argumentation Theory is the study of this interpersonal sense of argument. The formal aspect of this interpersonal sense should not be ignored. Whatever the situation is, an argument varies with its disposition that includes a consequence statement, and at least, a way of justification.

The dictionary definition of argumentation is: **“**The action or process of reasoning systematically in support of an idea, action, or theory.” (Oxford, n.d.). As the definition suggests, argumentation, in everyday language, is an activity that has a purpose of contributing to a statement and is done in an idiocratical way, i.e., with an organized plan. According to Frans H. van Eemeren, however, the meaning of argumentation in its technical sense should be further clarified because the notion requires the analysis of technical terms (2010). Nevertheless, a general definition of this technical sense can be given: a verbal, rational, and social activity which has the aim of convincing people of a position, either by justifying the proposition expressed in the standpoint or by refuting the opposing standpoint (van Eemeren & Grootendorst, 2010). Argumentation is verbal, since it cannot be ratiocinated without specific language because daily language is not argumentative by its nature; it is rational since it necessitates careful, intellectual considerations, and it is social because there is an aim of expressing one’s claim to another in a dialogic process (Kuhn & Udell, 2003; Goldstein, Crowell,& Kuhn, 2009; van Eemeren &Grootendorst, 2010). Here, a question might arise: can we not present an argument to ourselves, e.g., to aid in making a decision? To present an argument to ourselves is a self-reflective activity. In order for an argument to be a part of an argumentative practice, this argument must be expressed in the presence of at least one person other than ourselves. That is to say, constructing an argument or thinking carefully on arguments are not taken as argumentation unless they are expressed to other people. To clarify, it would be beneficial to present a term that is associated with argumentation: reasoning. Govier’s (1989, P.117) explanation of reasoning distinguishes reasoning from arguing as follows: “Reasoning is what you may do before you argue, and your argument expresses some of your (best) reasoning. But much reasoning is done before and outside the context of argument.” As it is clearly seen in this explanation, although reasoning and argumentation are closely related to each other, reasoning is a step in argument construction, while argumentation is the practice in which we express our claims and reasoning.

Another definition of argumentation, presented by the Polish School of Argumentation, is a reason-guided activity that is shaped by the rules and principles of logic (Budzynska, Araszkiewicz, Bogolebska et al, 2014). Although there is an emphasis on logic here, it is strongly suggested that validity alone is not enough to make a strong argument—trust is also an important factor, since arguments contribute to many institutional aspects of social life.

When the main points of these definitions are banded together, the context in which argumentation occurs has a crucial role. There is no standard way of convincing people or establishing trust; instead, methods change in accordance with the context of the claim. The difference between formal logic and Argumentation Theory is also important; the former is about reaching a conclusion using the data available, the premises, and the latter is about defending a claim and convincing people, using various methods, of the truth of the claim; it also necessitates a degree of intuition, which is the very element that complicates the argumentative activities in several contexts.

1.2) Types of Argumentation

The significance of context in argumentation can be seen in the different types of argumentation, since, in these types, goals and the ways to reach these goals change accordingly. As van Eemeren and Houtlosser (2009) express, different kinds of activity types depending on the sphere they take place (e.g., personal, public, technical) generate different types of arguments. That is to say, as there are numerous contexts, so too can there be numerous types of argumentation. It would be beneficial to briefly explain the major ones, those that have been studied the most.

1.2.1) Conversational Argumentation

Conversational argumentation is a branch of communication theory, and it is based on discourse analysis. Conversations progress in accordance with participants' intentions. That is to say, there is no fixed time interval or order of speaking in conversations, as there is in debates or other forms of formal speaking activities. Arguments of conversations are identified by specific points: the adjacency pair, which refers to the pragmatically related pairs that form from the conversation (e.g., question/answer, request/refusal), objection to or support of an utterance, comprehensibility of the propositional content for the supporting or the objecting claims, and performance (extension to the proposal itself). So, in order to identify conversational arguments, cognitive processes should be considered: apart from the premise/conclusion relation, which element has the most important role, the speaker's intention, implication, or meaning (Jackson & Jacobs, 1992)?

1.2.2) Legal Argumentation

In this type of argumentation, the focal point is whether the arguments justify a point that is acceptable in terms of general and legal standards. The study of legal argumentation is a normative and descriptive one, which means, on the one hand, the theoretical model for acceptable argumentation should be developed, and, on the other hand, it should be agreeable in legal practice (Luhmann, 1995). Since every community has its own legal practice in accordance with its social norms, legal argumentation is shaped accordingly. The common point is that there are rules, and the conclusions are deduced from certain general rules that structure each practice. This sort of argumentation consists predominantly of written arguments.

1.2.3) Political Argumentation

Political argumentation is examined under the branch of *political discourse analysis* since arguments produced by politicians are open to the public in political discourses. The recipients in this public sphere are the masses. So, in political argumentation, depending on the circumstances, it is possible that there are thousands of people who produce arguments. In this type of argumentation, people are categorized as political agents and have specific roles as politicians, citizens, voters, etc., and the political context together with these roles determines the particular aims and goals of political argumentation (van Dijk, 1997). Since these arguments are open to the public, political arguments are shaped accordingly. Therefore, in this context, there is also the influence of public liability on argumentation.

1.2.4) Mathematical Argumentation

In light of van Eemeren and Grootendorst's aforementioned definition of argumentation, mathematical argumentation, together with scientific argumentation, is directly associated with educational science (2010). In the classroom environment, students are encouraged to build claims and support them with evidence while listening to others' claims and responding to them appropriately. The role of teachers in the application of mathematical argumentation is to introduce some basic content and then help students to participate in the learning process to acquire related knowledge (Ayalon & Hershkowitz, 2018).

As elaborated throughout this thesis, proponents of scientific argumentation have motivations and goals similar to proponents of mathematical argumentation motivations. However, the most important difference between scientific argumentation and mathematical argumentation is the latter's greater dependence on axioms and theorems. Unlike the objects of science, mathematical objects are abstract. Science enables observations and experiments, while mathematics is operational. So, in order to construct the foundations of mathematical argumentation, it is necessary to first introduce assumptions.

1.2.5) Scientific Argumentation

The primary element of this thesis, scientific argumentation, is briefly defined by Sampson and Schleigh (2013): "(...) an attempt to validate or refute a claim on the basis of reasons in a manner that reflects the values of the scientific community.". Here, the characteristics of argumentation, such as being a verbal activity that relies on reason, are examined. The social side of argumentation is also seen in this definition in two ways: by engaging in the activity of supporting or rejecting a claim, and by associating those claims to already-accepted findings.

As with the other types of argumentation, only introductory information about scientific argumentation is included in this chapter. After defining the theory and introducing the most prominent types of argumentation, it will be beneficial to focus on the history of Argumentation Theory in order to show its roots and development.

1.3) History of Argumentation Theory

Based on the current literature on argumentation, van Eemeren's and Grootendorst's (2010) approach to Argumentation Theory which is the most effectual one, which involves the following definition is: "Argumentation is a verbal, social, and rational activity aimed at convincing a reasonable critic of the acceptability of standpoint by putting forward a constellation of propositions justifying or refuting the proposition in the standpoint."

Van Eemeren and Grootendorst entitle their paradigm *the pragma-dialectical approach* in which argumentation is examined in real-life practice and not seen as a mechanical process. According to this approach, the quality of an argumentative discourse is correlated with the quality of the communication and interaction between the participants.(2010) It should be emphasized, however, that there are other substantial approaches and developments in the theory that were shaped before this approach. Indeed, the roots of the theory can be traced back to antiquity. The roots and the development of Argumentation Theory will be examined in four parts: the roots of modern Argumentation Theory in Aristotle's works, Lvov-Warsaw School, the founders of Argumentation Theory, and the need for the pragma-dialectical approach.

1.3.1) Modern Argumentation Theory and Aristotle

In order to avoid misunderstanding, it would be beneficial to note that Aristotle had never mentioned the Greek equivalents of the terms *argument* or *argumentation* in his known works nor had constituted a theory of communication. Nevertheless, Aristotle, especially his three treatises, are the strong and influential sources of modern Argumentation Theory. These three treatises are the *Topics*, *On Sophistical Refutations*, and the *Rhetoric* (Rapp & Wagner, 2012).

The *Topics* is basically about the conclusiveness and validity of claims. In this treatise, the focal point is the dialectical analysis of philosophical theses in terms of *endoxa*[1], and *paradoxa*[2]. In *On Sophistical Refutations*, incorrect and deceptive claims, i.e., the fallacies, are analyzed systematically. The *Rhetoric* is on persuasiveness and the type of persuasion that is considered proof. Persuasion is described in terms of *syllogismoi*, i.e., deductive arguments. But the *Rhetoric* refers to persuasiveness only in the context of public speaking, such as speeches in the political arena, in courts, and at funerals (Rapp & Wagner 2012).

These three treatises of Aristotle, as Rapp and Wagner suggest, cast light upon modern Argumentation Theory in terms of finding and constructing premises,

---

[1] This term can be understood as "acceptable premises".

[2] It is used as the opposite of *endoxa*.

evaluation of accepted opinions, and explanation of the factors of the persuasion process (2012). So, although being in a restricted context, i.e., specific types of public speaking, it may be said that argumentation has been a significant issue wherever there is social activity in which ideas are being shared.

1.3.2) The Lvov-Warsaw School

The Polish School of Argumentation is one of the most famous places where contemporary Argumentation Theory research is conducted by researchers from various disciplines. As stated in their school's manifesto, they have their origins in the Lvov-Warsaw School (LWS) (Budzynska, Araskiewicz, Bogolebska et al., 2014).

The LWS was established at the end of the 19th century by Kazimierz Twardowski, whose main motivation was to organize a strong philosophical circle and to build the area of scientific philosophy in Poland. The curriculum Twardowski shaped included formal logic, semantics, and the methodology of science. For philosophy to be irreproachable, Twardowski thought that it must follow an axiomatic path with clear concepts and evident principles in order to acquire objective truth. That is to say, philosophy, according to Twardowski, was a science that advances through logic in its broader sense (formal logic which mainly focuses on argument validity, semantics and the methodology of sciences) which preserves its skeptical approach towards metaphysical problems and their scientific endeavors (Wolenski 2017,Wybraniec-Skardowska, 2018).

At LWS, the Philosophy of Science was one of the most important departments. The philosophers from the LWS paid attention to explaining the unity and rationality of science by demanding "that every rationally accepted proposition be intersubjectively communicable and testable" and rejected all forms of irrationalism. To this end, different philosophers had presented their own points of view in terms of methodology (e.g.Wladyslaw Witwicki was specialized in psychology, and Jan Lukasiewicz was interested in logic, as the first students of Twardowski; Ajdukiewicz lectured logic for mathematicians) but the common point was that philosophy as a science has its own logical structure, and it is rational by nature (Wolenski 2017, Wybraniec-Skardowska, 2018).

The LWS has had an important impact on Argumentation Theory. First, the emphasis on the linguistic analysis of the philosophical proposition had been seen as a necessity to setting the metaphysical arguments aside and has highlighted the positivist approach in philosophy. Second, concentrating on logic had strengthened scientific philosophy and had created a standardized methods. Currently, in high school curricula, philosophy and science are seen as two distinct areas, which creates the common belief that ability in one is far different from ability in the other. In high schools, the philosophy of science is more about the history of science, which is also an important area, presenting a view of different theories in a chronological order, but the reasons behind these different theories are not illuminated. Last, the rejection of all the forms of irrationalities paved the way to the identification of fallacies that lead people to nonsensical ideas. Thus, the LWS inspired the Argumentation Theory by laying the foundations of it, by gathering the scholars from different domains together and engaging them into communicative and academic practices, and by offering a standardization.

1.3.3) A Step from Formal Logic towards Everyday Language: Founders of Argumentation Theory

In complicated arguments of different contexts, rules and abstractions of formal logic remains incapable. The motivation behind the creation of an alternative to formal logic, was presented in 1958 by Toulmin in his presentation of a model of argumentation, which cited elements such as claim, data, and warrant, and came to dominate Argumentation Theory for years (Van Eemeren, Grootendorst, Johnson, Plantin, & Willard, 2009). In some circumstances (including argumentation in scientific education), this model is still used, so it will be detailed later in the related chapter.

Perelman and Olbrechts-Tyteca, in the *New Rhetoric,* developed the effective techniques of argumentation by relating it to the structure of reality with the intention of developing the value judgements. They differentiate argument from formal proof by indicating that while arguments call for justification and take place in the dialogical contexts, in formal proof, instead of justification, validity is the substantial factor. Moreover, the language of formal proof is artificial and abstract while the language of arguments is natural and factual (Perelman, 1971; Van Eemeren, Grootendorst, Johnson, Plantin, & Willard, 2009).

However, neither Toulmin's nor Perelman and Olbrechts-Tyteca's views satisfied the need for a comprehensive Argumentation Theory, as van Eemeren and Grootendorst claim, because of their failure to understand logic: at the end of the day, they all saw logic as deductive syllogistic logic and tried to shape their new theories by the means of old approaches. They also ignored the fact that argumentation is mostly a discourse phenomenon that occurs in social life and specific contexts. It therefore should have been evaluated in terms of linguistics (Van Eemeren, Grootendorst, Johnson, Plantin, & Willard, 2009).

1.3.4) Birth of Pragma-Dialectics

Although the founders of Argumentation Theory indicated that formal logic is not enough to account for argumentation in everyday language, they could not create a comprehensive and practical alternative. Before continuing with the pragma-dialectic approach, it would be beneficial to explain informal logic, since it is the huge step towards the standardization of arguments in social life and specific contexts rather than the formal domains.

The Informal Logic movement, started with the journal of *Informal Logic*, first edited by Blair and Johnson in 1978, and since then the journal has published articles about Argumentation Theory. It is not a different kind of logic, instead, informal logic is a normative approach to argumentation in everyday language. The definition of validity in informal logic is different from the one used in formal logic. As first stated by Blair and Johnson, premises in informal logic must be i) relevant, ii) sufficient, and, iii) acceptable. Informal logic was a crucial step towards the pragma-dialectical approach with its new relation between the premises and the conclusion (Van Eemeren, Grootendorst, Johnson, Plantin, & Willard, 2009). Today, proponents of informal logic focus on the principles of communication, non-verbal modes of arguing as well as the verbal modes, different kinds of argumentative dialogues, accepitibility of premises in terms of their justification, informal validity which means more than the formal relation of premises and conclusion, and the effects of the audiences in an argumentative practice (Groarke, 2019).

Together with the informal logic movement, the formal theory of fallacies, i.e., errors in reasoning, by the Canadian logicians Woods and Walton was influential for the pragma-dialectical approach. They explained the principles of fallacies in their book *Argument: the Logic of the Fallacies* in 1982. Their approach to fallacies is plural, meaning that not all fallacies can be analyzed in the same way; however, for the sake of formality, they developed a methodology: fallacies must be analyzed in a comprehensive logical system which includes the systems of dialectical logic (Van Eemeren, Grootendorst, Johnson, Plantin, & Willard, 2009).

The first attempt to create a pragma-dialectical model of argumentative discourse resulted in an ideal model of critical discussion. This model was dialectical because it included the exchange of arguments. It was also pragmatic because argumentative actions in this kind of discourse were functional speech acts. The model had 4 stages: i) confrontation, in which differences of opinions emerge, ii) the opening, which characterizes the starting points, iii) argumentation, in which the exchange of reasons occurs, and iv) the closing, where the outcomes of a discussion are found

(Van Eemeren, Grootendorst, Johnson, Plantin, & Willard, 2009; van Eemeren & Grootendorst, 2010).

There were, however, some questions which cannot be answered by the ideal model of critical discussion such as how it is possible to know what kind of arguments are produced and how this theory can explain the effect of different contexts on argumentative discourses. These questions brought the importance of empiricalization, contextualization, formalization, and conventionalization to light. The first one was to ensure the connection was made between Argumentation Theory and the reality in which the argumentative discourse takes place. In order to do that, both qualitative and quantitative researchers were consulted. Contextualization was the second development after the empiricalization. It entailed the consideration of the contexts where the arguments are produced. For a standardized application of argumentation, in order to explain the dynamics behind the argumentative practice in specific contexts, formalization has emerged (van Eemeren, 2015). Formalization is also significant in the need for computerization: researchers who focus on discourse analysis in the field of artificial intelligence are strongly interested in this step. Importance of formalization can be seen in AI research, as Bench-Capon and Dunne indicate: some of the issues of 21st century in the intersection of argumentation studies and artificial intelligence are argument schemes, computational models of natural argument, and a world wide web of argumentation (2007). The last step, conventionalization, is completion of three steps: when the relevance of an argument to the context is grasped, well-established, and the consequences of the argumentative context is foreseeable, it means that the argument is conventionalized. (van Eemeren, 2015).

To conclude, argumentation is a reason-guided and social activity, and it actualizes in communication as constructing, transferring, and sharing ideas, thoughts, and knowledge. This has been in use since the ancient Greeks. This chapter aims to introduce the general points and the elements of Argumentation Theory—its history and types.

Today, there are different types of argumentation that come into view as new focal points emerge. Each of these areas and focal points has their own protocols, and, as a result, communication is shaped accordingly. For instance, while conversational arguments are shaped in the course of dialogues, legal arguments are mostly presented in the written form, since the former is personal communication, while the latter is official and, especially with public prosecutions, is open to the public. These different types can be diversified as the different contexts occur, but they are introduced in this chapter to show that argumentative activity is not arbitrary, and, within different contexts, argumentation and reasoning change.

Argumentation is a challenging activity: the communication itself is a complicated practice because everyday language is far different from formal language. In this complicated environment, to attain a standardization is still necessary. As it is explained in this chapter, informal logic is used for this standardization wherever a communication activity occurs. Unlike the formal logic, informal logic takes meaning into consideration, and the use of the argument indicators depends on the context. Researchers who are interested in informal logic focus on the relations in real life and conversational environments. That is to say, informal logic is the way to detect and evaluate the arguments of the social domain.

As mentioned, Argumentation Theory is examined by different disciplines. Two of these disciplines are educational sciences and philosophy. The use of argumentation as a tool in the school environment is explicitly a concern of the educational sciences. Determination of the quality and the quantity of the information that should be given at a certain academic level is a significant issue for educational scientists. In the following chapters, it will be shown that the methods prepared for the purpose of argumentative education have deficiencies of their own. At this point, philosophy scholars are the ones who check the way the methods are implemented in argumentative lectures.

The theme of this thesis, the relationship between argumentation and science, is also a challenging area. Science is an innovative area in which many things have changed over time. Although the first thing that comes to mind when science is the subject is its certainty, the production and approach to scientific knowledge is not immune to change. Therefore, the informal logic of argumentation must be taken into the consideration during the preparation of an argumentative science curriculum.

Within all these challenges and the nature of science and argumentation, the interdisciplinary work of educational scientists and philosophy scholars is defended in this thesis to bring an effective, productive, and complete argumentative curriculum.

CHAPTER 2

ARGUMENTATION THEORY IN NATURAL SCIENCE EDUCATION

In this chapter, the core of this thesis, Argumentation Theory in natural science education, will be elaborated. There are important studies showing that argumentation-based learning in the class environment has several benefits. First of all, science is a social and progressive, therefore an argumentative, activity that has developed with the collaborations of scientists throughout the history of science, and this side should not be ignored in the classroom environment. Second, it makes it easier for students to learn scientific topics in the curriculum since students are active in the learning process. Third, it strengthens students' creativity in this collaborative and social classroom environment, leading to the acquisition of new perspectives. More important than these benefits, argumentative-based learning requires caution and suspicion towards what is stated as undeniably true. It includes an argumentative instinct; an instinct that should be explored. Argumentative thinking, at the most basic level, necessitates a standard method to identify arguments in a specific topic. This chapter will describe this standard method, the claims of the experts on the subject, and the content of the arguments in the natural sciences. Moreover, the crucial role of philosophy will also be covered, since, in order to arouse the argumentative instinct, a philosophical way of thinking should be developed.

2.1) Getting Inside Scientific Argumentation

From this section on, "scientific argumentation" refers to the application of arguments in the natural sciences. In a broad sense, scientific arguments are the claims that were just hypotheses before a great number of tests and observations were completed. When these tests and observations are enough to support an idea, the results are taken into consideration by experts, and, if there is nothing to invalidate the idea, it is accepted as a scientific theory: scientists are not arbitrarily form conclusions, they aim at generating explanatory and predictive theories and models of what they focus on (Sandoval, 2003). So, the first thing about scientific argument is its unbreakable bond with the data collected from observations and experiments. That is to say, scientific arguments are objective and predictive arguments, and they arise from research, trials, and approvals.

The other thing that should be emphasized is the universality of scientific arguments: a strong scientific argument is applicable anywhere because it has been verified and accepted by experts. With this feature, scientific arguments differ from the arguments in the domain of daily life, and the arguments from the social domain in which observations and experiments may produce different results depending on the culture, people, and time.

In science classes, validated hypotheses, theories, laws, or rules are taught as objective and universal, and because of these two main characteristics, objectivity and universality, it may be thought that the only way to teach students science is to give those scientific claims directly in accordance with the curriculum: delivered by textbooks and teachers to students. However, such a direct way of teaching and learning a scientific subject ignores one important point—all those scientific principles were once only ideas, and thanks to a successive path of constructing strong, validated, trusted scientific claims, they are now theories or laws. This successive path of constructing strong scientific, validated, trusted scientific claims is nothing but the scientific method. Everyone who has completed high school can write down the steps of this method by heart:

1) Identify the question that needs to be answered.

2) Perform background research.

3) Construct your hypothesis.

4) Test your hypothesis.

5) Collect data.

6) Examine the data.

7) Compare your hypothesis to the experiments' results and, if something is problematic, change your hypothesis until it becomes faultless.

Keeping the scientific method in mind, let us contemplate the intersection of philosophy and science. Philosophy is difficult to define because of the broad sense the term has. But as Wilfrid Sellars expresses "The aim of philosophy, abstractly formulated, is to understand how things in the broadest possible sense of the term hang together in the broadest possible sense of the term." (Philosophy Foundation, n.d.). As it is seen, philosophy, stereotypically, an occupation which includes difficult and inapprehensible ideas that were suggested by people called philosophers. The history of philosophy is filled with different ideas and different points of view, and all these ideas and points are valuable in their own way in the history of philosophy. That is to say, since the history of philosophy is not as progressive as science, it may be thought that the relationship between science and philosophy is incompatible. However, this approach towards philosophy is stereotypical and unfounded: In the core of philosophy there is *systematicity*, without which all those philosophical ideas and points of view would just be idle opinions that would be forgotten; there is *consistency*, without which trust cannot be determined; there is *critical approach*, thanks to which people are not doomed to dogma and trusting what they are told without question; there is *universality*,[3]

[3] Philosophical ideas are subjective and universal. They are open to criticism, but there will never be an objective philosophical theory since philosophical claims belong to people who produce them in a proper way. Scientific claims are objective and universal. They are also produced by people, but these claims are about the world that exists independently of people's minds.

which means all the ideas and points of view are open to evaluation by anyone; and most importantly, there is *curiosity,* which leads people to think, question, and search for an answer. In light of these points, let us turn back and delve further into the scientific method. First of all, the curiosity of the scientist is the first step toward the construction of a scientific claim. The second step, background research, must be a careful and elaborated part in which previous research on the issue is reviewed. The hypothesis is the scientist's first attempt to state a claim, but it is a temporary claim until it is carefully tested. The other steps, including data collection, examination, and result comparison, are the steps that must be done in order for a scientific claim to be universal, and if there is any inconsistency in any of these steps, a new hypothesis must be constructed.

The motivation behind a scientific question is very similar to a philosophical curiosity that comes to light in a critical manner. Moreover, the construction of a scientific claim is as systematic as a philosophical claim. There is always reasoning, as activities necessitate careful analysis and research, which is very far from passive learning, but, ironically, even the scientific method as a subject in the curriculum is given to students to be passively learned by heart.

Of course, science is precise while philosophy is postulational. Science is progressive, and it leaves old theories behind while philosophy is like an eternal pool of claims throughout history. Science is factual while philosophy is conceptual, but the intersection of these two domains should not be ignored because of the philosophical basis of science education: it is the argumentative way of learning science. At this point, even though there are almost certain claims that reflect the precision of a scientific subject, they can be grasped by students via the application of argumentation in a classroom environment. That is to say, even scientific claims are convenient for philosophizing, not within themselves, but within the methods with which they are applied.

2.2) Contemporary Claims on Argumentation in Science Education

It is natural that the experts may differ in terms of their focuses on the theory, but the common point, as Deanna Kuhn expresses, is that although mastery of scientific theories and concepts is important, learning how to engage in scientific discourse is equally important (2010). Argumentation Theory offers both teachers and students methods that make teaching and learning activities easier, unlike the traditional teacher-led education in which students are passive learners of "what has to be known" and the teachers are non-stop speakers who repeat the same bulk of information every year. Argumentation-based education gives students the active and leading role in learning by allowing participation in class activities, and it assigns the role of expeditors to teachers in this developing learning environment. Within this situation, teachers are able to see the problems and difficulties the students may have and solve them immediately without waiting until the exam period to see which students fail.

The literature on argumentation in science education is continually expanding. The theory is gaining importance as the success of actively learning students becomes evident. What should never be forgotten is that, in order to delve into scientific argumentation, a philosophical approach is necessary, since argumentation is not just a written set of rules that can be applied by anyone who can read them; it is a complicated practice and it contains many possibilities in itself (e.g. idea construction, and expression) depending on the subject. Otherwise, it would only be a simple debate activity in which the only goal for someone is to defeat the opponent. Of course, it does not mean that debates can never teach anything, but in this kind of situation, the only focus, victory, would engulf other achievements.

2.2.1) Argumentation Practice in Science Classes

Before delving into the philosophical foundations of Argumentation Theory, it would be beneficial to present experts' ideas of the argumentation practice in science education in order to see how challenging it is. This will be examined in two areas: the social aspect, which is the external part of the practice, and the cognitive aspect, which is the internal part.

2.2.1.1) Argumentation as a Diplomatic Negotiation: The Social Aspect

As Duschl and Osborne note, classical science education (education without argumentation) does not help students understand the subject, as it is controlled by the teacher and it focuses only on plain facts (2008). In this kind of education, information becomes something constant and closed to change, and learning becomes nothing but memorization. It is so ironic, since one of the most basic things to be said about science is its dynamism: scientific knowledge can always be changed by better scientific knowledge. So, any science environment should let more than one voice express an idea. Duschl and Osborne describe this kind of atmosphere as student-centered, in which science is taught as an inquiry into inquiry by focusing on "how we know." They claim that this kind of education addresses the epistemic goals (2008).

At that point, it would be beneficial to explain the epistemic goals of a lecture that attaches importance to "how we know." First, the process of information gathering is crucial since trustworthiness of the results depend on reliable resources. Second, the way students express their findings and share them with peers must be managed well. Do students ground their claims in a suitable way? Do they confront a problem while listening to others (e.g. becoming distracted, being unwilling to listen to others' claims)? Do they respond properly (e.g. objecting to the claims, not to the person) ? Third, the findings and the gained knowledge must be tested. Since it is a science lecture, the answers are definite, but this way helps students understand the answers and improve their social skills, as well, in this environment of productive discussion.

Duschl and Osborne (2008) also emphasize the impropriety of the “argumentation as war” metaphor. Instead, they define argumentation as a diplomatic negotiation. In the frame of science, at the end of the day, students must agree on one particular answer, but they reach this answer by themselves.

The social aspect of the argumentation activity, to sum up, brings students together to meet on a common ground of critiquing, problem solving, claim constructing, and expressing ideas to others, and this aspect accommodates to the nature of science. As Lemke (1990, p.9) expresses:

> *Talking science* means observing, describing, comparing, classifying, analyzing, discussing, hypothesizing, theorizing, questioning, challenging, arguing, designing experiments, following procedures, judging, evaluating, deciding, concluding, generalizing, reporting, writing, lecturing, and teaching in and through the language of science.

Therefore, the social aspect also arouses the curiosity of the students in terms of how they know and how people construct and defend their claims. Instead of learning what is stated by the teacher, which is not a way that encourages students to question anything, the students contribute significantly to their own learning process.

2.2.1.2) Delving into Reasoning: The Cognitive Aspect

As it has been stated, science starts with curiosity, a very basic and pure part of the human mind. When the learning process encourages passivity, however, curiosity might begin to wither. As a result, all the subjects in the curriculum, including the ones that emphasize the importance of active questioning and non-stop learning, might become unquestioned material without deep understanding. The cognitive aspect of the Argumentation Theory brightens the learning part of the activity.

Schwarz asserts that argumentation and learning form a complex relationship with at least two parts:

i) Learning to argue: This side of the argumentation and learning relationship involves learning to reason, to explain, and to challenge, together with learning to achieve a specific goal through argumentation.

ii) Arguing to learn: This side of argumentation represents the plan of the lecture in which a specific goal is fulfilled through argumentation. In the educational framework, the implicit goal of arguing to learn is to grasp or to construct specific knowledge (2009).

The benefits of argumentation result from its cognitive aspect, according to Schwarz. During argument generation, in solitary or in groups, students find a chance to contemplate given claims and see what there is behind them. After that, they feel the need to express their findings. The desire to present one's claim to others is taken as the "self-explanation effect." Argument generation in an argumentative activity, however, is even more effective. It is no longer sufficient for students to merely express themselves; it is also important to convince other students by listening to them and respond accordingly (2009). For instance, it becomes very important to catch others' contradictions and faults. This effect is called the accountability effect, in which the students have to explain themselves against contradictory opinions. So, as Schwarz says, argumentation practice brings students these cognitive gains (2009).

As for argumentation in science education, Schwarz makes some outstanding points. Assessing the alternatives, classifying the evidence, and evaluating the possible lifespan of a scientific theory are essential in scientific activity. There may be truths in science, but if it is forgotten that science is a social activity and its theories might be formed by various external factors, the evaluation will be deficient (Lemke, 1990; Duschl & Osborne, 2008; Schwarz, 2009). In the science classroom environment, students should be encouraged to evaluate all the possible claims and evidence that ground the claims while bearing in mind that they are engaging in a social activity, the subject of which also having been socially formed.

Schwarz also notes the difficulty students face during the argumentation activity in class. The first difficulty is about the concept of validity: students tend to take an argument as valid if they believe that the premise is true, even if the evidence is contrary to what they believe. Their beliefs have very strong influences on them. Secondly, the students may have confirmation bias and select evidence for their argumentation accordingly. So, strengthening their ability to evaluate evidence might be a challenge. The last difficulty Schwarz explains, is also related with the evidence part of argumentation. Students tend to jump to a conclusion before they have enough data to support their claim (2009).

Schwarz presents both the benefits and challenges of an argumentative-based science learning. As the benefits show, it is very important to provide students such an educational environment in which they feel free to contemplate the theories and express their opinions in the presence of others. However, this activity is not as easy as it is expressed. There are many important challenges related to it, and these challenges show that a philosophical point of view is necessary for this kind of task.

The challenges can be listed as such: how to detect a valid and strong argument while avoiding the fallacies, how to find trustworthy justifications, how to reach a conclusion, and how to generate a proper argument. Of course, the social and cognitive sides of Argumentation Theory reveal the benefits and the philosophical aspect of the theory, but what should be done for the sake of the process is to present a standard way for both argument detection and argument generation.

2.3) Argument Detection: The Philosophical Foundations of Argumentation Theory

So far, it has been emphasized that students' activities in their learning processes are beneficial in social and cognitive terms. Argumentative-based learning in scientific education offers this activity and provides students with significant advantages. In order to make use of these advantages, a method to detect the arguments in the subject is necessary. In this part, a general method to do so by Alec Fisher will be presented.

Fisher's method (2004) aims to show that an active way of learning does not require a deep understanding of the subject. To know as much as possible is favored by passive learning in which the learner takes what is given to them by the teachers or the experts (Fisher, 2004; Knight& Wood, 2015). Such passive learning, relying on the experts, impairs the imaginative and creative part of the learners, and requires them to learn everything by heart. In active learning, however, the most important thing to be done is to identify the arguments, to evaluate them, and to see the reasons why one should trust these arguments through a chain of reasoning. Fisher (2004, p.1) draws an analogy between the formation of the argument and riding a bike: "at first it may feel challenging, but, once it is achieved, it will be seen how far one can move forward without too much effort."

Fisher's method (2004) basically focuses on the written arguments of the experts, the *real* arguments as he describes, and extracting the arguments from the relevant texts. For these purposes he uses some key components of the arguments such as *reason, conclusion,* and *establishment*. However, as he expresses, these key components can be grasped in the activity itself, so it is not necessary to explain them in detail. To be active as much as possible in the learning process requires learning the key components during the learning activity (Fisher, 2004).

At this point, it should be again notes that argumentation activity is a method different from the applications of formal logic, in which the procedure progresses within the rules of the truth tables and formulas. The argumentation activity is closely related with the arguments in everyday language, so this activity is under the branch of informal logic: the arguments are not crystal clear as they are in formal logic. Therefore, the clues to identify arguments, the argument indicators, should be taken into consideration.

Fisher's method (2004) is simple and easy to follow. Firstly, one should read the expert's text very carefully and circle all the argument indicators throughout the text: conclusion indicators, reason indicators, and hypothetical indicators.[4] The next step is underlining the conclusions that are clearly stated (conclusion indicators) and similarly bracketing the reasons for them. After identifying these conclusions, one should identify the main conclusion and mark it *C*. There may be more than one main conclusion. Then, the reasons that are presented in the text to accept *C* should be ascertained. At that point the questions such as, "Why, in this text, am I asked to believe in this conclusion?" should be asked. This step can be challenging, especially when the author's intentions are not clearly understood. When such a challenge occurs, Fischer offers readers a question to ask, which he calls the *Assertibility Question (AQ)*: "What argument or evidence would justify me in asserting the conclusion *C*? (What would I have to know or believe to be justified in accepting *C*?)" (Fisher, 2004, p.22).

AQ invites the readers to think carefully about the issue they are reading: it is a way to make them active in the learning process. AQ may be answered in two different ways: i) findings to justify the author's claims may be the same as what is expressed in the texts, or ii) findings to justify the author's claims show a difference with what is expressed in the text. If the second way results, then it can be said that there is no way to reconstruct the author's arguments as an extracted argument list. However, if the reasons are clearly stated in the text for every conclusion *C*, or if the findings to support author's claims are the same as what is expressed in the text, then one should write those reasons down until the main reasons are reached. (Fisher, 2004).

Fisher (2004) states that understanding an author's argument that is not clearly indicated by the argument indicators greatly depends on the person's ability to judge

[4] The list of the argument indicators is given in the appendix.

and the person's argumentative instincts. Moreover, it depends on the person's prior knowledge about the issue, as Fisher also expresses (2004). Here, it may be said that at one point, the reader must know about the subject beforehand, but Fisher never claims that one may never need any knowledge to learn by argumentative activity. Depending on the context, prior knowledge may be beneficial during the argument evaluation activity and looking deeper into the subject. However, the most significant point of Fisher's method is the way it makes learners' minds active, and by doing so, Fisher aims to get the reader to adopt a habit: approaching with suspicion towards what is given, which is also one of the typical approaches of scientists (Roe, 1961). That is to say, Fisher's method suits the interrogative, active, and critical nature of science.

Fisher's method of argument extraction can be applied in its most basic form depending on the level of the learner: for the younger learners, it would be beneficial to start with the text in which the argument indicators are clearly used and the intentions of the author can be read easily. In time, when the learner's argumentative activity improves, the complexity of the texts may be augmented with different claims, subtle justifications, and conclusions.

This method would be a good start for learners to see how arguments are formed. After becoming accustomed to arguments, the learners will come to form their own arguments and benefit from the role of argument in the learning activity. To put it in a different way, argument abstraction can be the first step before the argument generation.

2.4) Ways of Argument Generation

One of the most important factors in the argumentation activity is the way the arguments are generated. Constructing and expressing arguments can be very difficult for learners, as a process of careful understanding, evaluating, and reacting is required (Schwarz 2009, Kuhn, Hemberger, & Khait, 2016).

Sampson and Clark (2008) claim that, in this difficulty, what should be focused on in students' argument evaluations are:

i) "The structure of complexity", which can be seen as the philosophical side

ii) "The content of an argument" (in science classes, this part should be taken into consideration according to the scientific subject)

iii) "The nature of justification", which refers to the evaluation of ideas and claims that support or validate an argument.

To provide these necessities, there are methods that fall under two main topics: the domain-general frameworks and domain-specific frameworks, as Sampson and Clark specify (2008).

2.4.1) Domain-General Frameworks

The assumption of the domain-general frameworks is that the factors that are needed to generate a quality argument are not context dependent. Following particular steps in argument evaluation creates strong arguments (Sampson, & Clark, 2008). Here are two examples of domain- general frameworks:

2.4.1.1) Toulmin's Model of Argument

The twentieth-century British philosopher Stephen Toulmin's Model of Argument consists of six steps:

1) Introduction of the problem: *the claim*

2) *Data* offering

3) *Warrant* exploration

4) Offering of factual *backing*

5) Discussion of counter-arguments and providing *rebuttals*

6) Conclusion (Erduran, Simon, & Osborne, 2004; Sampson & Clark, 2008).

Toulmin's method is used by the proponents of domain-general frameworks to evaluate the strength of an argument in every context, but here, as Sampson and Clark indicate (2008), there is an important problem: the researchers, here the learners who generate the arguments, personal perspective may influence some of the steps, such as the approach to the claims, data collection, and warrant exploration (Sampson & Clark, 2008).

The reason behind this problem lies in the fact that science is factual, not logical or hypothetical. Therefore, although there may be nothing wrong with an argument's validity, it may not reflect reality.

2.4.1.2) Schwarz & Colleagues' Understanding of Strong Argument

Baruch Schwarz and his colleagues define an argument as "a conclusion with at least one supporting reason". Arguments can be elaborated with qualifiers. The strength of an argument is based on a hierarchy: a compound argument is stronger than a simple assertion, as they claim (Sampson & Clark, 2008).

They put a strong emphasis on the quality of reasoning. Instead of focusing on the content, they focus on structure and justification: if the reasons are strong, so is the argument, and they assert that students' simple assertions may be developed after an intervention (Sampson & Clark, 2008).

Domain-general frameworks generally focus on the formal side of the arguments. While Schwarz and his colleagues' method is mainly a grammatical way of argument evaluation, Toulmin's framework is a more extensive method when all the steps are applied carefully. However, as emphasized by Sampson and Clark (2008), the significant thing here is that this method does not explain how to carefully apply the steps.

2.4.2) Domain-Specific Frameworks

So far, neither Toulmin nor Schwarz' frameworks explain how scientific arguments are different from the arguments of other domains, and since their frameworks are not sufficiently explanatory, domain-specific frameworks may be needed. Here, some domain specific frameworks will be presented.

2.4.2.1) Zohar & Nemet's Understanding

Anat Zohar from Hebrew University of Jerusalem focuses on the content of the justification, and Flora Nemet defines argumentation as informal reasoning. Strong arguments are those with relevant, specific, and accurate scientific concepts and facts. Without these elements, the conclusions are not considered valid (Sampson & Clark, 2008).

After teaching students about argument quality and relevant scientific content, they observed an increase in both the quality of arguments the students produced and the degree they used specific scientific knowledge as a part of their justifications (Sampson & Clark, 2008).

They consider content knowledge and argumentation practices as intimately linked (Sampson & Clark, 2008).

The limitation of their framework is to the lack of a way to evaluate content or a method to assess how well a student takes into consideration all available information during argument generation (Sampson & Clark, 2008).

2.4.2.2) Lawson's Arguments

Anton Lawson from Arizona State University believes science educators should consider how students generate the type of arguments that are used and valued by scientists rather than focusing on the general argument structure (Sampson & Clark, 2008).

This kind of approach is hypothetico-predictive, and its quality is measured by its deductive validity: whether conclusions of scientific arguments that are generated by students follow the premises that are given as justifications. . This kind of activity, however, is difficult for students because this expectation, of generating and testing hypotheses, necessitates developed argumentative skills which should be gained in progress of time (Sampson & Clark, 2008).

2.4.2.3) Sandoval's Understanding on Quality

William A. Sandoval's emphasis of argument quality has two sides: conceptual quality and epistemic quality (Sampson & Clark, 2008).

According to Sandoval, proper use of the concepts and information of the related topic leads to strong arguments. Causal claims, together with warrants will show why something is the way it is. These two factors are necessary to construct a complete explanation of a scientific claim (Sampson & Clark, 2008).

Domain-specific frameworks may be a more detailed and attentive way for generating arguments, compared to domain- general ones, but the challenge lies in the expectations of the learner being too complicated, since argumentative activity is a challenging activity (Schwarz, 2009; Kuhn, Hemberger, & Khait, 2016). The common point of these domain-specific frameworks is that it requires the learner to have some knowledge of the related concepts and the proper use of those concepts in the related domains. The domain specific frameworks are not the ideal first steps of the argumentative way of learning.

2.5) The Steps towards the Argumentative Way of Learning

So far, it has been shown that practicing argumentation in science education is beneficial for students, but it is also difficult and complicated. Although there are various standpoints on how it should be done in the classroom, at the end of the day, difficulty and complexity are their common problems. In order to solve these problems, a philosophical approach is necessary because without it, Argumentation Theory cannot be grasped.

First of all, a student should learn what an argument is in the informal context. That is to say, informal arguments are not always as clear as they are in formal contexts. For that purpose, it is important to awaken students' argumentative instincts and use Fisher's method of argument abstraction to identify arguments is a suitable way to do so. Since this method is the basis of the argumentative activity, it is important to specify the texts appropriate to improving learners' argumentative skills.

Being able to identify the arguments would also be helpful for generating arguments and presenting those in front of the others. Domain-general frameworks here may be enough for simple and well-known subjects in which the facts are clearly stated, but it will be beneficial to remember Fisher's *Assertibility Question*—why a conclusion should be accepted—at every step of this domain-general framework. Domain-specific ways of argument generation may be applied in the more advanced levels, after gaining the argumentative instinct and learning at least basic concepts to add to knowledge already held.

To conclude**,** in terms of its results, science in the educational context may seem to have a limited space for argument: there are scientific laws that must be taught if they are in the curriculum. However, this "give the formulas, expect the answers" type of teaching seems to be inadequate, since the practice of science itself does not fit with this understanding. Within the scientific context, questioning, reasoning, and criticizing have important roles. Moreover, any exam within this system can be completed with simple online research or a dictionary and a formula sheet. An argumentation-based way of learning incorporates students into the learning environment, and it is possible to apply this method in science classes because of the relationship of the nature of argumentation and science. There are different theories on this issue, as it has been explained, but the common point is that it eases the students' learning process and helps them to gain the knowledge, and retain it longer, by awakening their argumentative instincts and by including them into their own learning processes. Extracting the arguments from experts' texts, as Fisher believes (2004), is a good start in improving students' argumentative ability. Then, in terms of the argument generation, students may benefit from domain-general or domain-specific frameworks depending on their level of knowledge.

In the active educational environment, teachers should always be ready as a facilitator and a controller of the argumentative activities of the students. Since these are difficult activities, teachers should plan the in-class activities very carefully. The resources to be used should be arranged from basic to complex if they are written texts. Teachers should carefully monitor in-class activities and intervene whenever a problem occurs, such as improper use of concepts or appeals to fallacies. Within the activity, students and their argumentative skills will improve, and, in time, their capacity of learning, arguing, and producing ideas will also improve.

There are difficulties in argumentative practices. The most serious difficulty is introducing students to the basics of both argumentation practices and scientific subjects. The basics are the definitions of the main points and the concepts. Fortunately, even these main points are taught in the course of argumentative practice. Depending on the level of the students, interesting texts and in-class discussions can be designed with the intention of students can actively grasp the basics in the argumentative environment. How to practice the methods is the subject of the upcoming chapters.

CHAPTER 3

ARGUMENTATION AND CRITICAL THINKING

In this chapter, one of the most important skills of the 21^{st} century, critical thinking, will be characterized as an outcome of argumentative science education. For this purpose, 21^{st}-century skills, learning and innovating skills, as well as life and career skills, will be discussed and associated with Argumentation Theory, particularly in science education. The role of philosophy in critical thinking will also be underlined in order to show how this outcome, critical thinking, comes to light as an effect of the philosophical approach.

3.1) 21^{st} Century Skills

In the most general sense, 21^{st}-century skills, the skills of the information age, are the faculties that are considered by the experts in the business world important for the professions of today and the future, so they have been taught in K-12 (from kindergarten to the 12^{th} grade) classroom environments. These skills are grouped by three main topics by the Partnership for 21^{st} Century Skills: learning skills, literacy skills, and life skills (Partnership for 21st Century Learning, n.d.).

Learning skills are comprised of four skills: critical thinking, creative thinking, collaborating, and communicating. In the following parts, the first one of those four will be expatiated. Briefly, critical thinking involves examining and considering information. It is a personal activity in which people analyze what is explained, asserted, or taught. Together with critical thinking, creative thinking is also crucial for idea generating. This part can be seen as the preceding step towards the social part of learning: after the analysis, a new idea or claim, or, at least, an outline of a new way of thinking is generated and ready to be shared. The last two activities are the social parts of learning skills in which a team works on an activity such as idea sharing, problem-solving, or brainstorming (Partnership for 21st Century Learning, n.d.). To clarify, these steps do not have to be ordered. For instance, during the communication part, critical and creative thinking may be performed, but when they are evaluated on their own, critical thinking is the most individualistic of these four learning skills: it is possible for people to think critically by themselves.

Information literacy, media literacy, and technology literacy are the three components of the literacy skillset. These are needed to keep informed about the global trends and to become accommodated to a rapidly changing environment (Partnership for 21st Century Learning, n.d.). Fortunately, opportunities to access literature have been continuously increasing, and, so, literacy skills have become easily accessible day by day.

Life skills, mostly function to prepare students for the future's continuously growing and changing business world: flexibility, initiative, social skills, productivity, and leadership—avoiding attachment to the old ways of doing things, to old ideas, or to old knowledge is essential for progress. Taking the initiative is as important as being able to participate in group activities. Presenting a product, such as a project, a new idea, a work of art, etc., benefits from strong life skills. In the education environment, students are encouraged to find projects they can direct in order to develop their leadership abilities (Partnership for 21st Century Learning, n.d.).

These skills are taught in schools which are recognized for their prosperous curricula, and successful graduates. In the past, only the private schools with high tuition costs used to provide such an education environment. Fortunately, at the present time, public schools have also adapted their curricula to the need for 21st-century skills. There are elective courses such as media literacy, creative writing, and entrepreneurship. The profits of the practices within those courses are undeniable, but, essentially, the most important thing to focus on is the root of all those 21st century skills: all of these skills necessitate viewing the world with changing perspectives and the ability to adapt to the continuously developing world (Partnership for 21st Century Learning, n.d.). In order to do so, one should also learn how to classify information and how to use it effectively without losing in the information. Thinking, literacy, and practice are important but conducting them and abstaining from overdoing it is also important. It does not mean that there should be another course to meet this need. Schools have limited time each day, and, although their curricula are more progressive than the past curricula, the number of courses is scheduled based on available time. It does mean that adopting a constructive, innovative, and active style of teaching and learning should be regarded as the argumentative way of teaching and learning.

Since argumentation is a social activity (Kuhn & Udell, 2003; Goldstein, Crowell, &Kuhn, 2009, van Eemeren &Grootendorst, 2010) in which claims are created and shared, and reasoning is the most important part of this activity, it can be said that learning, literacy and life skills improve in the argumentative way of education. To put it all in simple terms, in the argumentation activity, the very first step is to have a claim on a particular issue. This claim may be a result of one's own perspective, but, to defend it or to change it, a method must be employed. As the argumentation activity proceeds, this claim may be supported or discarded in favor of more credible and stronger claims. These two opposing decisions, defending a claim or discarding it, have a common point in argumentation: thinking through and evaluating every aspect of something in terms of strength and weakness. This is the part that improves critical thinking: argumentation improves critical thinking autogenously. As mentioned, since critical thinking is the most individualistic part of the learning skillset, it can be taken as the initial skill, the development of which will help the development of the other skills.

In order to show the connection between argumentation and critical thinking, as well as how critical thinking avails other skills' development, critical thinking will be explained in detail in the following section.

3.2) Defining the Concept: Critical Thinking

Critical thinking, in a general sense, is defined by Hitchock (2018, para.1) as "careful thinking directed to a goal."Concepts, methods for idea clarification, and ways of expression change in accordance with the domain (Hitchock, 2018). In the following sections, critical thinking will be associated with argumentative science education, but, first, the history of critical thinking will be discussed in order to see its transformation, as well as how it has been in people's lives throughout intellectual history, even if the term itself is under the umbrella of the contemporary education environment.

In the first decade of the twentieth century, American philosopher John Dewey developed a concept: reflective thinking. With this concept, Dewey referred to an active, persistent, careful, and scientific attitude of mind to form or support any belief or knowledge, so Dewey is seen as the father of the term "critical thinking." (Hitchock, 2018). This way of thinking has an important place in Dewey's philosophy of education, in which his pragmatic point of view can be seen. For Dewey (1959), rather than the knowledge itself, the activity of learning should be considered. He expresses that as there is continuous growth in the world, so must there also be in the education system. Within a progressive education system, experiences generate other experiences and prepare the students for life after school (Dewey, 1959). Since then, Dewey's claims have influenced education theorists, and critical thinking became a goal of education.

3.2.1) Critical and Non-Critical Thinking

After defining reflective, critical thinking, Dewey strengthened his theory with examples, two of which are given below, in order to draw a line between what is critical thinking and what is not (Hitchock, 2018).

i) The woman with a rash: a woman unexpectedly gets a rash on her throat and upper chest. She then remembers she had recently developed a red mark on her right hand, but she is not sure whether it is a rash or something else, like a scar. She lies on her bed and thinks about the possible causes:

Cause n1: Two weeks ago, she was prescribed a new medication for her blood pressure and warned by her physician that she should be careful about allergic reactions such as rashes, shortness of breath, etc.

However, she has been taking her medication for two weeks and she has never experienced a problem like this before.

Cause n2: She began to use a new cream on her neck and upper chest one day ago.

However, she did not use her cream on her hands. The red mark on her right hand, if it is an allergic reaction, cannot be explained by this cream.

Cause n3: She has been taking probiotics for one month.

In a similar way of thinking as with cause n1, she does not think the problem is the probiotics.

Cause n4: She has recently started to use a new eye drop.

However, she does not think that eye drops cause such an allergic reaction.

Cause n5: She feels hot and sweats, particularly from upper body.

The cause of the rashes is likely sweating.

She will go for a short vacation, and, during this vacation, she will not be able to contact her physician. So, she decides not to take her new medications for her blood pressure and stops using her new cream. She thinks she will consult with her physician about her medication after this vacation (Hitchock, 2018).

ii) Typhoid or not: A physician is suspicious, after the initial examination, that a patient may have typhoid but decides not to jump to this conclusion without ordering more tests and gathering more information (Hitchock, 2018).

These two examples, respectively from daily life and professional life, show how people use critical thinking during decision-making. From these examples it can be said that critical thinking can be formulated as a careful and rational evaluation that creates a strong, supported claim.

The opposite of critical thinking is to take shortcuts leading to unreliable results; this is non-critical thinking. Instinctive decisions may be an example for this way of non-critical thinking. Accepting claims without questioning is also far from thinking critically.

Within the educational context, traditional education does not support critical thinking. Instead, students are supposed to accept what is stated by teachers, but since the popularity of 21st-century skills has risen, traditional education has begun its decline, replaced by a progressive, active education. So, the argumentative way of teaching and learning has spread in increments, but when the question is which one, argumentation activity or critical thinking, should come first, the answer entails a focus on the philosophy of critical thinking.

3.3) Philosophy and Critical Thinking

As critical thinking is a careful, interrogative, rational activity, its relation with philosophy cannot be denied: the history of philosophy abounds with interrogators who analyze their predecessors' findings and construct their own claims based on their own attentive, particular considerations. If the critical perspective is separated from the history of philosophy, there remains nothing. From the ancient Greeks to contemporary philosophy, critical thinking essentially has been a part of the philosophical activity.

Finocchiaro (1989), explains the nature of philosophy in six notions: content-freedom, judiciousness, rationality, practicality, universality, and critical-constructiveness. By content-freedom means that philosophy is characterized by its scrutinizing approach rather than its subject. Therefore, it can be applied to anything that is questionable. Judiciousness is very much like this content-freedom by having multiple sides. The philosophical approach is judicious to the extent that it avoids taking extreme positions. Although the writer claims that taking extreme positions is at variance with the philosophical approach, many prominent philosophers have taken extreme positions when defending their theories, but, still, they adopted an investigative attitude, which should never be lost, and their claims are open to be questioned, just like their predecessors'. Avoiding extreme positions may mean avoiding dogma. Philosophizing is a reasoning activity in which the philosophers' logic plays an important role in terms of concept clarification, comparison, and making a strong, trustful claim. As well, the philosophical approach is also practical, as people express their claims, and the ones that are expressed well correspond to practical life in many ways (Finocchiaro, 1989). At the present time, the practical side of philosophy has gained significance, and this is why it is seen in many domains, including education. Argumentation activities in which people construct, share, criticize, and defend ideas, are at the center of those practical sides of the philosophical approach. Philosophical approaches and all works of the philosophers are universal, since they are for the humanity. In other words, philosophy is for everyone (Finocchiaro, 1989).

As the last notion that is explained by Finocchiaro (1989), "critical constructiveness" is the one that is the focal point of this chapter. Being able to reason, judge, and criticize freely in any context results in various ideas, claims, and standpoints that are not randomly constructed. Critical constructiveness can be taken as the combination of critical and creative thinking: it is the result of careful reasoning activity and produces ideas.

Critical thinking is the heart of the philosophical approach, so, in the educational context, instead of giving the rules of critical thinking as a separate subject, it would be beneficial to teach students the philosophical approach that naturally includes critical thinking. In this context, this philosophical approach to teaching and learning is the argumentative way of education.

3.4) Argumentative Science Education and Critical Thinking

As explained in the previous chapters, in argumentation-based learning, students are the most active part of the system, while the teachers act as facilitators. Teachers should help students learn basic concepts and prepare them to acquire knowledge by themselves.

Argumentation in social sciences may be seen as more suitable for argumentation because, in the social sciences, unlike in the natural sciences, there can be more than one theory and various points of view. What should be argued in a domain characterized by a main focus on objective, quantitative knowledge? What should be argued is not the results of the natural science research but the claims and ideas which lead to these results.

Let us take cloning as an example in order to explain this issue better. In order for students to learn about cloning, they must at least be informed about cellular structure and genetics. This basic information may be gained with the help of the teacher or self-directed research. The crucial point here is to avoid making them passive even during the basic knowledge acquisition. Then, the scientific texts that are chosen carefully by the teacher can be given in order to identify arguments about cloning. In argumentative science education, the teacher paves the way for active learning by, for instance, checking their work during argument identification or creating a debate environment, especially during challenging situations. When the thinking process starts, the learning process also starts. During this period, the teacher is always there for the students who experience difficulties with basic concepts, how to begin questioning, or how to express their ideas. At the end of the day, while discussing the pros and cons of human cloning, students should understand how cloning is done and be familiar with the studies on and claims about the issue.

Let us remember what is happening in an argumentative education environment: First of all, students start to reflect on themselves and construct a claim with their current knowledge: at the most basic level, this will be done as the argument abstraction within the relevant text. This is the individualistic part of this process. They then express their claims in the class and listen to each other. Here, the social activity starts; they see that there may be more than one claim about a particular issue. This awareness leads them to think of other claims and respond to them in an argumentative manner. Here active reasoning plays an important role because they never stop thinking critically in the argumentative environment.

Since the philosophical approach is context-free, it can be applied in every educational subject. Application of this approach is what is known as argumentative education, in which students learn in active discussion. In this environment, students learn how to think and how to express their ideas. Automatically, critical thinking, one of the most important skills of the 21st century, develops as a result. As this skill develops, argumentative learning becomes increasingly fruitful and students learn more easily.

3.4.1) The Main Components of the Critical Thinking for the Use of Argumentation Theory in Science Education

Critical thinking skills develop automatically during argumentative education. In order for these skills to be irreproachable, the main components of critical thinking should be taken into consideration. Here, the role of teachers comes into prominence; teachers are supposed to watch the students carefully in argumentative environment. Since it is a place in which the students express their ideas and react to each other, there is always a risk for the qualified discussion to turn into a pointless, unfruitful exchange of ideas, or, even worse, verbal or physical fights. So, the responsibility of the teacher here is to provide a healthy environment of argumentative activity. The main components of critical thinking are logic, language, assumptions, fallacies, consistency, soundness, reflection, and analysis.

3.4.1.1) Logic

As it was explained in the previous chapters, the logic of scientific argumentation is informal logic. Although it focuses more on meaning and utterances, it has some significant notations in common with formal logic. The elements of an argument, which are the premises and the conclusion, and the basic types of reasoning, which are deduction, induction, and analogy, are those significant notations in common with formal logic.

Fisher's method to identify arguments in experts' text is partially based on the recognition of premises and conclusions with reason indicators, conclusion indicators, and hypothetical indicators. In some cases, arguments can be identified intuitively, but in complicated cases, such as in complex text or discussion, students may not identify arguments or may not understand these basic concepts properly. Here, the basics may be introduced to them by examples or explained to them during argumentative activities, but the basics of the logic should be grasped for a qualified argumentative practice and effortless critical thinking.

As for the types of reasoning, the students should grasp the advantages and disadvantages of them. Deduction, or derivation is inferring a conclusion from the given assumptions, or axioms in a finite set of statements (Cook, 2009). Induction is reaching to an empirical conclusion by means of empirical premises (Blackburn, 2005). Analogy is reaching a specific conclusion on the basis of the similarity between the individual terms: it is asserting that “since the things are alike in some ways, they will probably be alike in others.” (Blackburn, 2005). Students should be able to choose the most suitable method when required. The way to teach them properly is to create such an environment in which these methods are needed. Again, the teacher’s role as a facilitator in the argumentative education comes to light.

3.4.1.2) Language

Argumentation is not an arbitrary activity, so, both in the written and in the conversational context, one of the most important facts to take into consideration is language. The language can be examined as three aspects: syntactic, semantic, and pragmatic.

The syntactic aspect of language is about the structure of expressions, and is the purely formal aspect (Blackburn, 2005). Each type of sentence has their own structure. Ill-formed sentences should be avoided. The improper usage of sentences should be corrected.

The semantic aspect is the part where meaning of words and signs are formed (Blackburn, 2005). Here, teachers must ensure clarity of elements related to meaning, such as whether students use concepts in a proper manner or whether they can respond to an opponent appropriately.

The pragmatic aspect is closely related to the semantic aspect, but it is context-dependent: “the relationship between speakers and their signs.”(Blackburn, 2005). Each context has its own type of argumentation. Ignoring the practical aspect may result in absurd constructions.

3.4.1.3) Assumptions

In an argumentative environment, students deal with the claims. At this point, to be able to distinguish the facts with the assumptions is necessary.

As well as the structure of a sentence, noting the implication of an expression may be helpful to clarify assumptions. The best way to ensure students grasp assumptions is to expose them. Fisher's hypothetical indicators, which are explained in the second chapter, are helpful with identifying assumptions.

For teachers, the important point here is to discourage students' use of assumptions or facts to manipulate others or to distort others' reasoning. In order to prevent this, the next component, namely, the fallacies, has to be grasped to ensure they are avoided.

3.4.1.4) The Fallacies

The fallacies are ill-formed arguments in which the reasoning that leads to the conclusion is faulty (Dowden, n.d.). In order to abstract, generate, or evaluate an argument, one should have the knowledge of what-not-to-do, as well as what-to-do. There is a good many number of fallacies. In this part, the most common fallacies, especially in the scientific domain, will be listed.

i) Ad hominem: during argument evaluation, it is significant to specify the defects of the argument, not the personal features of the one who constructed the argument. *Ad hominem* is the attacking of personal traits, such as tone, academic success, the age of the speaker (Dowden, n.d.; van Eemeren & Grootendorst, 1992; Siegel &Biro, 1997). This fallacy is encountered in every domain. Ad hominem may be performed indirectly or subtly. For instance, when someone expresses their claim and the opponent responds by bringing forward the facts of a more prestigious person's claim, and the respondent emphasizes this trait of this relative to the one who express their claim, this is also ad hominem in the sense that this opposition aims at manipulating a claim using a personal, irrelevant feature.

ii) Appeal to emotion: When an emotion is emphasized during an argumentative activity, and it is aimed to stop reasoning, it is called *appeal to emotion* (Dowden, n.d.). Arguments may evoke feelings, but it does not mean that those feelings should shape the argument. For instance, when the subject is the risks of kin marriage in terms of genetic disorders, it is irrelevant to indicate how it may hurt the feelings of people who are married to their relatives.

Appeal to emotion may emerge together with irrelevant assumptions such as “Suppose that nothing bad happens to the baby...” or personal facts such as “My parents are relatives, but my sister and I are both healthy.” The irrelevance lies in the fact that individual cases do not decrease the risks of the given situation. This is why knowing how to use assumptions and facts in a proper manner is important.

iii) Appeal to faith: it is the fallacy in which religious standpoints are used as argument stoppers. It can be encountered especially in the evolutionists/creationists debate. “This argument is against God’s words”, “I can understand you, but I ignore your claims because it goes against my faith”, “it can only be seen with the eyes of faith” (Brümmer, 2001) are examples of this fallacy.

iv) Appeal to nature: it is the belief that scientific improvements, together with technology, threaten the world. This fallacy’s foundation is the idea that, in nature, everything is perfectly fine and healthy. What is faulty in this reasoning is the fact that it is ignoring the benefits of the improvements in science. It is a biased way of understanding science (Fallacy Files, n.d.).

v) Observation selection: In order to support a claim, ignoring the counterpoints that weaken then claim, while accepting points that support the claim is called *observation selection* (Bostrom, 2002). Researchers’ observations should be carefully evaluated to ensure the researchers embrace all the related parts of what they study without any bias.

As well, there many fallacies and distortions that may lead to faulty reasoning or conclusions. Fallacies may not always be seen clearly, and when they are not, they may be manipulative. It is not possible to list all fallacies that may occur in the scientific domain, but it is significant to bear in mind that, during the argumentative activity, one should carefully evaluate all the conclusions that are reached and all the justifications that support those conclusions. The argumentative activity improves the ability to identify fallacies whenever they occur. Teachers should be careful with fallacies. In some cases, it may be quite difficult to differentiate them from well-formed arguments. At this point, the quality of argument gains importance. Regarding quality, consistency and soundness should be sought.

3.4.1.5) Consistency

In order to produce strong and qualified arguments, one must be careful to avoid supporting opposing claims in the same topic. Consistency is the absence of contradiction (Blackburn, 2005). Here, the most important point to remember about consistency is that it should never be confused with changing one's mind. As a result of the argumentative activity, beliefs can change. A claim may even be discarded in favor of the opposing claim. As long as one does not support a claim and its opposite at the same time, consistency will have been achieved.

The difficulty with respect to consistency is that in long texts or discussions, when the expressions in them are not stated clearly, inconsistency may be overlooked. Here, teachers must be careful in terms of identifying the arguments. As soon as an inconsistency occurs, and if none of the students identify it, the teacher should point it out.

3.4.1.6) Soundness

In order for an argument to be sound, two elements are necessary: i) the argument must be valid, which means its conclusion can be deduced from its premises, ii) the premises and the conclusion are true (Blackburn, 2005). An example would be illuminating here:

Argument I:

Cystic fibrosis is a hereditary disorder. If the parents are the carriers of this disorder, there is a 25% chance that the baby will be disease-free, a 25% chance that the baby will be born with the disease, and a 50% chance that the baby will be a carrier.

This baby has the disease.

Therefore, the baby's parents are carriers.

Argument II:

All birds can fly.

Doves are birds.

Therefore, doves can fly.

Both of these arguments are valid. In both, the conclusion can be deduced from the premises, but while Argument I is a sound argument, as both the premises and the conclusion are true, Argument II is not a sound argument since the first premise is wrong: there are birds that cannot fly.

Unsound arguments may cause fallacies and in order for a student to be able to construct sound arguments, this student must have comprehensive knowledge of the related subjects.

3.4.1.7) Reflection

In the argumentative context, reflection means contemplating one’s own thoughts. In the argumentative environment, before expressing their ideas, students are motivated to consider their thoughts even if they are sure about them.

Reflection is an important component of critical thinking because it prevents dogmaticalness.

3.4.1.8) Analysis

Analysis is a general component of critical thinking and after enough practice, it becomes a habit. It is the ability to identify arguments, to find the premises and conclusions, to see the contradictions, weaknesses, and fallacies. Since practice will bring progress, teachers should prepare argumentative practices at all levels from difficult to advanced.

All the components of the critical thinking should be taught to the students, but the teaching process should not be draining and coercive. Instead, students should be motivated by their teachers to engage in argumentative practices, and they should be observed carefully so that faults can be corrected.

All the components of the critical thinking should be taught to the students, but the teaching process should not be draining and coercive. Instead, students should be motivated by their teachers to engage in argumentative practices, and they should be observed carefully so that faults can be corrected.

To conclude, critical thinking is one of the most prominent skills of the 21st century, and its promotion is in the best interest of the educational domain. It is seen as something to be taught in order to be successful both in school and after graduation. However, this skill is not a new one; it is part of the very essence of the philosophical approach, and careful thinking cannot be seen as non-critical. That is to say, instead of being a distinct area, critical thinking is a skill that can be developed during argumentative practice in science education.

Argumentation-based learning is a rising trend in education (Duschl & Osborne, 2002; Kuhn, 2010), and it is the opposite of the traditional learning in which the student is only supposed to learn what is taught by the teacher. In argumentation-based learning, students are active in the learning process by constructing and expressing claims and responding to others'. Argumentation-based learning can be seen as the application of the philosophical approach in the educational context because of the careful and attentive reasoning activity.

Such an environment in which claims are produced and shared, critical thinking naturally comes to light as a result of examination. The relation between argumentation and critical thinking is mutual; as a natural result of the argumentation activity, critical thinking provides an environment for freedom of thinking, freedom of expression, construction of ideas, and the sharing of them. Therefore, the argumentative education environment, because of its nature, is the best place to gain one of the most important skills of the 21st century.

To establish qualified argumentative practice and natural critical thinking, there are certain components both teachers and students should grasp. The teacher, as the designer of the argumentative educational environment, must be very careful to correct student errors. These errors may result from the fallacies, which risk being mistaken for real arguments. In this chapter some of the most common fallacies in the scientific domain are given. Fallacies of reasoning is a wide topic that should never be neglected in the course of argumentative practices wherever this practice occurs.

CHAPTER 4

PRACTICING ARGUMENTATION

Previously, what was taken into consideration can be classified as the theoretical aspects of the Argumentation Theory and its place in the scientific context, as well as its benefits in terms of an important skill of the 21^{st} century, critical thinking. Now, it is time to present their fields of application. This chapter aims to show how argumentative practice has been actualized throughout the world, as well as what has been done at the institutional level.

4.1) Contemporary Practices of the Argumentation Theory in Science Education

As it had been explained, Argumentation Theory is an expanding area in the educational context, so there are a great number of methods that can be applied as long as they make the students active in their own learning processes. Bearing in mind that each of these methods has its own benefits and properties worthy of criticism, it would be beneficial to introduce the most recognized and quickly developing fields of the application of their philosophical aspects. In order to do so, those fields will be examined under two categories: the concept-based practices and the actuality-based practices.

4.1.1) The Concept-Based Practices

Scientific subjects require a basic level of conceptual knowledge, depending on the student's level. Concept-based practices refer to the basics of a wide scientific topic, such as "force," will be targeted, and the subtitle of the topic, for instance, "magnetic force," will be elaborated.

In concept-based practices, neither the specific applications of a subject nor its exceptional cases emphasized; such issues are of secondary importance. The most crucial thing here is to ensure students grasp the subject in general terms. Therefore, it can be said that the concept-based practices are more like introductory practices of complex scientific subjects.

What should never be forgotten here is that, the argumentative way of learning does not make students passive in the learning environment; therefore, even in the process of concept learning the students should play the most active role, with the teacher acting as a facilitator who observes and directs their activities.

It would be more illuminating to explain the concept-based practices with an example, and fortunately, there is a method particular to philosophy in the educational context. In this method, development of student thinking capacity and subject comprehension are the focus in a conceptual base: Philosophy for Children.

4.1.1.1) Philosophy for Children

In 1974, Matthew Lipman established the Institute for the Advancement of Philosophy for Children and claimed that young children are able to think rationally, so, when the correct method is applied, they are also able to respond philosophically. Lipman is the founder of Philosophy for Children (P4C) Theory. Nowadays, P4C is applicable for any age and any subject (The Philosophy Foundation, n.d.). For this reason, the practice of this theory is an example of a domain-general method.

In the origin of Lipman's theory, there is the influence of John Dewey's concept of growth, which is what Dewey (2004) understands about education: "the educative process is a continuous process of growth," and he explains that it is an end beyond itself, which means the growth is for the sake of growth. According to Dewey's standpoint, education, as in the other domains of life, must be a continual reorganizing, reconstructing, and transforming process. Dewey (2004) sees learning as a lifelong practice, so students should be taught how to develop personally.

Therefore, the teacher's role at school is to help students develop their knowledge, instead of being the one who teaches. Dewey's understanding of growth is more like knowledge cultivation in which the teacher is a facilitator.

The Philosophy for Children movement started with Lipman's novel, *Harry Stottlemeier's Discovery* (The Philosophy Foundation, n.d.). The main character, Harry Stottlemeier, is a primary school student who one day daydreams during a science class. In this class, the teacher teaches subjects in a traditional way, by teaching the students what is specified in the curriculum and assuming they will learn everything by heart. In such an environment, Harry drifts away from the lecture and starts to think about something else. As soon as his teacher realizes that Harry is not listening to him, he asks a question about the subject he is teaching, "What is it that has a long tail, and revolves around the sun once every 77 years?"(Sharp, 2010) and, not surprisingly, Harry cannot answer correctly.

The beginning of the book depicts an ordinary moment for the ones who were educated in a traditional way of schooling. The stereotypical question of "What have I just said?" might be asked many people during their student lives by their teachers. However, the argumentative way of thinking is, as it has explained in the previous chapters, far different from this traditional way. In the argumentative way of learning, the teacher never asks a question that requires memorization. In Lipman's book, Harry feels embarrassed after his teacher asks him a question. Throughout the book, Harry thinks about the question and the incorrect answer he gave; he talks to his friends and realizes why his answer is wrong. When he finds out that he reaches the answer by a reasoning activity he discovers something very important:

> To me, the most interesting thing in the whole world is thinking. I know that lots of other things are also very important and wonderful, like electricity, and magnetism and gravitation. But although we understand them, they can't understand us. So, thinking must be something very special (Pritchard, 2018, para. 43).

Harry Stottlemeier’s discovery is an example of growth in Dewey’s sense, as he finds a way to develop personally through his own reasoning activity. Lipmann’s book explicitly depicts reflective thinking, the active way of one’s own learning, as an ability a child can intuitively achieve. However, it should be noted that students like Harry are exceptions. Most students lose their courage when teachers question them the way Harry’s did. Most students prefer accepting everything without question, since the traditional way of teaching inhibits their sense of wonder and their capacity for discovery. Therefore, students should be motivated and directed towards questioning in the class environment, and the best way to start questioning a subject is to question the basics of it. In the basics, there is nothing but conceptual knowledge.

Starting from “thinking about thinking,” the Philosophy for Children movement has been developing. The reason behind this development is its effects on students’ learning capacities. The methods may vary from practitioner to practitioner. For instance, while some practitioners prefer to invite the learners to think about the subjects by telling stories that are related to the basics of a subject and including them in the story at each step, some practitioners may prefer to set game-like in-class activities. One important point here is, whatever the activity is, the practitioner or teacher is not the chief part of it. Being just a facilitator means letting the students reason and express themselves in the classroom environment and keeping them motivated and focused. The other important point is, whatever the subject is, students should gain the basics of the subject in the active learning environment, in which the students have the leading role. The basic parts do not include historically important dates, or names and facts, or even the formulas. All these things can be found quite easily with a quick internet search. Students should gain understanding, through reasoning, of the concepts of the subject.

At this point, it would be beneficial to reinforce this claim with an example to show how it can be applied in scientific subjects.

During my Philosophy for Children Practitioner training, I designed a sample science lecture with the group I was a part of. The topic of this lecture was “Effects of Force,” and the target was 4th graders.

Our group consisted of three teachers and me, a philosophy graduate student. This was beneficial, as during this practice we saw that all of us were necessary: teachers should always be a part of the class to ensure the learning process is successful, and a philosophical approach should never be neglected because it directs the students’ active roles in their learning by reasoning. In other words, this workshop shows the very clear mutual affection between philosophy and education, philosophy referring to the argumentation practice.

The role of the teachers during this class design was to designate the achievements, as specified by the Ministry of Education, of the subject and preparing the answer key, since there is only one true answer in scientific subjects. My responsibility was to turn this learning process into an activity in which thinking, constructing and sharing arguments occurred. In other words, the philosophical aspect, which maximized the benefits of the lecture, was mine. So together, we prepared a group activity called “the concept-meter”

Firstly, the students were divided into four groups of 3 to 4. Then they were given cards on which the effects of force (e.g., the fall of an apple, the pulling force when a magnet pulls a needle, the collapse of a building during an earthquake, etc.) were written. The instruction was simple: “Put these effects in an order in such a way that you determine the standards.”

In this activity, the students were other participants of this P4C training, not the real 4th graders, but, although most of them were schoolteachers, we had four different orders because they had four different standards. While, for instance, one group put them in an order according to the magnitude of the force, the other group’s standard was the destructive effect of the force, but each group had only one true answer according to their standards. In order to determine the answer, they discussed the concept of force in their group, then they decided the order together and explained their reasoning to the others, and, finally, they shared their results with other groups, listened to their responses, and answered them accordingly. We, as the designers during this whole period, were only listening and helped only when needed. We also focused on their argumentation, and if there was a problem related to the logic of arguments, expression, or response to others' arguments, we gently and quickly fixed it. At the end of the day, in this argumentative environment, they reached their own answers and found the right one according to their standards with and thanks to a deep understanding of all the concepts related to the subject.

This concept-meter activity would be helpful due to three of its aspects: first, it creates an environment in which students collaborate and produce ideas. Second, it improves their inquisitive nature and, in the environment of sharing and reacting to the ideas, the achievements are obtained by their own endeavors. Third, and the most importantly, this way focuses on the basics of the subject in an argumentative environment. It is clear that without a proper understanding of the basics, nothing can be learned completely.

This concept-focused method can be applied at any level of education whenever a new topic has to be taught, with proper modifications, depending on the curriculum. However, until the high school level, since the most important basics of school-level science should already have been taught, instead of concept-based practices, actuality-based practices would be more suitable.

4.1.2) The Actuality-Based Practices

With a sufficient level of understanding of the concepts, e.g., knowing what is meant by "force" when it is used in the scientific context, students are able to focus on how those concepts are related to each other in practical life and how they find a place in specific domains. Therefore, it can be said that actuality-based practices are one step ahead of concept-based practices. When actuality-based practices are implemented, it means that the students are ready to grasp more advanced topics.

To continue with the force example, while the essence, i.e., whatness, of the force and its types have been grasped by the concept-based practices, the problems that require the association of these concepts can be solved by actuality-based practices.

In the traditional way of learning, the problems are solved via given formulas without any questioning. The reasons behind those formulas are mostly neglected. The stereotypical questions from the students, such as, “What am I going to do with this bunch of information in real life?” cannot be answered fully, but in actuality-based practices students are also able to see the knowledge and real-life relation.

Actuality-based practices serve very useful purposes in problem solving, idea development, making inferences, and associating information with real life. Again, in these practices, students have the leading role in their learning activities as the actuality-based practices are also argumentative activities. As long as the teacher keeps the students active in their learning of the complex subjects in the curriculum, actuality-based practices can be planned in any way. There is a project that can be classified as an actuality-based practice. At this point, it would be beneficial to introduce this project: The Thinking in Science Classrooms (TSC) Project

4.1.2.1) Thinking in Science Classrooms (TSC)

The TSC Project was introduced by Anat Zohar and Flora Nemet from the Hebrew University in their article that was published in 2001. In the year they published this article, argumentative studies had already become significant, but their specific implementations in scientific domains were relatively fresh. This project is appropriate for examination because its frame can conveniently be adapted to the contemporary changes in the educational context and resources.

The TSC Project evaluated the relation between argumentation skills and scientific knowledge. The main element of this project was the *Genetic Revolution—Discussions of Moral Dilemmas* (short: *Genetic Revolution*) unit. This was a specially designed unit for Grade 9 students with two main purposes: learning several topics in human genetics and fostering argumentation skills (Zohar & Nemet, 2001).

The traditional way of teaching scientific topics can be boiled down to three steps: 1) Giving students the information while they are silently listening or reading

2) Exemplifying the subjects with questions that can be solved using the given formulas

3) Testing whether the students can use the given information. These steps, in general, do not include questioning. It also requires no idea development. None of these steps can show the difference between learning and memorizing.

The TSC project, however, attached importance to learning and expressing what has been learned. The results are pleasing: the effects of the use of the designed unit, *Genetic Revolution,* had positive effects on students in several ways. After this implementation, it was reported that students' argumentative skills had improved. In the written tests, students developed their scientific knowledge and the ability to merge that knowledge into argumentative expressions. In the oral discussions, the number of students who reached a conclusion with at least one justification increased (Zohar& Nemet, 2001). The conclusions were clearer as the activities within the context of the unit proceeded. Students' conversational turns per minute decreased, meaning they tended to talk longer on an issue instead of wandering off during their conversations. The idea units per conversational turn increased, which means students became more productive in terms of idea generation. Moreover, as the transfer tests showed, students' argumentative skills regarding the dilemmas of everyday life improved. That is to say, the students began to use their argumentative skills, such as reaching a conclusion with proper justification or expressing the points they agree or disagree, in any situations. This point shows that their critical thinking skills improved as a result of these argumentative activities. These results are the summaries of what is given in detail by the studies that are expressed in the statistics (Zohar & Nemet, 2001). Since the details of the statistical analysis are beyond the scope of this thesis and in the field of the educational sciences, it would be beneficial to look more closely at the methodology and the questions of the project.

As the main part of the TSC project, the *Genetic Revolution* unit consists of the moral dilemmas in the context of human genetics (Zohar & Nemet, 2001). Moral dilemmas represent difficult choices between two options, considering the ethical values of behavior, in a challenging situation. For instance, to legalize euthanasia or not is a moral dilemma that should be considered from different standpoints because of the irreversible nature of euthanasia. In the context of the unit, there were 10 moral dilemmas that necessitated incorporation of human genetics knowledge into the answers. In the article, three of those moral dilemmas are examined. The first two dilemmas were about genetically transmitted diseases, and both asked whether the pregnancy of each dilemma should be ended due to the possibility of disease in the baby. The third dilemma involved a negative trait, alcoholism. The moral dilemmas were chosen to create an authentic environment for argumentation; it was thought that this way would keep the students' attention by giving them a chance to express their ideas while referring to their knowledge of the given scientific topic (Zohar & Nemet, 2001).

The *Genetic Revolution* unit has its own special curriculum which is quite different from the traditional curriculum. As a part of this project, two schools were chosen with similar student levels of education and backgrounds. Both schools had an experimental group in which this special unit was implemented and a comparison group, which followed traditional methods of teaching and learning the same topics in the special curriculum but without the moral dilemmas. Both groups were first given a pretest consisting of their prior knowledge about human genetics in order to measure improvement throughout the academic year. The pretest results of both of the groups were very similar: only a minority of the students were able to apply their specific knowledge to argument construction. That is, only a minority of them were able to give an answer with properly justified conclusions. After the pretest, the experimental group began the *Genetic Revolution* unit while the comparison group continued with the traditional method (Zohar & Nemet, 2001).

The teachers who implemented this unit were educated before the project because, unlike the traditional way of teaching and learning, this project makes students active, which required special instruction for the teachers. As the authors observed, even in the traditional lectures with an argumentative objective, the students were not greatly encouraged to reason or to express their justifications (Zohar & Nemet, 2001). Therefore, this situation again shows that the argumentative way of teaching and learning necessitates a collaborative academic studies involving education and philosophy scholars.

After the pretests, both the experimental group and the comparison group attended the same numbers of science classes every week. The lectures of the comparison group were the traditional in-class activities. The students in the experimental group were much more active in learning. The lectures of the *Genetic Revolution* unit proceeded as such: at the beginning of a subject, the students were introduced the subject. Here, there is an excerpt from the introductory part of the dilemma on the Cystic Fibrosis to set an example:

> Cystic Fibrosis (CF) is an autosomal recessive genetic trait. It is one of the most prevalent genetic diseases. In England and the United States one out of 2000 newborns is affected and one out of 20 people is a carrier (Zohar & Nemet, 2001, p.44).

The introductory part includes all of the fundamental information on Cystic Fibrosis. After reading this part, all were informed that if a pair of parents are both carriers of this disease, their children have a 25% chance to be born with the disease because of its autosomal recessive character. The students were supposed to read and understand this part on their own while answering the questions which include a moral dilemma. Here is the moral dilemma of this part: “Rebecca and Joseph both have brothers who are sick with CF (an autosomal recessive trait). Rebecca and Joseph got married and Rebecca is now pregnant. Should they abort the embryo?”(Zohar & Nemet, 2001).

At this point, students were directed to answer this question with their knowledge and moral standpoints included. Here, it should be noted that the important aspect was not their moral standpoints but the way they were expressed, as the function of the moral standpoint aspect was meant to reflect their argumentative skills. Moreover, the students were also supposed to express their thoughts on their friends’ arguments both in the written context and in the in-class discussions. Here is a sample question: “Your friend disagrees with you. Define his/her position. Offer reasons for that position (what will your friend say to convince you that s/he is right?)” (Zohar & Nemet, 2001).

The answers were evaluated in terms of the conclusions the students reached. If their conclusion included no justification, it was called a “pseudo-conclusion,” and the score of this answer was 0. If their conclusion included one justification, the score of this answer was 1. If their conclusion included two or more justifications, which means that the student’s argumentative skills are strong, the score of this answer is 2. This scoring system was meant to measure the development of their argumentative skills and scientific knowledge throughout the unit (Zohar & Nemet, 2001).

Before the second lecture, which was on Huntington disease, students were given a lesson which was entirely on argumentation. In this lesson, arguments were defined and explained with all their structures. Between the first and second lectures, students showed significant development in terms of argumentation skills.

Furthermore, students were asked to formulate arguments about every dilemma. By doing so, students had many opportunities to construct arguments (Zohar & Nemet, 2001).

At the end of the semester, the experimental group developed in terms of three important achievements: i) argumentative skills, both in the academic domain and in daily life, ii) learning skills, and iii) recognition skills. This showed that argumentation skills and students' knowledge on scientific subjects mutually develop. The comparison group, who were subject to the traditional way of education, did not show improvement in given achievements after the pretest (Zohar & Nemet, 2001).

4.2) Some Points on the Concept-Based Practices and the Actuality-Based Practices

It is intended here to show that on the abstract notion, which usually underpins advanced subjects, concept-based practices can be implemented. For the more complex subjects, which include the relations between concepts and can be related to the practical life, actuality-based practices would be more proper. However, it does not mean that these practices are mutually exclusive; they can be implemented together whenever they are needed.

The Philosophy for Children movement is not given here as the only way of implementing concept-based practices. It is just an example that directs students to think about the concepts and express their thoughts on those concepts. The most widespread application of this movement is the social domain in which values are the focus. However, it can also be applied in the scientific domain. Scientific subjects being exact and objective is not an obstacle. Even with exactness and objectivity, students were able to reach the answers in the scientific domain with questioning, idea construction, and contemplation.

As an actuality-based practice, dilemmas can be successfully implemented. First, dilemmas create an environment in which students find a chance to relate the subjects to real life. Second, it broadens students' horizons during their discussions. In general terms, TSC may be illuminating, but some crucial elements should be improved. For instance, greater attention should be given to students being educated in terms of argumentation: even a lecture that teaches argumentation carries the risk of turning into a traditional way of teaching. Instead of teaching them how to argue, awakening their argumentative instinct and keeping their attention should be the goals. At that point, Fischer's method, which was discussed in the second chapter, can be implemented by identifying the arguments in specially designed short essays in accordance with the subject.

In both of the methods, students must be kept active in their learning processes. During their activities, teachers should always be ready to help whenever the student needs support.

The argumentative way of teaching and learning, whatever its method or practice, serves a specific curriculum that is determined by the Ministry of Education. Although it liberates the students, it must remain within a framework. For a comparison, it would be beneficial to explain an alternative method of schooling—the independent institution that does not follow a mandated curriculum.

4.3) An Alternative Way of Education: Sudbury Schools

The Sudbury Model of Education, which was founded in 1968 by a group of parents and educators, is radically different from any kind of school using curricula assigned by the Ministry of Education. Instead, the curriculum is established by the students. Each student has his/her own curriculum can choose what to learn, which makes students very active, as the argumentative way of teaching and learning does.

The students are also able to decide by whom they are evaluated or even whether they are evaluated at all. The examination system is established by each student.

The Sudbury philosophy is based on responsibility, freedom, and trust. The claim is that, if the students are given a chance, they will follow their desire to learn and will be successful in the area they choose. In this sense, it is similar to the argumentative way of teaching and learning.

Students of different ages (from 4 to 18) are mixed together, socializing together and learning together. It was possible to see them playing instruments or computer games together, as well as doing mathematics or reading Shakespeare. Teachers here never interfere unless a student asks.

Within such a system, students create their own learning environment. Since all the students with similar areas of interests socialize together, they learn how to work together. It is thought that this way is the only way to prepare them for the future (Sudbury Valley School, n.d.).

A school with no curriculum in which the only authority is the student who wants to learn according to their own interest may be regarded as problematic by people who believe that children have no capacity to make the best choices for themselves. But who actually has that capacity? The question is worth thinking about carefully. This alternative form of education is mentioned in this thesis because the evolution of education towards active learning is highly encouraged by educational scientists. If the next step after the traditional, teacher-led education system is argumentation-based education, one day there may be more schools that adopt the Sudbury way of education.

To conclude, this chapter presented examples of argumentative practices that were examined under two branches: concept-based and actuality-based. Those branches were chosen in accordance with the subject’s attribution. The basics of scientific subjects are the concepts without which complex and concrete relationships cannot be defined and expressed.

How to keep students active and motivated during their learning process is a matter important to today's educational context, and its answer lies in the interdisciplinary work in the fields of educational sciences and philosophy. Since there is a curriculum that must be followed, but the traditional way of teaching creates learning problems regarding memorization, and the construction and expression of ideas, a new way of teaching and learning has become necessary. This way is the argumentative way in which students reach answers through their own efforts with reasoning and questioning.

Using dilemmas to teach topics is an intriguing way to motivate students and keep them attentive during lectures. However, even this curriculum has some weak points regarding how to teach students the basics of argumentation. Planning a lecture just for argumentation may be a choice, but it would be better to teach the basics in an argumentative environment.

Philosophy for Children (P4C), a rising research area, may be a good choice especially for concept teaching. The P4C method can be applied in every domain and every level of the K-12 system. Starting from thinking about thinking, P4C has been developing and is practiced by teachers.

Although it is still controversial, Sudbury schools, an alternative form of education independent from a fixed curriculum, is remarkable. It is grounded on students' own goals and enthusiasm, and it provides an environment of free learning. In terms of keeping students active in their learning processes, the argumentative way of education is similar to the Sudbury schooling system. It should be remembered that the Sudbury system is curriculum free, while the argumentative way of education uses standardized curricula.

CHAPTER 5

CONCLUSION

5.1) Summarizing What Was Explicated

Traditional learning creates passive students. Teachers have the leading role in the classroom environment: they talk the most, they give students the information required by the curriculum, and they evaluate student performance with in-class or take-home examinations. Students, on the contrary, mostly listen to their teachers, take notes, and are supposed to learn what is given in a limited period without questioning what is given to them. There is a stereotypical question that is asked by all students during their academic lives: “when will I use this particular information in real life?”

Such questions reflect the doubt of traditional learning efficiency. There are a great number of studies that show underachievement of students who are traditionally educated, as measured by remembering what was learned in short and long periods. One of those studies, which is a comparative one, is explained in the previous chapter.

Compared to the traditional way of learning, argumentative learning is illuminating. Argumentation Theory is the basis of argumentative learning. Briefly, argumentation is a reason-guided activity that is shaped by the rules and principles of logic (Budzynska,A raskiewicz, Bogolebska et al., 2014). The type of the logic that should be implemented depends on the academic subject. For instance, in mathematical argumentation, the rules of formal logic are implemented, while in other fields, such as the social sciences, law, or political science, informal logic is used. Formal logic has basic methods of reasoning and is based mainly on deduction. Validity in formal logic is defined by the abstract relationship between the premises and the conclusion. Informal logic, however, involves social relations instead of formulas and abstractions.

To explain with an example, in formal logic, these two arguments represent the same thing:

Argument I:

All philosophers are mortal. (Premise 1)

Socrates is a philosopher. (Premise 2)

Therefore, Socrates is mortal. (Conclusion)

Argument II:

All philosophers are purple. (Premise 1)

Socrates is a philosopher. (Premise 2)

Therefore, Socrates is purple. (Conclusion)

Both arguments are valid. For each, given premise 1 and premise 2, the conclusion follows. However, with informal logic, more than validity is needed; arguments must correspond to reality. The argument must relate to its field in informal logic. Therefore, in social relations, the meanings that are given in those relations and the way the arguments are constructed and used are the important factors of informal logic.

The sum total of related concepts and written rules can be formulated as Argumentation Theory. The subject of this thesis, the role of Argumentation Theory in scientific reasoning and science education, requires a focus on two basic elements, the nature of science and scientific argumentation, as a matter of course.

Science first brings to mind the reliability of the domain. When a claim is scientific, it is understood to be well thought out and tested. In order for a claim to become a scientific theory, it must follow strict steps known as the scientific method. The steps of this method, roughly, involve forming a question, researching the question, constructing a hypothesis, testing the hypothesis through experiment, analyzing the results of the experiment, and, if the hypothesis is found to be true, drawing a conclusion and reporting it. This clarity and explicitness of the steps may be misunderstood as being far from attributed meanings. However, the nature of science is so constructive, and creative nature of argumentation. However, it may still be thought that, since theories and formulas of science are as certain as those of mathematics, the most suitable way to understand science and to solve scientific problems is to teach learners those theories and formulas in a traditional way, as there is nothing left to argue regarding finalized formulas. This is a contradictory point of view when the nature of science, as it is explained in the main chapters and summarized here, is based in thought: unlike the objects of mathematics, the objects of science are concrete. The concepts of science evolve out of the relations of these concrete objects. For instance, the formula of the relationship between force and mass, that is, “F=ma” may seem like an abstract combination of letters, and just by knowing this formula may seem to be enough to solve related scientific problems, but it is not the case. Each letter in this formula corresponds to facts and relations in real life. The traditional way to teach students the scientific subjects makes those subjects nearly meaningless. The meaning is reduced to practicing those formulas in exams. Learning formulas by heart may bring a top grade, but it never guarantees learning those concepts intimately and perennially, but being active in the learning process makes a difference.

Before moving to scientific argumentation in science education, it would be beneficial to emphasize a general point that argumentative education is not a magic wand that will fill all the deficiencies in education. However, a considerable number of studies (Zohar & Nemet, 2001; Dusch & Osborne, 2002, Kuhn, 2010); show that the argumentative way of teaching and learning, instead of a traditional way, improves students’ learning and conversational skills, the permanence of the information over time, and the degree of creativity of both the students and the teachers. Students' development in terms of creativity is easy to follow; they are the most active part of the learning process when they produce claims and responding to others. In order for them to produce a claim, they investigate the subject carefully. Therefore, their sense of wonder, which is suppressed in the traditional way of teaching and learning, is aroused. As a positive outcome, when they react to others' claims, their critical thinking skills, one of the important skills of the 21st century, also improve. Nowadays, critical thinking is given as a separate lecture in many schools but in an argumentative way of learning. Teachers' development in terms of creativity is also worthwhile. In the argumentative way of teaching, teachers do not talk about the subject throughout the lecture period. They are the facilitators who observe and control the argumentative class. Their role here is to identify the lack of knowledge and inefficacy of argumentative skills in order to fix them as soon as these problems occur. Keeping the students active, as well as motivated, in the lecture necessitates well-designed in-class activities, which should be meticulously prepared by the teachers. The argumentative way of teaching, therefore, also motivates the teachers to develop and use their creative sides, unlike the traditional way of teaching, which is performed as statements of facts while watching the students lose their concentration as the lecture continues. The conversational part in class environment is significant in the argumentative way of teaching and learning. Of course, in argumentative education, written arguments on a related topic are also evaluated. For argument evaluations, there are some acknowledged methods for argumentative education that can be collected under the topics of domain-general methods and the domain-specific methods.

The supporters of the domain-general methods assume that the factors involved in creating qualified arguments are not context-dependent. There are some basic steps that should be followed in order to attain a strong argument, regardless of the domain. As a domain–general method, Toulmin's Model of Argument is famous in the educational context. This model has six basic steps which are respectively: i) introduction of the problem, ii) data offering, iii) warrant exploration, iv) offering factual backing, v) discussing counter-arguments and providing rebuttal, and vi) the conclusion (Erduran, Simon, & Osborne, 2004; Sampson & Clark, 2008).

The supporters of the domain-specific frameworks point out that since the domain-general frameworks do not indicate how the arguments in science differ from the arguments of other domains, the domain-specific features and context of a field, such as science, must be emphasized in order to reach strong and qualified arguments (Sampson & Clark, 2008).

Both of the methods may have benefits on their own. For instance, the domain-general methods can be helpful for the introductory parts of a subject, such as the basics of an issue. The more multifaceted parts, such as the advanced topics of a scientific subject, necessitate focus on a high number of concepts, claims, and investigations; the domain-general methods may fail to satisfy because these methods evaluate the form of arguments instead of their content. For the domain-specific methods, listed in the second chapter, the problem is the ambiguity of teaching students context-related features. The question that is not answered satisfactorily here is how to provide an argumentative environment in the course of students' education on context-related characteristics.

Both methods can be developed and diversified. Since the Argumentation Theory is a rising area and its benefits in the educational context are continuously being emphasized (Zohar & Nemet, 2001; Dusch & Osborne, 2002, Kuhn, 2010), this development is imperious. These methods receive punctilious focus by educational scientists. The methodology of how to apply them in the class environment is in their working area. The statistics of success when they are applied is also one of the most important things they focus on. However, the weaknesses in these methods are the results of the absence of the philosophical approach. The motivation behind this thesis is to point out the need for the strong collaboration between philosophy and educational sciences.

Both the domain specific and the domain-general methods may be reinforced by a philosophical point of view. As with this approach, Alec Fisher's method is explained in the second chapter. This method is based on evaluating written arguments. This evaluation involves identifying the premises and the conclusion of a text which is written by the experts on a specific issue. Here there are some questions that should be asked by the reader, such as, "What argument or evidence would justify me in asserting the conclusion *C*? (What would I have to know or believe to be justified in accepting *C*?)" (Fisher, 2004).

The detailed explanation of Fisher's method can be found in the second chapter. Here, it would be beneficial to note that Fisher's method invites the reader to think carefully and question the information given. These two basic things are quite important in terms of the development of argumentative skills, and these skills are suppressed in the traditional way of education. This method can be seen as a domain-general method that is especially detailed and widely evaluated. While Toulmin's method strongly depends on the warrants reached by the researcher and is therefore susceptible to researchers' bias, Fisher's method invites the reader to question everything that is stated by the experts themselves. In Fisher's method, as long as a reader can identify the premises and the conclusion in the text, this reader can also evaluate the strength of the arguments. Moreover, Fisher's method also lacks a requirement for a good command of a subject. During the reading exercises and argument identification and evaluation, the information about a subject is also acquired.

In the fourth chapter, a significant study is detailed. In this study, an argumentative curriculum was designed and implemented in an experimental group, while, concurrently, a second group is educated in a traditional way in the same science subject. In the argumentative curriculum, the concepts and the problems related to the topic of genetics are conveyed through everyday dilemmas. The questions, e.g., "Should couple X abort their fetus in the case of the genetic disease Y?" invites the students to think about two distinct things, morality and genetics, in the same context. Their moral side was not evaluated in this study, but the strength of their arguments, as well as their command of the subject, was carefully evaluated in both the written and conversational contexts. At the end of the study, it was shown that the students who had an argumentative way of scientific education developed their knowledge of the subject and argument construction, while the students who had the traditional way of education did not show progress.

The benefits of argumentative education in science, as indicated in this thesis, is explicit. In this sense, there is a consensus that it is more productive than traditional education since the way to produce, practice, and transfer knowledge has changed. The traditional way of education might have been useful when gathering information was difficult, when books were not easily accessible and the technology was not as efficient as it is today. So, people holding needed information were few, and there was a need to transfer this knowledge from one person to many. Today, however, to find knowledge is not difficult. Books are available to everyone, and online platforms are filled with credible sources. Instead of telling the students that "F=ma," making them find their own way of defining the force-mass relationship and other concepts should be the way of educating them. The argumentative way of science education, in this sense, is promising.

5.2) The Philosophical Side

While applying an argumentative curriculum and evaluating the results in science education is in the field of the educational sciences, the core of this curriculum should be detailed by philosophy scholars.

The first reason philosophy scholars are needed is that argumentative science education is based on the applications of informal logic. Besides the validity of the arguments, in informal logic, real-life relations are also evaluated. That is to say, informal logic requires more than the form and validity of the arguments. Since science is a social, developing, and creative domain, the practice of informal logic must be very detailed and attentive.

To proceed in argumentative science education, it is important to avoid logical fallacies, which are, briefly, the wrong ways to draw a conclusion. Science is dangerously open to fallacies in the sense that some subjects are open to moral discourse. Therefore, for a qualified argumentative science education, fallacies must be successfully identified, and this should be addressed in the curriculum. Fallacies have been studied by philosophy scholars all over the world.

Any topic in science can be learned in an argumentative way. There is no need for a topic to be open to discussion as it is, for instance, in the case of the anti-vaccination movement. Of course, it would be useful to design a debate environment on this issue, and it would also serve as a platform for knowledge acquisition. As explained in the fourth chapter, however, even topics like genetics, which are clear and certain, and which can be expressed mathematically, can be designed to be part of an argumentative curriculum. The area of philosophy can address a topic in a way that can be discussed in terms of informal logic.

Here it might seem problematic to decide how to give the basics of an argument. The challenge of the argumentative education is the risk that at any point the lecture may become traditional in method. This may have several reasons, such as the teacher starting to talk more than the students, creating a one-way information flow. This risk is especially high when teaching the basics. The basics are the concepts of a related topic and the main concepts of argumentation are “argument,” “premise,” and “conclusion.”

To ensure students acquire the knowledge of the basics of argumentation, two ways might be followed: The first way is to design a lecture that is only on the concepts of argumentation, but this may lead to a teacher-to-student knowledge transfer. The second way conveys the concepts in the activity itself. Fisher’s method is very applicable in this context. Appropriate to the students' level, an argumentative text may be chosen, and students are motivated to identify the arguments. This way is helpful for students to discover their argumentative instincts.

The concepts of science can be taught in the argumentative way as well. In other words, even lectures in which the basic definitions are provided can be designed in terms of argumentative education. In the fourth chapter, the argumentatively designed lecture on "force" was explained. A method that is particular to the domain of philosophy was established based on Philosophy for Children. This method by Lipman can be applied in every domain, but, unlike Toulmin's domain-general method, Philosophy for Children has domain-specific practices. For instance, while in social subjects, the moral issues are open to discussion through a story told or read by the facilitator, in our case the teacher, in science, since there is only one true answer for a particular problem, can apply different exercises, such as concept-meter. In the fourth chapter, this concept-meter is explained.

Depending on the level of the students, that is to say from which grade a student is, curriculum decisions are related to the field of education. However, how to teach these subjects in an argumentative way and which method to choose falls to the field of philosophy. Therefore, argumentative curriculum should be an interdisciplinary work of these areas.

5.3) The Role of Argumentation Theory in Scientific Reasoning and Science Education

As it is emphasized several times, although the nature of science is quite argumentative, there is a view that, since science can be formulated, there is no place to argue the scientific facts. However, as Fisher shows, even experts' arguments are open to question.

Science is one of the most difficult subjects for students: it necessitates understanding of the concepts and the relations between the concepts, as well as solving the related problems. In these circumstances, the most suitable way to gain permanent knowledge becomes a matter of issue.

Argumentative science education in this sense is helpful. In the previous chapters, the theories and the studies related to its benefits were discussed. Here, it would be beneficial to emphasize these benefits one by one to show how they may be developed in the future.

First, the argumentative way of learning in science classes motivates the students by making them active during their learning processes. While in traditional education, the formulas are nothing but temporarily held information needed to pass the exams, to work on what is learned improves the quality of education. In this way, students find a chance to express their thoughts in front of others instead of being passive listeners.

Second, the argumentative way of learning in science classes teaches students how to question what they are told. In this way, students learn not to accept they are told as fact. Asking questions continuously will help them see it is not odd to respond to what they think may be wrong, weak, or incomprehensible. In the traditional way, although the teachers invite the students to ask questions, how many of them find a courage to do so?

Third, the argumentative way of learning in science classes shows students it is not unusual to have different ideas on a same topic. Although there is one right answer for the scientific problems, there may be many ways to reach this answer or, sometimes, there are counterexamples that prove that an answer can change. Sometimes, as in the example in the fourth chapter, moral dilemmas can be related to scientific concepts, so the reactions and thoughts on the same subject may even be more pronounced. The student, in this way, sees that it is not a matter of feeling angry. Together with the first two benefits, the argumentative way of learning in science classes improves students' critical thinking skills.

Last, and most important, within the argumentative way of learning in science classes, all students are carefully watched by the teacher. Without turning the lecture into a traditional one, the teacher is able to correct mistakes as soon as they are made and see who needs assistance. In the exams of the traditional way of education, most of the time it is enough for a student to write a definition that is learned by heart or solve a problem just by applying a formula, but those exams never show whether a student actually understands a particular issue. The exams that can be easily solved with a dictionary and a formula sheet do not tell a teacher anything about the comprehension of an issue, but an argumentative way of teaching will.

As for the teachers, the argumentative way of teaching in science classes motivates them in the sense that they see more motivated and active students in their lectures. Instead of observing their boredom, seeing their enthusiasm will bring them occupational satisfaction. Moreover, the lectures may turn into dynamic, constructive, and creative periods where teachers may find a chance to display their creativity by creating an argumentative environment.

Therefore, the role of Argumentation Theory in scientific reasoning and science education is reciprocal. The benefits of the theory make its practice worthwhile.

5.4) On the Future of the Philosophical Approach to Educational Sciences

This thesis focuses on the Argumentation Theory in science education. For future research, the role of Argumentation Theory in educational sciences would be an enlightening subject to examine in detail.

Today, there are different types of schools all over the world. In Turkey, the traditional school system still protects its relevance and, since the national examination system's measurement and evaluation style correspond to the traditional way, students must embrace this system. There are some lectures in which students are supposed to be active and productive, but since the curriculum of those lectures is not covered by the content of the national examination system, most students do not take them seriously.

As an alternative system, International Baccalaureate has a more argumentative curriculum in comparison to our national one, but this system is also a teacher-led system. Although there are some lectures in which students are supposed to produce written arguments and make some presentations that are open to in-class discussions, due to its teacher-led structure, students are not encouraged to express themselves completely.

As stated in the fourth chapter, the Sudbury schooling system is the only system that sets students free in every part of their learning processes. Students are not subjected to an examination unless they choose to be. This system is controversial and approached with suspicion because of its strong emphasis on freedom. One of the most likely questions about Sudbury system asks about children who choose to skip essential subjects such as mathematics, science, and grammar. The answer is that no subject is essential. Students are individuals of their own making, and it is their own responsibility to learn what they select.

Although the students that are enrolled in Sudbury schools are the most active ones in these three schooling systems, a curriculum-free and exam-free environment is far from the argumentative way of education, since the argumentative way necessitates a detailed and well-established curriculum. The argumentative way of education would be the most proper way to identify the students' needs and weaknesses on a particular subject in the learning environment. The measurement and evaluation system of the traditional way may be problematic because of the abovementioned reasons, and that of the Sudbury system is far from being objective. The argumentative way of education has a standard that ensures students are active and motivated.

The parts to be focused on of the argumentative way of education is open to be diversified. Since the teaching and learning environment is quite different from the traditional one, the measurement and evaluation methods must also be different. In class exercises, homework, individual work, and group work are the topics that are worthwhile.

Sources such as books and online exercises are another area that should be discussed. The sources of the traditional way of education are stricter and proceed as such: the lecturing part, the questioning part, and the answer key. The books used in the argumentative way of education must also keep the students active and motivated with interesting and challenging questions.

The questions to be included in the resources is another focal point for the future of the argumentative way of education. For that purpose, questions can be classified according to their means, such as questions designed for concept learning, relational questions, and questions that aim to teach problem solving.

The relationship between argumentation and learning has a wide scope which will be approached with interdisciplinary means in the future. Although the traditional way of education is still valid and dominant in our country, like every researcher

who is interested in this area, I am hopeful that I can develop my research on this issue in my future studies, and that one day an argumentative way of education will be the prevalent one.

REFERENCES

Argumentation(2010). In *Oxford dictionary of english* (3rd ed.). Oxford University Press.

Ayalon M., & Hershkowitz R. (2018). Mathematics teachers attention to potential classroom situations of argumentation. *The Journal of Mathematical Behavior, 49(1), 163-173*.

Bench-Capon, T., Dunne, P. (2007). Argumentation in artificial intelligence. *Artificial Intelligence,* 171(10), 619-641.

Binkley, R. (1995). Argumentation, education and reasoning. *Informal Logic,* 17(2), 127-143.

Blackburn, S. (2005). Analogy. In *The Oxford Dictionary of Philosophy*. Oxford University Press.

Blackburn, S. (2005). Consistency. In *The Oxford Dictionary of Philosophy*. Oxford University Press.

Blackburn, S. (2005). Induction. In *The Oxford Dictionary of Philosophy*. Oxford University Press.

Blackburn, S. (2005). Pragmatics. In *The Oxford Dictionary of Philosophy*. Oxford University Press.

Blackburn, S. (2005). Semantics. In *The Oxford Dictionary of Philosophy*. Oxford University Press.

Blackburn, S. (2005). Soundness. In *The Oxford Dictionary of Philosophy*. Oxford University Press.

Blackburn, S. (2005). Syntax. In *The Oxford Dictionary of Philosophy*. Oxford University Press.

Bostrom, N.F.(2002). Anthropic bias: observation selection effects in science and philosophy. In R. Nozick (Ed.). *Studies in philosophy: outstanding dissertations. Routledge*.

Brümmer, V.(2001). On three ways to justify religious beliefs. *Ars Disputandi*, 1(1), 18-30.

Budzynska, K., Araszkiewicz, M., Bogołębska, B., Cap, P., Ciecierski, T., Debowska- Kozlowska. et al. (2014). The polish school of argumentation: a manifesto. *Argumentation*, 28(3), 267–282.

Cook, T. (2009). Deduction. In *A Dictionary of Philosophical Logic*. Edinburgh University Press.

Cremin, L.A. (1959). John dewey and the progressive education movement. *American Journal of Education, 67(1), 160- 173.*

Dewey, J. (2004). *Democracy and education.* New York: Dover Publications.

Dijk Van, T. (1997). What is political discourse analysis. *Belgian Journal of Linguistics*, 11(1), 11-52.

Dowden, B. (n.d.). *Fallacies.* Retrieved from https://www.iep.utm.edu/fallacy/#AdHominem

Duschl, R. A., & Osborne, J. (2002). Supporting and promoting argumentation discourse in science education. *Studies in Science Education*, *38*(1), 39–72.

Eemeren Van F.H. (2015). *Reasonableness and Effectiveness in Argumentative Discourse: Fifty Contributions to the Development of Pragma-Dialectics.* Springer.

Eemeren Van, F.H., Grootendorst, R. (1992). Relevance reviewed: the case of argumentum ad hominem. *Argumentation,* 6(2), 141-159.

Eemeren Van, F.H., Grootendorst, R. (2010). *A systematic theory of argumentation: the pragma-dialectical approach.* New York: Cambridge University Press.

Eemeren Van, F. H., Grootendorst, R., Johnson, R. H., Plantin, C., & Willard, C. A. (2009). *Fundamentals of Argumentation Theory: A Handbook of Historical Backgrounds and Contemporary Developments.* New York: Routledge.

Eemeren Van F.H., Houtlosser, P. (2009). Strategic maneuvering: examining argumentation in context. F.H. van Eemeren, P.Houtlosser (Eds.). *Examining argumentation in context: fifteen studies on strategic maneuvering. John Benjamin Publishing Company.*

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.*

Fallacy Files. (n.d.). Appeal to nature. Retrieved from: https://www.fallacyfiles.org/adnature.html

Finocchiaro, M.A. (1989). Philosophy as critical thinking. *The Journal of Philosphy for Children,* 8(1), 2-3.

Fisher, A. (2004). *The logic of real arguments.* New York: Cambridge University Press.

Goldstein, M., Crowell, A., & Kuhn, D. (2009). What Constitutes skilled argumentation and how does it develop. *Informal Logic*, 29(4), 379-395.

Govier T., (1989). Critical thinking as argument analysis. *Argumentation*, 3(2), 115-126.

Groarke, L.(2019). Informal logic. In E.N.Zalta (Ed.) *The stanford encyclopedia of philosophy*. Retrieved from https://plato.stanford.edu/archives/sum2019/entries/logic-informal/

Hitchcok, D. (2018). Critical thinking. In E.N. Zalta (Ed.) *The stanford encyclopedia of philosophy*. Retrieved from https://plato.stanford.edu/archives/fall2018/entries/critical-thinking

Jackson S., & Jacobs S. (1992). Structure of conversational arguments: pragmatic bases for the enthymeme. In J.P. Benoit (Ed.), *Readings in Argumentation.* New York: Foris Publication.

Knight, J., Wood, W. (2005). Teaching more by lecturing less. *Cell Biology Education,* 4(1), 298-310.

Kuhn, D. (2010). Teaching and learning science as argument. *Science Education*, *94*(5), 810-824.

Kuhn, D., Hemberger L., Khait V. (2016). *Argue with me: argument as a path to developing students' thinking and writing.* Routledge.

Kuhn, D., & Udell, W. (2003). The development of argument skills. *Child Development*, 74(5), 1245–1260.

Lemke, J. (1990). *Talking science: language, learning, and values*. Ablex Publishing Corporation.

Luhmann, N. (1995). Legal argumentation: an analysis of its form. *The Modern Law Review,* 58(3), 285-298.

Partnership for 21st Century Learning. (n.d.). Framework for 21st century learning. Retrieved from: http://www.p21.org/our-work/p21-framework

Perelman, C. (1971). The new rhetoric. In M. Bar-Hiller (Ed.). *Pragmatics of natural languages*. Springer.

Pritchard, M. (2018). *Philosophy for children.* Retrieved from: https//plato.stanford.edu/Archives/spr2018/entries/children

Rapp C., & Wagner T. (2012). On some Aristotelian sources of modern argumentation theory. *Argumentation*, 27(1), 7-30.

Roe, A. (1961). The psychology of the scientist. *Science,* 134(3477), 456- 459

Rowland, R. (1987). On defining argument. *Philosophy & Rhetoric*, 20(3), 140-159.

Sampson, V., & Clark, D. B. (2008). Assessment of the ways students generate arguments in science education: Current perspectives and recommendations for future directions. *Science Education*, 92(3), 447–472.

Sampson ,V., & Scheigh S.(2013). *Scientific argumentation in biology: 30 classroom activities.* Arlington, VA: NSTA Press.

Sandoval, W. (2003). Conceptual and epistemic aspects of students' scientific explanations. *The Journal of the Learning Sciences*, 12(1), 5-51.

Schwarz, B. B. (2009). Argumentation and learning. In Mirza N., & Perret.-Clermont. A.N.(Eds.) *Argumentation and education: theoretical foundations and practices*. Boston: Springer.

Sharp, A. (2010). *Studies in philosophy for children.* Philadelphia: Temple University Press.

Siegel, H., Biro, J. (1997). Epistemic normativity, argumentation, and fallacies. *Argumentation*, 11(3), 277-292.

Sudbury Valley School. (n.d.). Theory. Retrieved from: https://sudburyvalley.org/theory

The Philosophy Foundation. (n.d.). Philosophy for children. Retrieved from: https://www.philosophy-foundation.org/p4c

The Philosophy Foundation (n.d.). What is philosophy. Retrieved from: https://www.philosophy-foundation.org/what-is-philosophy

Walton, D. (1990). What is reasoning? What is an argument. *The Journal of Philosophy,*87(8), 399-419.

Woleński, J. (2015). *Lvov-warsaw school*. Retrieved from: https://plato.stanford.edu/archives/win2015/entries/lvov-warsaw/

Wybraniec-Skardowska U. (2018) Introduction. the school: its genesis, development and significance. In Garrido Á., Wybraniec-Skardowska U. (Eds.) *The lvov-warsaw school. past and present. studies in universal logic*. Springer International Publishing: Birkhäuser, Cham.

Zohar, A., & Nemet, F. (2001). Fostering students' knowledge and argumentation skills through dilemmas in human genetics. *Journal of Research in Science Teaching*, *39*(1), 35–62.

APPENDICES

A. THE LIST OF SOME ARGUMENT INDICATORS

Premise Indicators
Assuming that
Given that
If
Supposing that

Conclusion Indicators
Therefore
Thus
So
Hence
As a result
Consequently
Which proves that
Justifies the belief that
Demonstrates that

Reason Indicators
Since
Because
For
Follows from the fact that

Hypothetical Indicators
If ..../then
Provided that
Suppose
Let's think about
Imagine that
What if.

B. THE STEPS TO FOLLOW TO EVALUATE ARGUMENTS

1st Step: Follow Fisher's method to detect arguments.

- If it is a written material, read it very carefully. If it is a conversation listen and take notes.
- Specify the arguments indicators. You can check the list given in the Appendix A.
- Identify the main conclusion.
- Always ask yourself: "Why would I accept the main conclusion in this circumstances? What is given me in the text? What is told me during this conversation?"

2nd Step: Write down the argument you detected.

3rd Step: Check soundness of the argument: are all the premises and conclusions true? Are they related with the context given? (Informal Logic)

4th Step: If it is sound, check the validity of the argument: are the premises necessarily followed by the conclusion? (Formal Logic)

5th Step: If it is also valid, you have a strong argument.

C. TURKISH SUMMARY/TÜRKÇE ÖZET

Argümantasyon Teorisinin Bilimsel Akıl Yürütmedeki ve Fen Bilimleri Eğitimindeki Rolü

Argümantasyon iletişimin sağlanabildiği her alanda fikir, düşünce ve bilgi aktarımının gerçekleşmesi için akıl yürütmeye dayalı, sosyal ve etkili bir aktivitedir. Belirli ifade kalıpları ve yöntemleri ile temelde kendine özgü bir biçimi ve yöntemi olan argümantasyonun etkililiği fikir, düşünce ve bilgi aktarımında standardizasyon ve objektiflik sağlamasından gelmektedir. Argümantasyon, ilgili literatürdeki en genel tanımı ile, karşıdaki bireyin bir iddiayı, görüşü benimsemesi amacıyla ya savunulan iddianın, görüşün temellendirilmesi ya da karşıt bir iddianın, görüşün çürütülmesi şeklinde gerçekleşen sözsel, akılsal ve sosyal bir aktivitedir (van Eemeren & Grootendorst, 2010). Argümantasyon sözseldir çünkü muhakemesi kendine özgü, keyfi olmayan, gündelik ifadelerden oldukça farklı olabilen dilsel ifadelerle mümkündür; argümantasyon akılsaldır çünkü iddiaları, görüşleri anlama ve onlara karşılık verme durumları için dikkatli, derinlikli düşünme eylemi gerektirir; argümantasyon sosyal bir aktivitedir çünkü iddiaları, görüşleri karşıdaki bir insana ifade etme amacı olan bir diyalog sürecini barındırır (Kuhn & Udell, 2003; Goldstein, Crowell,& Kuhn, 2009; van Eemeren &Grootendorst, 2010). Bu noktada belirtmek gerekir ki, kişinin kendi kendisine argümanlar sunması (örneğin, bir konu ile ilgili kendi kendisini motive etmesi, ikna etmesi gereken durumlar söz konusu olduğunda) argümantasyon olarak değerlendirilmemektedir. Bu ancak argümantasyon etkinliğinin bir parçası olan bireysel akıl yürütme olarak değerlendirilebilir. Argümantasyon aktivitesinin gerçekleşmesi, iddiaların, görüşlerin ifade edileceği bir başkasının varlığını gerektirmektedir. Tanımında özellikleri belirtilen argümantasyon etkinliği, hem bir iddiayı, görüşü savunan tarafın hem de bu iddianın, görüşün karşıtını savunan ya da bu iddia, görüş hakkında herhangi bir tutumu olmayan tarafın aktif bir biçimde kavrama, bilgi oluşturma ve o bilgiyi aktarma basamaklarında rol almasını sağlamaktadır. Argümantasyon aktivitesinin çeşitli alanlardaki rolü, gerçekleşme biçimi ve sonuçlarının çeşitli disiplinlerdeki araştırmacılar tarafından çalışıldığı alan, ilgili literatürde Argümantasyon Teorisi olarak geçmektedir ve günümüzde yoğun olarak çalışılmaktadır.

Argümantasyonun temelindeki biçimsel ve yöntemsel belirlilik, argümantasyon aktivitesinin gerçekleştiği bağlama göre ve dolayısıyla bilgi içeriğine ve bu içeriğin hitap ettiği kişilere göre çeşitlenmektedir. Bir başka deyişle, argümantasyon aktivitesinin gerçekleştiğini işaret eden belli başlı dilsel ifadeler her bağlamda bulunsa da, bağlamlar arasında farklılaşan durumlar söz konusudur. Bu tezde argümantasyon aktivitesi eğitim bilimleri bağlamında incelenmektedir. Eğitim bilimleri bağlamında ise fen bilimleri eğitimine odaklanılmaktadır. Bu odaklanmanın birkaç sebebinden ilki, fen bilimleri eğitiminin kapsadığı kavramlar, bu kavramlar arasındaki ilişkiler ve bu ilişkilerin ortaya çıkardığı bilimsel problemlerle kalabalık ve kavranması kolay olmayan bir içeriğe sahip olmasıdır. İkincisi, fen bilimleri her ne kadar kanıtlanmış iddiaları ve teorileri içerse de bu teorilerin değişmeye kapalı olmamasıdır. Bir başka deyişle fen bilimleri aktif ve dinamiktir; kanıtlanmış da olsa bu kanıtlanmalar dayatmalar gibi değişime, gelişmelere, eleştirilere kapalı değildir. Üçüncüsü ise fen bilimlerinin, diğer bilimlerin (ör: sosyal bilimler, formel bilimler) de olduğu gibi, dikkatli, derinlikli ve odaklı bir düşünme gerektirmesidir. Bu üç sebep bir arada düşünüldüğünde, fen bilimlerinin yapısının argümantasyon temelli bir eğitime uygun olduğu, dolayısıyla da argümantasyon temelli eğitimin fen bilimleri derslerinden verim alınmasında önem arz ettiği ortaya çıkmaktadır.

Bu tezde Argümantasyon Teorisi felsefi ve eğitimbilimsel olmak üzere iki bağlamda ele alınmıştır. Bunlardan ilki olan felsefi bağlamda, Argümantasyon Teorisi'nin fen bilimleri eğitimine uyarlanışına ve mevcut yöntemlerde gerekli düzenlemelerin yapılmasına odaklanılmıştır. Eğitimbilimsel bağlamda ise çağdaş fen bilimleri eğitiminde Argümentasyon Teorisi'nden nasıl faydalanılacağına odaklanılmıştır.

Argümantasyon, fen bilimleri eğitiminde bir standardizasyon sağladığından, kendine özgü bir mantıksal çerçevede incelenmelidir. Bu mantık çerçevesi ise enformel (biçimsel olmayan) mantık. Argümantasyon Teorisi göstermektedir ki formel (biçimsel) mantığın modelleri, sosyal bir çevre olan öğrenme alanında yeterli olmamaktadır. Bunun en önemli sebebi, formel mantığın yalnızca öncül ve sonuç önermeleri arasındaki geçerlilik ilişkisine, yani biçimsel, yapısal bir ilişkiye odaklanmasıdır. Enformal mantık ise öncüllerin argümanın üretildiği bağlamla olan ilgisine, yeterliliğine ve kabul edilebilirliğine de odaklanır (van Eemeren, Grootendorst, Johnson, Plantin, & Willard, 2009). Burada bir yanlış anlaşılmaya mahal vermemek adına belirtilmelidir ki argümantasyon aktivitesinde formel mantığın da önemli bir yeri vardır. Enformel mantığın vasıtasıyla uygun öncüller ve sonuçlar elde edildikten sonra bu öncüllerin ve sonuçların bir arada geçerli olup olmadığı formel mantık ile anlaşılır.

Fen bilimleri alanında argümantsyon incelendiğinde, karşımıza "bilimsel argümantasyon" kavramı çıkmaktadır. Bu kavram en genel anlamıyla argümanların fen bilimleri alanında uygulanması demektir. Bu noktada, fen bilimlerinin yapısı gereği argümantasyona ne kadar uygun olduğu ortaya çıkmaktadır. Belirli basamakları içeren bilimsel yönteme bakıldığında bu uygunluk net bir şekilde anlaşılacaktır. Bu basamaklar sırası ile şu şekildedir: Zihinde bir sorunun ya da problemin belirmesi, bu soru ya da problemle ilgili araştırma yapılması, bu araştırmaların spnucunda bir hipotez oluşturulması, very toplanması, toplanan verilerin kontrollü deneyler vasıtasıyla incelenmesi ve nihayetinde hipotezin doğru olup olmadığının belirlenmesi ve eğer yanlışsa yeni bir hipotezin kurulması. Görüldüğü üzere bilimsel yöntem, başlangıç noktası olan soru ya da problem basamağından itibaren derinlikli ve elştirel bir süreç içermektedir. İroniktir ki bilimsel yöntemin kendisi bile fen bilimleri eğitimi kapsamında öğrencilere ezberletilmektedir.

Bu noktada argümantasyon temelli bir eğitim ile, argümantasyon temelli olmayan eğitimin, yani klasik eğitimin farkını belirtmek aydınlatıcı olacaktır. Klasik eğitim belirlenmiş bir müfredat çerçevesinde öğretmenin sınıf içinde aktif olarak konuyu anlattığı, öğrencinin ise bu esnada konuyu sessizce dinlediği ve bilgisini sınıf içi alıştırmalarda ve sınavalarda tek başına kullanması gerektiği bir eğitim biçimidir. Tipik olarak sınıfta tahtanın önünde ortalama kırk beş dakikalık bir ders süresinde öğretmenin sürekli konuştuğu ve öğrencinin ise nadiren katıldığı bu eğitim modelinde öğrenciler kendi öğrenme süreçlerinde pasiftir. Argümantasyon temelli eğitimde ise öğrenciler aktiftir; bilgi oluşturma sürecinde sınıf arkadaşları ile birliktedir. Kendi fikirlerini sınıfta bulunan herkesin varlığında ifade eder, fikirlerini ifade eden sınıf arkadaşlarını dinler ve onlara cevap verir. Öğretmenin bu ortamdaki rolü önemlidir. Öğretmen, argümantasyon aktivitesinin gerçekleştiği bu ortamda bilgi akışını, ifade ediliş biçiminin uygunluğunu, verilen cevapların niteliğini değerlendirir, gerektiği yerde müdahale eder. Burada belirtilmelidir ki, argümantasyon temelli bir eğitim de belirlenmiş bir müfredatı takip eder. Klasik eğitimden farkı, konuların işleniş biçiminin ve öğrenme pratiğinin farklılığından kaynaklanmaktadır.

Argümantasyon temelli fen bilimleri eğitiminin faydaları sosyal ve bilişsel olmak üzere iki açıdan ele alınmıştır. Argümantasyonun sosyal açıdan fen bilimleri eğitimine faydası, öğrenme pratiğinin "Neyi biliyorum?" sorusundan ziyade "Nasıl biliyorum?" sorusu merkezinde ilerliyor olmasından kaynaklanmaktadır. Fen bilimlerinin dimanik, eleştiriye açık ve sosyal yapısının argümantasyon temelli eğitime uygunluğu argümantasyonu karşı tarafın argümanlarını çürütme amaçlı bir savaş olarak görülmemesi, bir uzlaşma, bir fikir birliğine varma yolu olarak görülmesini de beraberinde getirir. Öğrenciler argümantasyon temelli bir fen bilimleri eğitiminde fikir sunmayı, iddialara ve fikirlere karşı çıkmayı ve sonuçta kanıtlanmış, incelenmiş, güçlü bir fikre ulaşabilmeyi deneyimler (Duschl, & Osborne, 2008). Argümantasyonun bilişsel açıdan faydası ise öğrencilerin pasifize edildiği klasik eğitim sisteminde bastırılan merak duygusunu açığa çıkarması ile birlikte öğrencilere iki önemli yettenek kazandırmasıdır: Tartışmayı öğrenmek ve öğrenmek için tartışmak. Bunlardan ilki, sınıf içi argümantasyon aktivitesinde iddialar ve fikirler tartışılırken kavga etmemek ve konudan sapmamak anlamına gelirken ikincisi merak duygusunun da yardımıyla bir iddiayı ya da fikri savunurken destekleyen görüşleri ya da karşı argümanları da değerlendirmeyi kapsayan süreç içinde gerekli kazanımların sağlanması demektir (Schwarz, 2009).

Argümantasyon temelli bir fen bilimleri eğitimin faydalarını deneyimleyebilmek, argümanları tespit edebilmeyi ve argüman oluşturabilmeyi gerektirmektedir. Bu tezde Argüman tespiti için Fisher'ın modeli sunulmaktadır. Bu model, argümanları uzmanlar tarafından yazılan metinlerden çıkarmayı öğreten bir modeldir. Temel basamakları ise şu şekildedir: İlk olarak metin dikkatlice okunmalı ve argümanları belirten belli başlı sözcükler daire içine alınmalıdır. Bu sözcükler, anlatılanbın bir sonuç mu, neden mi yoksa varsayım mı olduğunu bize gösterir. Bunları belirledikten sonra yapılacak şey açıkça belirtilmiş sonuç ifadelerinin altını çizmek, okuyanı bu sonuçlara ulaştıran neden ifadelerini de köşeli parantez içine almaktır. Bu basamaktan sonra ise ana sonuç (sayıca birden fazla olabilir) S harfi ile belirtilir. Okuyanı ana sonuca ya da sonuçlara ulaştıran nedenler de belirlendikten sonra okuyucu, Savlanabilirlik Sorusu olarak isimlendirilen şu soruyu sormalıdır: "S sonucunu savlamamı temellendirecek argüman veya kanıt nedir?" (Fisher, 2004).

Fisher'ın modeli enformel mantığın metinler üzerinde uygulanmasından sonra tespit edilen argümanların nedenlerinin ve sonuçlarının güçlülüğünü, inandırıcılığını ve bağlama uygunluğunu gösterir. Bu uygulamadan sonra elde edilen argümanın geçerli olup oladığı ise formel mantık ile denetlenmelidir. Fisher'ın modeli ile öğrenciler metin üzerinden argüman tespit edebilmeleri, argümanları işitsel bağlamda da tespit edebilmelerini kolaylaştıracaktır.

Argüman oluşturma yöntemleri ise iki ana başlık altında toplanmıştır: Bağlamsal olmayan yöntemler ve bağlamsal yöntemler. Bağlamsal olmayan yöntemlerin temel savı, nitelikli bir argüman oluşturmanın bağlamla ilgili olmadığıdır. Bir diğer ifadeyle, bu yöntemler ile her bağlamda güçlü ve güvenilir argümanlar elde edilebildiği iddia edilmektedir (Sampson & Clark, 2008). Stephen Toulmin'in altı basamaklı argüman modeli buna örenk olarak verilebilir. Sırasıyla bu basamaklar; iddia oluşturma, veri toplama, destekleyici bulma, olgusal dayanak bulma, karşı argümanları tartışma ve onları çürütme ve sonuç şeklindedir (Erduran, Simon, & Osborne, 2004; Sampson, &Clark, 2008). Toulmin'in modelinde önemli bir açıdan problem teşkil etmektedir. Modelin basamaklarından veri toplama ve olgusal dayanak bulma kısımlarında kişi objektif olamayabilir ve kendi iddiasına yakın dayanakları dikkate alırken diğerlerini gözardı edebilir (Sampson &.Clark, 2008). Bağlamsal yöntemler ise argüman oluştururken bağlamın önemli olduğunu, içeriğin, argümanların niteliğinin bağlamdan bağımsız olarak değerlendirilemeyeceğini savunur. Bu yöntemlere örnek olarak da Anat Zohar ve Flora Nemet'in içerik temellendirmesine odaklandıkları çalışmaları verilebilir. Zohar ve Nemet, öğrencilere argüman niteliği ile ilgili bilgilerin ve fen bilgisi dersinin içeriklerinin tanıtılmasından sonra argüman üretme becerilerinin ve dersle ilgili bilgilerinin arttığını gözlemlemiştir (Sampson & Clark, 2008). Bağlamsal yöntemlerin kendi içindeki problemler ise öğrenciden beklenilenin çok fazla olabilmesi ve öğrencilerin argüman oluştururken bağlamı dahil etmesinin standart bir yöntemini tarif edememesi olarak söylenebilir (Sampson &Clark, 2008).

Argümantasyon temelli fen bilimleri eğitiminin pratik karşılıklarına örnekler sunmadan önce, bu tarz bir eğitimin hem sosyal hem de bilişsel faydasını bünyesinde barındıran bir yetinin de kazanıldığını belirtmekte fayda olacaktır. Bu yeti, gününümüzde 21. Yüzyıl becerilerinden biri olarak tanımlanan eleştirel düşünme yetisidir (Partnership for 21st Century Learning, n.d.). Eleştirel düşünme, 20. Yüzyıl düşünürü olan John Dewey tarafından geliştirilen "refleksif düşünme" kökeninden şekillenmiş, aktif, dikkatli ve bilimsel bir düşünme şekli olarak tanımlanır (Hitchock, 2018). Eleştirel düşünme, Dewey'nin odaklandığı alanlardan biri olan eğitim felsefesinde önemli bir yere sahiptir: Dewey, öğrenme sürecinde bilginin kendisindense sürecin, yani aktivitenin önemli olduğunu savunmuş, eğitimin devamlı bir büyüme olması gerektiğini belirtmiştir (1959). Günümüzde pek çok eğitim kurumunda öğrencilerin seçmeli ders olarak alması için açılan ve öğretmenler tarafından seçilmesi için teşvik edilen eleştirel düşünme eğitiminin, argümantasyon temelli bir eğitimin hali hazırda bir parçası olacağı için ayrıca bir ders olarak açılmasına gerek yoktur. Başka bir deyişle, eleştirel düşünme yetisi argümantasyon temalı bir eğitimlşe beraber otomatik olarak kazanılır.

Eleştirel düşünmenin, öğrenciler tarafından bilinmesi gereken bazı temel yapı taşları vardır. Bu temel yapı taşlarından mantık, öğrenciye düşünme eğitiminin başında kazandırılmalıdır.

Argümantasyon Teorisi'nin temelinde olan enformel mantık ve enformel mantığın önermelerinin sonuçlarıyla ilişkisi denetleyen formel mantık, akıl yürütme yöntemlerinden tümdengelim, tümevarım ve analoji ile beraber öğrenciye kazandırılmalıdır. Burada dikkat edilmesi gereken en önemli nokta şudur ki, bu kazandırma esnasında öğrenci, klasik eğitim sisteminin öğrenciyi pasifize eden yöntemi ile eğitilmemeli; bu yöntemler ona sınıfta öğrencinin bilgiye aktif bir biçimde ulaşmasını kolaylaştıracak ve bilgi akışını ve bilgi akış ortamını denetleyecek olan öğretmen tarafından hazırlanan aktiviteler eşliğinde sunulmalıdır.

Mantık ile birlikte dilin de (hem yazılı hem de sözlü olarak) argümantasyon aktivitesine uygun olarak kullanılması önemlidir. Burada semantik, sentaktik ve pragmatik açıdan dilin nasıl değerlendirileceği de aktif bir biçimde öğrenci tarafından deneyimlenmelidir.

Dilin kullanımı ile birlikte öğrenciler varsayımları olgulardan ayırmayı öğrenecektir. Bilimsel argümantasyonda varsayımlar, kanıtlanmış ama eleştiriye açık olan olgulardan ayrılmalı, öğrenciler birbirlerine görüşlerini ifade ederken manipülatif olmamalı, bu durum öğretmen tarafından dikkatlice denetlenmelidir. Mantıksal ya da dilsel açıdan yapılan herhangi bir hata, akıl yürütümedeki hataya, akıl yürütmedeki hata ise argümanın kusurlu olmasına neden olacaktır.

Bu noktada öğrencinin safsataları güçlü ve geçerli argümanlardan ayırabilmesi gerekmektedir. Safsatalar ise sınıf içi bilgi alışverişi, tartışma, fikir beyan etme ortamında tespit edildikçe öğretmen tarafından düzeltilmelidir. Bilimsel argümantasyonda en sık rastlanana safsataları belirtmek faydalı olacaktır. Ad hominem, üretilen argümanlar yerine argümanı sunan kişinin kişisel özelliklerini temel alan (kişinin yaşını, tecrübesini, kökenini vb.) karşı çıkışlar yapmak anlamına gelmektedir (Dowden, n.d.; van Eemeren & Grootendorst, 1992; Siegel & Biro, 1997). Duygulara başvurma safsatası argümanın içeriğinden uzaklaşarak argümanın kişide uyandırdığı duyguların vurgulandığı durumdur (Dowden, n.d.). Bilimsel bir olgu olan akraba evliliklerinin risklerinden söz edildiğinde taraflardan birinin "bu konu beni rahatsız etti çünkü benim annem ve babam da akraba." şeklindeki duygusal karşı çıkışı, akraba evliliği ile ilgili argümana verilmiş bir cevap ise bu noktada duygulara başvurma safsatasından bahsedilebilir. İnanca başvurma safsatası ise olgusal dayanaklara inanç ile ilgili, yani olgusal olmayan, subjektif karşı çıkışlar yapmaktır (Brümmer, 2001). Bir diğer safsata olan "Doğal ise iyidir" safsatası, bilimin ve bilimle birlikte gelişen teknolojinin, doğal olanı yok ettiği; doğal olanın ise kendinden iyi, mükemmel ve sağlıklı olduğu yönündeki bir önkabulü sorgusuzca kabul etmekten doğan bir safsatadır (Fallacy Files, n.d.). Gözlem seçimi safsatası da kişinin kendi düşüncesine ve görüşlerine uyan destekleyicileri seçip, uymayanları görmezden geldiği durumu belirtir (Bostrom, 2002).

Eleştirel düşünme süreci için öğrenciler ayrıca tutarlılığın ve sağlamlığın ne anlama geldiğini de bilmelidir. Tutarlılık çelişkinin olmadığı durum demektir (Blackburn, 2005). Burada vurgulanması geren en önemli husus şudur ki, kişinin bir konu hakkında olan fikrinin değilmesi tutarsızlık değildir. Tuatarsızlık, aynı bağlamda bir iddiayı karşı-iddiası ile birlikte kabul etmektir. Sağlamlık ise bir argümanın öncül ve sonuç ilişkisi bakımından geçerli olması ve aynı zamanda bütün öncüllerin ve sonuç önermesinin doğru olması anlamına gelir.

Eleştirel düşünme yalnızca başkasına ait fikirlerin ya da iddiaların değerlendirilmesini değil, kişinin kendi düşüncelerini de değerlendirmesi anlamına gelir. Bu sebeple, öğrenciler kişinin kendi düşünceleri üzerine derinlikli kafa yorması, yani refleksiyon da kazanılması gereken bir alışkanlıktır.

Son olarak öğrenci düşünceleri, iddiaları ve fikirleri analiz etmenin ne anlama geldiğini mutlaka deneyimlemelidir. Eleştirel düşünme, bir bütün olan düşüncelerin basamakalarını ve elementlerini belirleyebilmeyi gerektirir. Bu basamaklarda ve elementlerde olan herhangi bir kusur safsatalara sebebiyet verebilir, fikirlerin ilerlemesini ve bilgi akışını durdurabilir.

Faydalarının ve yöntemlerinin açıklandığı argümantasyon temelli fen bilimleri eğitiminin pratikteki karşılığı Kavram-temelli pratikler ve aktüalite-temelli pratikler olmak üzere iki başlık altında toplanabilir. Bunlardan kavram-temelli pratiklerin amacı, öğrencilere fen bilimleri derslerinin temel kavramlarını kazandırmayı amaçlar. Bu amaç doğrultusundaki yöntemlerden biri olarak, Çocuklar için Felsefe örnek gösterilebilir. Çocuklar için Felsefe hareketi, 1974 yılında Mathew Lipman'ın Çocuklar İçin Felsefeyi Geliştirme Enstitiüsü'nü, çocukların da akılcı düşünebildiği ve doğru yöntemlerle felsefi cevaplar verebildiği iddiası ile kurması sonucunda ortaya çıkmıştır. Günümüzde Çocuklar İçin Felsefe, çeşitli uygulama yöntemleri ile birlikte bağlam farketmeksizin uygulanmaktadır (The Philosophy Foundation, n.d.). Bu sebeple, Çocuklar İçin Felsefe bağlamsal olmayan yöntemlerin pratikteki karşılığı olarak değerlendirilebilir. Çocuklar İçin Felsefe hareketinin temelinde Lipmann'ın çocuk romanı olan *Harry Stottlemeier'ın Keşfi* vardır (The Philosophy Foundation, n.d.).

Kitabın ana karakteri Harry Stottlemeier, klasik eğitim tarzında, öğretmen odaklı bir fen bilimleri dersinde düşüncelere dalar ve derse olan dikkati dağılır. Bunu fark eden öğretmeni ise dersin konusu ile ilgili bir soru sorar; Harry sorunun doğru cevabını veremez (Sharp, 2010). Süreç içinde Harry kendi kendine düşünerek, düşünme üzerine düşünerek soruya neden yanlış cevabıı verdiğini kendisi bulur ve asıl önemli olanın düşünme eylemi olduğunun farkına varır (Pritchard, 2018).

Düşünmeyi temele alan Çocuklar İçin Felsefe, günümğzde eğitim alanında kullanılan bir yöntem haline gelmiştir. Yöntemde vurgulanan en önemli husus şudur ki, burada çocukların süreç içinde aktif kalarak kavrama dair bilgiyi kendi kendilerine kazandıklarından emin olunmalıdır. Bu süreçte öğretmen, kolaylaştırıcı rolündedir. Kolaylaştırıcı, öğrenmeyi hedefleyecek ve kolaylaştıracak, bununla birlikte çocukları sürekli aktif tutacak sınıf içi etkinlikler tasarlar. Bu etkinlikler, seviyeye göre fen bilimleri eğitimindeki kazanımları içermeli, bu kazanımların öğrenilip öğrenilmediği etkinlik esnasında kolaylaştırıcı rolündeki öğretmen tarafından değerlendirilmelidir.

Aktüalite-temelli pratikler ise kavramlara dair yeterli bilgi kazanıldığında bu kavramların birbirleri ile ilişkilerinin gözlemlenebildiği pratiklerdir. Bu pratiklere örnek olarak Anat Zohar ve Flora Nemet'in birlikte yönettiği Thinking in Science Classrooms Project (Fen Sınıflarında Düşünme Projesi) örnek olarak verilebilir. Bu proje, argumantasyon becerileri ile bilimsel bilginin arasındaki ilişkiyi saptamayı amaçlayan bir çalışmadır ve özel hazırlanmış bir ünite olan *Genetic Revolution: Discussions of Moral Dilemmas* (Genetik Devrim: Ahlaki İkilemlerin Tartışılması) ünitesinin uygulanmasıdır. Bu ünite, belitli bir müfredatın kazanımlarını, ahlaki ikilemlerin yardımıyla sunan bir ünitedir. Homojen bir biçimde oluştutulmuş kontrol grubu ve deney grubu bulunmaktadır. Kontrol grubuna bu kazanımlar öğretmen odaklı klasik eğitim modeli ile verilirken deney grubuna özel ünite uygulanır. Özel ünitenin kapsamı içerisindeki ahlaki ikilemler tamaen öğrenciyi sınıfta aktif tutmak ve birbirleri ile iletişimlerini sağlamak amaçlıdır. Örnek vermek gerekirse bu ahlaki ikilemlerden biri Kistik Fibrozis hastalığı ile ilgilidir: Kistik fibrosis taşıyıcısı bir çift evleniyor, bebek bekliyorlar ve otozomal resesif olan kistik fibrosis hastalığının bebekte görülme olasılığı %25 iken bebeğin taşıyıcı olma olasılığı %50, bebeğin hastalıksız dogma olasılığı ise yine %25tir. Buradaki ahlaki ikilem ise şudur: Çift, hamileliğe son verme kararı almalı mı? Bu noktada öğrencinin ahlaki duruşunun herhangi bir önemi yoktur. Öğrencinin vermesi beklenen cevapta hastalık ve genetiği ile ilgili bilginin olması, bununla birlikte yanıtını temellendirmiş olması gerekmektedir. Bu ünite kapsamındaki bölümlerde öğrencinin bilgilendirildiği bir okuma kısmı, yanıtlaması gereken sorular, sınıf içi tartışma, arkadaşlarının düşüncelerine cevap verme gibi gereklilikler vardır. Üniteler arasında ise öğrencilerin mantık ve argüman üretme ağırlıklı bilgilendirme dersi bulunmaktadır. Çalışmanın sonunda görülmüştür ki, bu özel ünitenin uygulandığı öğrencilerin hem argüman oluşturma yeteneklerinde hem de dersten öğrendikleri bilimsel bilgilerin miktarında ve kalıcılığında ilk zamanlarına göre artış söz konusu iekn klasik eğitim modeli uygulananlarda bu hususlarda herhangi bir gelişme döz konusu değildir (Zohar &Nemet, 2001).

Bu aydınlatıcı çalışmadaki tek problem, ünite aralarında öğrencilere ayrı bir ders olarak verilmesi şeklinde planlanan mantığa ve argümana dair derslerin öğrencinin aktif öğrenme sürecini kesintiye uğratıp uğratmayacağıdır. Öğrencinin aktif bir alandan, öğretmenin kendisine bilgiyi açıkladığı pasif alana geçmesindense, bu yetenklerin de aktivite esnasında kazanılması sağlanmalıdır.

Bu noktada, kavram-temelli bir pratiklerle aktüalite-temelli pratiklerin arasındaki farktan yola çıkılarak, kavram-temelli pratiklerin aktüalite-temelli olanları öncelediği çıkarımı yapılabilir. Bu çıkarım kavram kazanımının kavramların birbiri ile ilişkisinin kazanımından önce gelmesinin mantıksal gerekliliğinden dolayı yapılmış da olsa, bu, kavram-temelli pratiklerin ileri düzey kazanımlarda hiçbir zaman uygulanamayacağı anlamına gelmemektedir. Kavram temelli pratikler, yeni kazanılan kavramların öğrenilmesini kolaylaştırıcı olabildiği gibi, kavramlar arası ilişkilerin gözlemlenmesinin zor olduğu durumlarda bilgi pekiştirici role de sahip olabilir.

Argümantasyonun tanımının, yöntemlerinin, faydalarının ve uygulanış biçimlerinin fen bilimleri eğitimindeki yerinin anlatıldığı bu tezde Argümantasyon Teorisi'nin fen bilimleri eğitimindeki öğrenmeyi ve hatırlamayı aynı zamanda da öğrencinin sosyal süreçlerini geliştirici rolü açıklanmıştır. Öğrenmenin her anının, kavramsal temellerin verilmesi, yöntemlerin kazandırılması da dahil olmak üzere, öğrencinin aktif olacağı şekilde gerçekleşmesi gerektiği savunulmuştur. Bu şekildeki bir eğitimin, fen bilimlerinin yapısına ve gelişimine uygun bir eğitim olduğuna dikkat çekilmiştir.

Argümantasyon temelli bir eğitim, yalnızca öğrenciyi geliştirmekle kalmaz, öğretmeni de geliştirir ve mesleği ile ilgili motive eder. Öğrencilerin aktif katılımlarını dikkatle izleme görevi olan öğretmenler, öğrencilerinin yanlışlarına yanlışların oluştuğu anda müdahale etme ve o yanlışları düzeltme imkanı bulur. Böylece öğrenciler anında aldıkları geri bildirimle, uygulama esnasında gelişir. Böylece, gelecekte, argümantasyon temelli eğitim yaygınlaştıkça öğrenciye özel öğrenme modelleri de geliştirilebilir.

Bu tez, gelecekte Argümantasyon Teorisi ile ilgili yapılacak çalışmalara, özellikle felsefenin eğitim bilimleri ile kesiştiği alana ışık tutma isteğiyle yazılmıştır. Tezin genelinde bahsedilen konular kendi içlerinde kapsamlı araştırmalardır ve geçmişten bu yana araştırılagelmiştir. Tezin ana konusu olan fen bilimleri eğitimi, bu eğitimin kapsamında olan bütün dersleri kapsamaktadır. Daha ayrıntılı çalışmalarda, bu derslerin argümantasyon biçimleri ayrıntılı olarak elealınabilir. Örneğin, fizik dalanının argümanlarının biyolojik bilimlerin argümanlarına göre olan farkı incelenebilir.

Değişen bilgi pratiğinin bilgiye ulaşmayı kolaylaştırdığı, kısa süreli bir internet aramasının insanları formüllere ve tanımlara ulaştırabildiği bir çağda, artık bilginin edinilmesinde aktifliğe yönelmesi umut vaadetmekle birlikte hala baskın olan eğitim biçimi klasik eğitim olmakla birlikte bu tezi daha önce yapılan çalışmalarla birlikte gelecekteki araştırmalara katkı sağlamak umudunu taşımaktadır.

D. TEZ İZİN FORMU / THESIS PERMISSION FORM

ENSTİTÜ / INSTITUTE

Fen Bilimleri Enstitüsü / Graduate School of Natural and Applied Sciences ☐

Sosyal Bilimler Enstitüsü / Graduate School of Social Sciences ☐

Uygulamalı Matematik Enstitüsü / Graduate School of Applied Mathematics ☐

Enformatik Enstitüsü / Graduate School of Informatics ☐

Deniz Bilimleri Enstitüsü / Graduate School of Marine Sciences ☐

YAZARIN / AUTHOR

Soyadı / Surname : ....
Adı / Name : ....
Bölümü / Department : ....

TEZİN ADI / TITLE OF THE THESIS (**İngilizce** / English) :
....
....
....

TEZİN TÜRÜ / DEGREE: **Yüksek Lisans** / Master ☐ **Doktora** / PhD ☐

1. **Tezin tamamı dünya çapında erişime açılacaktır. /** Release the entire work immediately for access worldwide. ☐

2. **Tez iki yıl süreyle erişime kapalı olacaktır.** / Secure the entire work for patent and/or proprietary purposes for a period of **two years. *** ☐

3. **Tez altı ay süreyle erişime kapalı olacaktır.** / Secure the entire work for period of **six months**. ***** ☐

***** *Enstitü Yönetim Kurulu kararının basılı kopyası tezle birlikte kütüphaneye teslim edilecektir.*
A copy of the decision of the Institute Administrative Committee will be delivered to the library together with the printed thesis.

Yazarın imzası / Signature .... **Tarih** / Date ....