THE UNIVERSITY OF SHEFFIELD

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Controversial issues in science education for functional scientific literacy: A case study of an implemented curriculum in Cyprus Science classrooms

A Dissertation Submitted in Fulfilment of the Requirements

for the Degree of

PhD in Education

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Abstract

This study has been designed to provide and interpret information from classroom based practice about the implementation of controversial issues in the science curriculum and relate it to the discussion about conceptual frameworks that situate controversial issues in science education. Since no tools were available from the science education research area to fulfil the methodological aims stated above, the study has taken a methodological orientation which resulted in the selection and modification of Schellens' (1985) argument typology scheme alongside Peirce's (1905) classification of the sciences to describe the epistemic part of the lesson, and to the selection of Walton's and Crabbe's (1995) typology of argumentative dialogues to describe the dialectical context.

The application of argument schemes was successful and it has enabled the description of the epistemic practices as situated in dialectical practice. The analysis has revealed the basic structural components in which the complexity of the discussion is built, consequences, needs (ends) and rules, and how these have been used within discussions: either to ground decisions about an issue, or to explain or evaluate societal agents' and own selves' actions, desires, decisions, views and positions, or own intentions towards a personal stated dilemma. Furthermore, they have revealed the instances in which each discipline, like Ethics, Natural Sciences, Psychology, and Sociology, had taken place. The results indicate an intersection of the disciplines and provide valuable information about how implementing controversial issues in the science curriculum might be related to enhancing thoughtful decision making, humanizing the science curriculum, or focusing on epistemological issues.

Acknowledgments

I would like to thank all the teachers that had participated in the study for their willingness to design and implement the controversial issues lessons, for the hours they had spent being interviewed, but mostly, for the enlightenment that they had provided to my limited conception of the issue.

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1. Introduction

1.1 <u>Area of study</u>

This study deals with the curriculum that is related to controversial socioscientific issues (SSI) in science classrooms. Implementing controversial issues in the science curriculum is a highly complex task. The complexity refers to the complex nature of the controversial issues, the diversity of teaching aims and priorities that situate them in science education, the confusing guidelines for teachers related to their stand in the classroom, alongside the involvement of teachers' and students' moral beliefs, emotions, needs and priorities in the discussion.

Controversies are large, social phenomena: people are engaged operating as individuals, as members of groups, or as institutional agents, having myriad interests and priorities, different levels of access to resources, different perspectives, and different modes of reasoning (Ross, 2006).

Disagreement might occur in different levels and for different reasons simultaneously, including the moral responsibilities of scientists, moral and other considerations regarding the use of science and technology products, considerations regarding the availability of government funds given for scientific research, the ownership of information and products, and the methods of science.

Different groups or individuals interpret the situation according to their own means and interests. Groups disagree over the authority in questioning and evaluating scientific evidence and in the ability of any groups, apart from scientists, to provide evidence at all. The limits of scientific knowledge and contextual factors that affect scientific endeavour are criteria used differently by individuals and groups during the discussion and resolution of controversial issues. Finally, there are disagreements referring to the place of values in decision making, the context in which the decision is to be made, and the role of the public in decision making.

Teachers and curriculum developers are therefore dealing with a really complex construction that might be used as the context, or the content, of a science lesson. A fact that makes the situation even more complex is that students and teachers are not only dealing with an “issue” existing out of them, but also act as members of the dispute, within the issue. When it comes to decision-making, values, emotions, ethical considerations of students alongside their personal experiences affect the way they deal with evidence: when presented with contradictory evidence students usually distort the evidence to adjust to their prior beliefs without being aware of doing so (Sodian, et al., 1991, p.759; Bell, 1999, p.13). Students dismiss scientific knowledge as irrelevant to decision making when reasoning about controversial issues (Zeidler, et al., 2002), ignore data that they ought to consider when evaluating claims or assimilate such data in ways that do not damage their current theories (Sandoval, 2001, p.1; Chinn & Brewer, 1998; Klahr, et al., 1990; Kuhn, et al., 1998, as cited in Sandoval, 2001, p.15).

When it comes to pedagogical decisions regarding controversial issues in science education, different perspectives describe different pedagogical outcomes from their instruction. Pedagogy on controversial issues provides several frameworks that include elements such as moral education, moral development, cognitive development and the support of the emotional belief system of the child. Those elements are presented as ‘supplementary’ in a controversial issues lesson, but there is no clear image as to whether they are contradictory.

Different views of the relationship and status of science and society impose different descriptions of the nature of socioscientific issues and assign different tools that a citizen should hold for the participation in the discussion and decision making about those issues. Additionally, different perspectives about science education in general, create different relationships between socioscientific issues education and science education.

The role of the teacher is not clearly defined, as several approaches proposed in the literature have conflicting elements and do not answer problems of **what** and **how** a teacher should or could teach about controversial issues in the science classroom. Because of this complexity and lack of clarity, teachers feel confused. They may highly value neutrality as an approach that safeguards them as professionals and provides a democratic classroom environment, but they struggle as they cannot provide balance under neutrality or avoid implicit expression of their views in the classroom. However, they seem more oriented in 'what' they want to teach, with most science teachers relying on the 'science part' and thus on the 'cognitive' element of the controversial issues framework, few of them being attached to a moral dimension and even fewer that combine all directions (Cotton, 2006; Levinson & Turner, 2001; Sadler, et al., 2006).

1.2 Focus of study

The aim of this study is to investigate and describe the implementation of controversial issues within a science curriculum - an open ended, complex and problematic task - and contribute to the discussion about the relationship between those two areas with interpretations from real classroom data. On the one hand, this study uses teachers as experts that curriculum developers and professional development program designers should involve in the design phase of their intended proposed curriculum, or professional development program. I actively stand from those positions while looking at the issue of curriculum development and professional development about controversial issues.

On the other hand, it recognizes the need to consider the problem of controversial issues teaching in not only philosophical terms, but in practical terms too. There is a need to describe and analyze how theoretical assumptions about science teaching and controversial issues might or might not apply in real science classrooms.

A primary methodological issue is the construction of research questions that would be able to address the aim of the study. The answers to those questions should be efficient in describing a controversial issues lesson in terms of curriculum situated in science education.

At a first glance, I determine two areas that enter the research space: Citizenship Education and Science Education. Those two entities might be seen as distinct, but overlapping curriculum areas that could serve each other in the context of controversial issues teaching. Actually, I will talk about an infusion of those two areas with different rationales and priorities, as it will be explored in the chapter on “Controversial issues and Science Curriculum”.

The possible relationship between learning about controversial issues and learning science situates controversial issues and science education in different, but overlapping frameworks. Some of those frameworks describe citizenship education in the service of science education and use controversial issues as “context” (Ratcliffe & Grace, 2003; Fullick & Ratcliffe, 1996; Kolsto, 2000; Lewis & Leach, 2001; Zeidler, et al., 2005; Gray & Bryce 2006; Hall, 2004). They describe the relationship between controversial issues and science education as “teaching science *with* controversial issues”; controversial issues are in the service of science education, for different purposes, including students’ epistemological development, the cultivation of argumentation skills and the humanizing of science curriculum with the introduction of morals and ethics related to science.

Others (Wellington, 2004, p.34; Crick Report, 1998, p.35; Ratcliffe & Grace, 2003) describe the teaching of controversial issues as an end in itself, situated in pedagogical outcomes for citizenship education. According to those frameworks, science education serves the teaching of controversial issues, especially in the promotion of thoughtful decision making. Therefore, they describe the relationship between controversial issues and science education as “Science education *for* citizenship”, or, “teaching *about* controversial issues”.

Finally, there are frameworks that introduce controversial issues as pedagogy by itself that serves the moral, emotional and cognitive development of the child (Zeidler & Keefer, 2003; Zeidler, et al., 2005; Sadler & Zeidler, 2003). Introducing controversial issues as pedagogy rests on a level above science education and citizenship education as distinct curriculum areas. The framework is not established on the grounds of citizenship, science, or moral education, but it is rather established on psychological grounds of how all those elements could contribute to the development of the child under a “functional scientific literacy”.

The reason for considering theoretical considerations about the introduction of controversial issues in science curriculum is the need to find a method that could be able to describe the lesson, under the complexity and the problematic nature of the situation.

A methodological problem to be addressed is to formulate such questions that their primary data could serve the description of a lesson both in science lesson terms, but also in socioscientific issues lesson terms. One question that is raised is: if I describe the lesson alongside those two dimensions, do I automatically regard learning science and learning about socioscientific issues as epistemologically distinct activities? (Levinson, 2006, p. 24) And if so, by which method would I address their boundaries?

A primary methodological solution for this problem is to set an ending point: describe one entity given the context of the other. Given the fact that this study is science education oriented, I define this study as one aiming to describe how controversial issues are "situated" in science education (Tiberghien, 2008, p. v) or vice versa, what science education is performed, and how this is done, under the context of controversial issues. How those areas were finally defined as epistemologically different is an issue to be explored in the methods and methodologies chapter of this study, as it has evolved as a research question in next stages of research.

1.3 Key research questions

Following Scott's and Mortimer's (2003) analytical framework for making meaning in science classrooms , a primary research need is to determine the "story" of the lesson and the "thematic pattern" of the dialogue (Lemke, 1990). Students and teachers are constructing complex meanings about a particular topic by combining words and other symbols, semantic relationships. The pattern of semantic relationships constitutes the scientific, or other, content of the discourse (Lemke, 1990 p.13, Scott, 1998 p.56).

The "scientific story" in a controversial issues lesson, as constructed both by teacher and students, should focus on elements - entities that their connection might describe the lesson in terms of science curriculum in the context of controversial issues. Such entities would be scientific concepts, evidence, ethics and values as those interact with other information, morals, values and emotions from the wider social space. It should also be able to reveal the connection of those entities: claims about figures of authorities, conflict points and other relationships might be a product of analysis of the data that such an answer to a research question could provide. As a result, the description of "the scientific story" in the context of controversial issues constructs a question of:

1. Which entities are found in a controversial issues lesson? (Scientific concepts, claims, values, ethical, metaphysical considerations, emotions, etc)

Under this general question, two sub-questions help in the dimension of situating the lesson in Science Education:

1.1 What is the relationship between the science, the personal and the social that those entities describe?

1.2 What other areas of knowledge and expertise are infused in the lesson?

In the case of the "scientific story" it is important, in order to understand participants' linguistic actions, to know in what kind of communicative event they have been produced, where and when they have taken place, and who the participants were (Edwards, 1997; Pomerantz & Fehr, 1997; Potter & Wetherell, 1987; Van Rees, 1992 as cited in Leitao, 2001). Therefore, there is a methodological consideration that derives from sociocultural perspectives, of relating content to context: content cannot be addressed without reference to a broader linguistic context and the knowledge of the speakers (Carlsen, 1991, p.162).

This study situates controversial issues as the “context” in the lesson. Consequently, I need a second question that would enable the description of the context in which the thematic pattern has been evolved, thus describing the matrix between controversial issues and science education, in terms of content.

By this, I do not regard context as static (Carlsen, 1991). Context, as defined in this research would be better understood as “socially constructed through interactions among participants in a social situation” (Kelly, et al., 1998, p.26). The broader “social situation” I define here is a “discussion about controversial issues in classroom settings”. Any further information about this situation will be a product of analysis and not a pre-research construction.

Summarizing, a second question is set down, that could situate the thematic pattern in the context of controversial issues. This question could be formed, following the previous sub-questions:

2. Under which context do thematic entities come up in the lesson?

Apart from describing what science has *been talked* in the classroom, I also need to describe what kind of science *has been done* in the classroom. Science curriculum includes, apart from conceptual and epistemological understanding, the development of science skills that include both procedural aspects of doing science alongside the development of thinking skills.

Those skills, as defined in this study, do not refer to practical work skills, i.e. measuring, recording, and organizing data. The discussion-based nature of the lessons does not allow such an analysis since the lessons this study refers to, did not include any practical work at all, in terms of first hand experimentation. The interest of this study focuses on the cognitive effort, the “minds on” activity, which is expressed through discourse in the classroom, the opportunities for pupils to talk their way into science (Mercer et al, 2004, p.83).

This study accepts sociocultural perspectives that define language as both a psychological and a communicative tool (Mercer, 1996): we use language not only to communicate and to share meaning but also to make sense of our experience, to constitute our thoughts (as cited in Mortimer, 1998, p.68). The study starts therefore with the assumption that reasoning is observable in the form of socially structured and embodied activity (Garfinkel, 1991; Heidegger, 1977; Suchman & Trigg, 1991 as cited in Roth & McGinn, 1998).

Zimmerman (2005) defines those discursive skills as *conceptual and procedural activities* included in scientific investigation and cites an expanded list of such activities deriving from literature: asking questions, hypothesizing, designing experiments, making predictions, using apparatus, observing, measuring, being concerned with accuracy, precision and error, recording and interpreting data, consulting data records, evaluating evidence, verification, reacting to contradictions or anomalous data, presenting and assessing arguments, constructing explanations (to self and others), coordinating theory and evidence, performing statistical calculations, making inferences, and formulating and revising theories or models (e.g., Carey, Evans, Honda, Jay, & Unger, 1989; Chi, de Leeuw, Chiu, & Lavancher, 1994; Chinn and Malhotra, 2001; Keys, 1994; McNay & Melville, 1993; Schauble, Glaser, Duschl, Schulze, &John, 1995; Slowiaczek, Klayman, Sherman, & Skov, 1992; Zachos et al., 2000 as cited in Zimmerman, 2005, p.4).

Having clarified theoretical considerations about the third question, I can now set it down:

3. By which conceptual and procedural activities are students and teachers negotiating the thematic pattern of the lesson?

3.1 What type of "doing science" do those activities describe?

As I regard the teacher an agent that, apart from constructing the scientific story -as the student does, orchestrates the whole procedure, I need to define his role beyond "negotiating" the thematic pattern of the classroom. I therefore regard him as one holding the authority to take and implement pedagogical decisions in the classroom. Learning is viewed as a process of social participation (Lave & Wenger, 1991), which requires modelling and coaching, and even in sociocultural perspectives that this study shares, the teacher is the more able peer, providing a scaffold for the students' performances and promoting their assumption of responsibility (Reigosa & Jimenez-Alexandre, 2007 as cited in Jimenez - Alexandre, 2007, p.98).

However, teachers' "strategies and approaches" that fall beyond his role as a peer of the group that also negotiates the thematic pattern through epistemic and other practices, are not going to be elaborated through this study, though there is enough data for performing such a description. The study focuses on curriculum, in a close definition that cannot encompass pedagogy, due to limitations of space.

1.4 The bounds of the research

This study is highly descriptive; it aims to describe what curriculum has been taught in the classroom alongside teachers' pedagogical actions and decisions, rather than deciding from a theoretical basis, what the teacher's "appropriate" stance should be, or what the curriculum should be. That is why, in this particular research, “evaluative” weights are not to be put, at least a priori, to teachers’ stances or practices. The effort is not to find “exemplar” teaching, or define such teaching but seeking methods of describing and analyzing what is really happening in the classroom, under the glance of curriculum in terms of functional scientific literacy.

Another aspect that needs clarification, is that this study does not aim to describe concepts or skills in terms of an impact of the lesson to the students’ behaviour: I do not describe what skills students have *gained* but rather what skills are they *using* during the lesson. Additionally, when talking about the scientific story I cannot assume that this story has been “conceptualized” as a “common knowledge” by all students (Scott, 2007). As Scott (2007) cites about a descriptive study about inquiry in science classrooms:

> *“What does it mean to say that the students “engaged in common practices” or developed “common knowledge” in the classroom? What evidence can we bring to support such claims, what methodologies might be developed to generate that evidence?” (p. 497)*

Therefore, what is to be described is not what has been gained as a skill, but rather what has been performed as a discursive skill important for learning and practising science (Mercer et al, 2004). This study, consequently, uses procedural and conceptual activities to describe the procedural part of the curriculum. Those activities though conceptual, are identified and described through externalized behaviours and not through internal mechanisms. What is to be described is the intermental (social) and not the intramental (individual) intellectual development, though Vygotskian principles, and also other research, indicates that those two are highly interrelated (Mercer, et al., 2004, p.360).

1.5 Personal and professional commitment to the research

In the years 2001-2007, I had been working in a team project at the Ministry of Education and Culture of Cyprus, aiming to enrich Science Curriculum with ICT tools (Lymbouridou & Sevastidou, 2008). Under this project, I have developed several webquests, which included, among others, environmental controversial issues, such as fox-hunting, handling mice overpopulation in an ecosystem, selection of renewable energy sources, and other topics.

Very soon, I realized that what I had prepared as a curriculum developer was not enough to help me deal with the complexities of controversial issues teaching. Though the issues were very interesting for the students and their participation was high, I had a feeling of inadequacy in addressing difficulties related to students' abilities to engage in an argumentative discussion, consider arguments beyond their position and weigh arguments. At first, I felt the need to find ways of improving my personal teaching practice, and reflect this experience on the teaching materials I've prepared.

In my Master's degree I have conducted research into such a lesson. I have tested the impact of an argument building software on students´ argumentative abilities, using a webquest related to the controversial issue of fox hunting. The perspective of the teaching intervention was oriented in promoting scientific argumentation: I was trying to help students include more scientific evidence to build their arguments, instead of building arguments based on emotions or value based elements like "the fox is a beautiful animal", which I had regarded as "personal", "irrelevant" information. The research was presented at the Sixth International Conference on Computer Based Learning, (Lymbouridou & Constantinou, 2003) and the criticism I received from that presentation referred to the categories of arguments I had used (relevant and irrelevant arguments, scientific and non scientific arguments). This was a first hint for me for further research on argumentation nature, but also on the relationship between science teaching and other areas such as emotional and moral development. A first attempt towards this dimension was a small scale research study referring to the place of argumentation on students´ epistemological beliefs.

Going beyond myself, my experience as an ICT advisor helped me realize that empowering teachers to adopt new technologies in their classrooms goes far beyond preparing and delivering curriculum materials to them. The transfer of this experience in the area of controversial issues teaching revealed a need to include teachers in the design and implementation phase of the innovation of including controversial issues in the science curriculum. Unfortunately, procedures in Ministries do not always take the research path. There were no established procedures of including teachers in the design or evaluation phase. However, as soon I had this opportunity, to put things under the research perspective through my PhD thesis, I grasped it. This research, therefore, consists, among others, of a self reflection procedure that aims to question what I had prepared as a curriculum developer, and an effort to empower me as a future curriculum developer or School Advisor in the areas of ICT, Science, or Citizenship.

1.6 Type of the study

This study adopts a naturalistic qualitative approach since it seeks to develop detailed holistic descriptions of the field and the phenomenon/situation studied, which concerns controversial issues teaching within science education. The method of interpretive case study was selected as appropriate to answer the questions of this study. The case was defined as “implemented curriculum for controversial issues in science education” and the lessons taught are considered as sub-cases of this case. The interpretive character refers to the capacity of the study to analyze data so as to provide categories that could interpret descriptions in terms of functional scientific literacy within a socioscientific dialectical context.

1.7 Study setting

The study used three lessons taught by primary school teachers that had acted both as designers and implementers of the suggested curriculum. The lessons were performed in primary Cyprus school classes, in typical science lessons of 80 minutes (two periods) with children of ages 10-12 years old (fifth and sixth graders).

The teachers who taught the lessons had participated voluntarily in a professional development seminar that was proposed by the Pedagogical Institute of Cyprus and had the main aim to help teachers connect theory and practice, by reflecting on their own teaching by using videos of lessons conducted under the thematic units of the seminar. All of the lessons had been videotaped and teachers had been interviewed with the use of video stimulated recall sessions, a method used to enhance better understanding of human interactions within the classrooms (Cashwell, 2001).

The main data sources for this study are video extracts, alongside extracts from conversations that took place during the video stimulated recall. Teaching materials, lessons plans, teachers’ presentations of their own lessons in conferences, are also used as secondary data sources.

1.8 The significance of the study

At the time that this chapter is being processed a TV headline cites: “science out of ethics”. The trailer is referring to an announcement of a Cypriot fertility doctor, who claims to have cloned and implanted human embryos (CYBC, 23 of April, 2009). Whether this is “science out of ethics” is an issue under discussion. However, this is one of the many issues which involve methods and products of science and technology about which citizens, students included, need to decide upon, or take a position towards.

Whatever the disagreements about the particular aims for science education in the context of socioscientific issues are, there is a widespread belief that the infusion of controversial issues into the science curriculum would be beneficial for science education as a discipline, and for students as members of the society. Several authors have argued that if scientific literacy represents the ultimate aim of science education, then scientific literacy must entail, at least in part, the ability to thoughtfully negotiate socioscientific issues and contribute to discourse regarding these topics (Bingle & Gaskell, 1994; Driver, et al., 2000; Hodson, 2003; Sadler, 2004; Zeidler, Walker, Ackett, & Simmons, 2002 as cited in Sadler, et al., 2006, p.354). Additionally, current perspectives on the nature of the scientific enterprise, which see argument and argumentative practice as a core activity of scientists, agree on the inclusion and central role of argument in science education (Driver, et al., 2000). A functional scientific literacy model should include personal, cognitive and moral development, since a cultural perspective towards education underscores the necessity to appreciate students as moral agents intimately involved with their own cultural, natural and technological environments (Zeidler, et al., 2005, p. 365).

Science in personal and social perspective lies as one of the four central goals that define scientific literacy in the USA (National Science Education Standards, NRC, 1996, p.21), whereas movements such as Science, Technology and Society (STS) and statements by bodies as the American Association for the Advancement of Science (AAAS, 1989), attempted a long time ago to introduce the discussion of teaching science for social responsibility (Cross and Price, 1996).

In the UK, teaching with or about controversial issues has fallen into two distinct movements: the reinforcement of citizenship education, which has been a statutory National Curriculum subject in England for all young people in key stages 3 and 4 (ages 11 to 16 years), since 2002, and the rehabilitation of the trust between science and the public.

Democratic citizenship in a modern society depends, among other things, on the ability of citizens to comprehend, criticise and use scientific ideas and claims (Qualifications and Curriculum Authority, 1998). On the other hand there has been an official concern about the attitudes of the general public towards science, deriving from the fact that society's relationship with science was in a critical phase, a “crisis of trust”. Mistrust of science was seen as dangerous to inhibit technological process and research due to public resistance in scientific advancements, and was breeding a climate of deep anxiety among scientists themselves (House of Lords, 2000). Science education has been called to educate future citizens both for enabling them to critically stand towards scientific claims and methods but also to avoid indoctrination, fear and mistrust in their decisions regarding the use of technological advancements.

In Cyprus there is not yet an official movement related to issues concerning science and society. However, several partial movements in different areas create a climate that shows the readiness of the educational system to seek new directions like the humanizing of science curriculum or reinforcing citizenship through science. The Ministry of Education and Culture has recently established a National Committee for Citizenship. The committee deals for the time being with issues related to drugs, youngsters and society and school bullying but, hopefully, they will deal with issues related to science and society in a time. Additionally, the National Curriculum is set under revision. Under the new mission stated, an active citizen is described, as "able to participate in work, politics, economy, culture and work" (Committee on Curriculum Revision, 2008). Science Curriculum is under revision within this project. Even if official statements regarding Science Education explicitly have not been published yet, I do hope that declarations about abandoning a "fact-transmitting" system to a "critical-reflective" one will be implemented and controversial issues find a place in science education because of the critical perspective they offer. Additionally, movements such as the inclusion of socioscientific issues as webquests for science lesson, a movement done under the integration of ICT in science, help towards this dimension.

Science teaching nowadays hardly includes any argumentation opportunities for students, whereas science teachers spend more time in transmitting facts and regard values as being out of the scope of science teaching (Levinson & Turner, 2001). Traditional science instruction has given a false impression of science as the unproblematic collation of facts about the world and makes controversies between scientists (historical or contemporary) look puzzling (Driver, et al., 2000). The traditional science curriculum, with its absolute views, does not produce citizens prepared to deal with real-world science, ‘which is more often than not equivocal and conflicting’ (Sadler, et al., 2006, p. 354). Infusing controversial socioscientific issues in the science curriculum is therefore defined as an innovation.

Science teachers feel unequipped in implementing such a change in their classrooms (Levinson & Turner, 2001; Gray & Bryce, 2006; Sadler, et al., 2004). A need that comes up, therefore, is teachers’ professional development: programs that will promote connections between ethics and science, to help teachers deal with challenges of organizing and facilitating argumentative discussions in the classroom. Additionally, high quality resources need to be developed, implemented, and evaluated (Sadler, et al., 2004). However, enabling teachers to deal with controversial issues teaching seems to be a difficult task. Professional development models, even if they had advanced better information with respect to knowledge and practical skills of teachers, required much more to enable teachers to deal effectively with the social, moral and ethical aspects and the shift in thinking required for tackling these issues in the classroom (Gray and Bryce, 2006).

A possible reason of failure of professional development programs, related to the infusion of science and ethics, is that any effort to develop and promote curricula must account for teachers’ perspectives on the issues being developed. Problems may arise if classroom teachers and their beliefs about reform are ignored (Bybee, 1993, as cited in Lumpe et al., 2000, p. 276). As Sadler, et al. (2006) cite:

> *“Regardless of the impassioned positions of university-based educators and researchers, if classroom teachers do not adopt and implement these suggestions for change, then reform*

> *is restricted to the pages of academic journals and conference rooms." (p. 355)*

There is a need, therefore, to change professional development programs from top-down delivery from "experts" to teachers, to opportunities for reflection and personal feedback on them (Gray & Bryce, 2006). One cannot simply give quality science curriculum materials to teachers and expect quality science instruction: teachers need opportunities to identify and clarify their own beliefs about teaching science (Haney & Lumpe, 1995; Lumpe et al., 1999 as cited in Lumpe et al, 2000, p.288).

Taking this a step further, Bernet and Hodson (2001) suggest that teachers should not only adopt and implement suggestions from outsiders, but also be included in the design phase of the innovation. There is a need to use teachers' knowledge, as this has been recognized by increasing numbers of educators and curriculum specialists as the major factor in curriculum development (Barnett & Hodson, 2001 p.428). Teachers therefore should make conscious choices of what is being added and what is being discarded, and why (Loucks-Horsley, et al., 2003, p. 46 as cited in Gray and Bryce, 2006, p.172). Those choices, in the case of controversial issues teaching, refer to the selection and prioritizing of pedagogical outcomes regarding moral education, moral development, cognitive development and the support of the emotional belief system of the child in the context of science education.

Summarizing the above paragraphs, the following implications are set down:

- Education for Citizenship and functional scientific literacy require the infusion of socioscientific controversial issues in science curriculum.
- There is a worldwide governmental and research based interest in the issue.

However,

- There is a need to deal with the complexity of teaching that rests on the complicated nature of the issue, the personal involvement of students during the discussion and the selection and prioritizing of pedagogical outcomes that could connect science teaching and controversial issues.
- There is an emerging need to design effective professional development that takes into account teachers' considerations and provides them reflection opportunities and, finally
- Teachers should be used as experts and designers of change.

This study actually uses teachers as experts, designers of change, and looks for the solutions or the struggles they had, when called to design and implement science lessons with controversial issues. It therefore contributes to the direction of taking into account teachers' considerations but also expertise in the design of related curriculum.

There is a lot of theoretical - philosophical discussion about the infusion of scientific information, claims and values with those of personal or social unfounded evidence, ethics, morals and emotions in an argumentative discussion about controversial issues. However this philosophical discussion, though helpful, needs to be supplemented with information about classroom based practice that might reveal different relationships between those entities. This study, due to its setting but also to its descriptive nature, does not use any preconceived ideas about how the topic should be taught. That is why it could contribute to the theoretical discussion by providing instances that could question or backup existing theories about controversial issues and science teaching.

Another gap that is cited in the literature, is one of taking into account fields like argumentation theory, for example, that stem from disciplines that philosophize about the scientific enterprise and study scientific discourses and practices in situ (Bricker & Bell, 2008). Those disciplines are not grounded in science education, but they can provide a means of analyzing and interpreting findings from science classrooms. As Bricker and Bell (2008) cite:

> *"We argue that it is in our community's (science education researchers) best interest to gather these various theoretical conceptualizations of scientific practices and discourses and then engage in thorough and thoughtful dialogue about what theoretical conceptualizations we wish to utilize in our research and practices and for what purposes." (p.474)*

This study will actually try to use such conceptualizations deriving from argumentation theory (Van Eemeren, et al., 1996), Toulmin's theory of argument (Toulmin, 1958), the classical view of argumentation by Aristotle (*Posterior Analytics, Rhetoric*, *Prior Analytics*), as well as from the area of informal logic (Walton, 1989), in the direction of determining a method of analysis of classroom argumentative talk, but also as "lenses" for discussing the results provided.

Therefore, apart from contributing to the discussion of pedagogy and curriculum related to controversial issues, this study could be useful in methodological terms. Different studies have highlighted the importance of investigating classroom discourse and other rhetorical devices in science education (Candela, 1999; Halliday & Martin, 1993; Kelly & Brown, 2003; Kress, Jewitt, Ogborn and Tsatsarelis 2001; Lemke, 1990; Mortimer, 1998; Mortimer & Scott, 2003; Ogborn, Kress, Martins, and McGillicuddy, 1996; Scott, 1998; Sutton, 1992 as cited in Scott, et al., 2006, p. 608). Additionally, a significant deficit in the literature is the lack of research on quantitative analysis of argumentation, not at the level of conversational analysis but at the level of conceptual categories that are of significance to science education (Erduran, 2008). I hope that this research could contribute to both those directions: situate controversial issues in science curriculum and provide data for the conceptual categories that are of significance to science education, by effective analysis of classroom discourse.

1.9 Structure of thesis

The thesis to be presented here is organized as an argument that supports several hypotheses related to the implemented curriculum of controversial issues in science education that emerge from classroom observational data and are interpreted in terms of dialectical practice and functional scientific literacy. Due to the additional methodological orientation of this study, this study also presents an argument supporting the description of the dialectical context as the socioscientific context for this study and also grounds the argument typology scheme used for the data analysis. Table 1 presents the structure of the thesis.

Chapter	Subchapter	Purpose
Literature review	The nature of controversial issues	Describe the nature of controversial issues
	Controversial issues and science curriculum	Describe and critically reflect on theoretical considerations about including controversial issues in science curriculum.
	Argumentation as a process	Present the dialectical aspect of argumentation and identify the elements that can describe it as a process.
	Reasoning and argumentation: a justification of a typology of argument schemes	Justify a typology of argument schemes that can be used as a means for analyzing argumentative talk in terms of arguments as products, and also describe the kind of reasoning and epistemic practice that indicate.
Method		Ground the data analysis process and provide basic schemes of analysis used in this study.
Results		Provide the results related to the interrelationship between science education and controversial issues teaching, alongside the methodological tools used in this study.
Discussion		Relate the relationship of functional scientific literacy and controversial issues as context with theoretical considerations regarding the implementation of controversial issues in science education. Present and justify the theoretical and methodological contribution of the study alongside limitations and suggestions for further research.

Table 1: Structure of thesis

2. Literature review

A first input from the literature review in this study was one of informing the study about the nature of controversial issues and the discussion that takes place within the science education field about their implementation within the science curriculum. This kind of review is presented in the sections *2.1The nature of controversial issues* and *2.2 Controversial issues and the curriculum*, within this chapter.

A second role that the literature review had on this study was to provide conceptualizations from areas beyond science education that could be used for the selection, modification and application of tools that would be efficient for data analysis: tools that could provide the results needed to answer the questions of this study. However, this kind of review was actually interactive with classroom data: instances from classroom data had pointed in search for relevant categories in the literature, conceptualizations from the literature had pointed to new categories and so on. However, such a complicated process has to be presented as a linear one; as it was too huge to be presented in the data analysis chapter - actually this would make the chapter very difficult to be read - I have decided to present this chapter as a theoretical input that informs the study, interacting with its data. In this sense the part *2.3 Argumentation as a process* discusses the way in which data analysis can grasp the dialectical part of the lesson, whereas *2.4 Reasoning and Argumentation, a justification of a typology of argument schemes*, grounds the decision about the selection and modification of Schellens' (1985) typology of argument schemes and explains how argument schemes have been related with epistemic practices so as to describe the epistemic part of the lessons.

2.1 The nature of controversial issues

Controversies are largely social phenomena: that is, they are those topics and issues about which numbers of people are observed to disagree (Bailey, 1971, p.69). The term controversy literally means ‘the clash of opposing opinions; debate; disputation’ (Brante, 1993, p.181 as cited in Linn, et al., 2004).

As mentioned in Crick Report (1998):

> *“A controversial issue is an issue about which there is no one fixed or universally held point of view. Such issues are those which commonly divide society and for which significant groups offer conflicting explanations and solutions.” (p.58)*

This definition gives two important attributes of controversial issues; the first one is that they involve society groups. The use of the term “significant” emphasizes the engagement of a great part of the society and not of minority groups. As Wellington (1986) points out, an issue should be considered to be important by an appreciable number of people if is to be defined as controversial (Wellington, 1986, p.3). Stradling (1984, as cited in Harwood & Hahn, 1990) stresses the density of the disagreement stating that controversial issues are those issues that *deeply* divide the society.

The second attribute found in Crick’s Report (1998) definition, is that we are talking about issues for which we are looking for solutions. The controversy is not descriptive, it is not about what is right or not, it is not about only what we think about something, but also how we act towards each other (Bridges, 1986, p. 21). The issues are controversial since there is a decision to be made (Kolsto, 2000).

The description of the nature of controversial issues is highly complex, as they are at the same time a product of discussion and a discussion, as a process, per se; individuals and social groups are engaged in those issues either as disputants, informants and informed and have roles of understanding, interpreting, arguing and deciding. Additionally, people are engaged either operating as individuals, as members of groups, or as institutional agents, having myriad interests and priorities, different levels of access to resources, different perspectives, and different modes of reasoning (Ross, 2006). These differences inevitably lead to a multileveled and multilayered construction that we call "controversial issues", a dispute about how social, political, and economic life should be organized and conducted.

For the purposes of this study, controversial issues in which science plays an important role will be analyzed. Specifically, I am going to analyze conflicts in and around science for insights into issues that concern the various roles of scientists and non-scientists in creating and interpreting the situation, the social construction and negotiation of scientific knowledge claims by disputing scientists and the public (Martin & Richards, 2005) and finally, the ways in which scientists and the public might participate in decision making. The role of science as an area of knowledge, but as a method of acquiring knowledge too, the role of the scientific community as a professional social group, but also the role of scientists as individuals - either in the generation or in the discussion of such issues- will be analyzed within the chapter.

If we set the phenomenon under a time momentum, it would be described as a social process with a beginning and an end. The stages, though not linear, of this phenomenon could be described as follows:

1. Conflict is created among several social groups, due to several reasons. Different social groups are engaged in a process of argumentation.
2. Social groups and the public in general, understand and interpret the situation,

thus formulating or changing positions. Several dialectical moves take place, including argumentation, at a personal or social level.

3. Decision making could be done in personal, community, professional, national and global level. However, as soon as no consensus comes out about the issue, the issue remains controversial.

The controversial nature of the issue is evident in all three stages: different actions of several groups create conflict in the society. Different groups of the society interpret the situation in different ways and finally, they use different priorities and procedures in order to come to a decision. The analysis that will follow will focus on the three stages - creation, interpretation and decision making about an issue - aiming to describe the points and levels of conflicts within those stages.

2.1.1 The spark of the dispute: An issue is generated

The central and increasingly contentious role of science and technology in modern society has given rise to a plethora of scientific and public controversies over scientific and technical issues (Martin & Richards, 2005, Sadler, et al., 2004). Additionally science has a role to play in the resolution of many of the issues deemed controversial in all societies (Oulton, et al., 2004).

2.1.1.1 Moral and social responsibilities of scientists

Science and technology affect the social: as social practices, science and technology do not simply affect society but they literally produce the social. Society is no longer the same after genetically modified plants have been released in the environment or after a specific virus (e.g., HIV) has been identified (Roth & Désautels, 2004, p.154).

Questions arise concerning the ascription of responsibilities to the scientists: scientists produce entities (bacteria, hormones, materials, etc.) that affect our lives and reconfigure social relations. It is predicted that the rapid acquisition of new genetic knowledge and related applications during the next decade will have significant implications for virtually all members of society (Lanie, et al., 2004). Cloning, stem cells, genome projects, global warming, and alternative fuels have become common elements of the national vocabulary as well as the currency of political debates (Sadler, 2004, p.513). The modification of our environment and of human nature, are issues that concern societal groups in the age of the “risk society.”

What are the responsibilities of scientists? And how can the risks be assessed? What if new methods of science like xenotransplantation might result in the transmission of viruses that would not only kill the recipient but could spread as an epidemic throughout the human species? What if the release of genetically modified crops in agriculture leads to environmental consequences, like the damage of non GM crops that we will never be able to restore?

2.1.1.2 The products of science under moral consideration

Additionally, the products of science are under moral consideration. Values of several social groups may come in conflict with the products of science. The discussion about GMF for example, includes arguments based on moral or metaphysical grounds claiming that such foods are incompatible with the fundamental values of certain individual moral agents or groups, such as religious and consumers groups (Pascalev, 2003, p.583).

Cloning is considered to be wrong under certain religion frames that modern culture, or scientific endeavour might not be able to conceive. The importance that Orthodox Church, for example, gives to human sexuality in the person's salvation frames cloning as wrong: as cloning includes the reproduction outside from the bodily union of spouse with the spouse, is considered as inferior (Bonikos, 2000, p.49).

In what stage of research should moral and ethical considerations of various groups enter the discussion? What is the point of discussing the moral aspects of a use of a product or a scientific method when it is already released?

2.1.1.3 Value of gaining knowledge

The value of gaining "knowledge", "seeking for the truth", the main core of science, but not of other social domains, constitutes in many controversial issues a reason for conflict. The pursuit of science as an activity is itself an implicit endorsement of the value of developing knowledge of the material world (Allchin, 1999, p.2). A significant number of scientists believe they have almost a moral duty to investigate new areas for study (Reiss, 2001).

However, this value can be questioned under the existence of other values or costs. There are views supporting that when carrying out a piece of research, information gained or ideas generated would be of worth, capable to increase the sum of human happiness or produce some other desirable benefits (Reiss, 2001). As any other domains that shape public and private life, science and technology become legitimate objects of reflection on the part of all citizens (Roth & Désautels, 2004, p.150). The autonomy that scientists should have is questioned: public cannot assume naively that scientists can choose without any constraints their subjects for study (Reiss, 2001, p.180).

When it comes to government funds given for scientific research, significant disagreements may be sparked in the public because of the different value that groups of people assign to “gaining knowledge” under the microscope of other needs, or morality. Priorities, as regarding funds, come up to the discussion: how can we know whether there are alternative possibilities for a problem to be solved and how would their efficacy compare with, new promising but, as yet, risky or morally questioned methods of science? (Levinson, 2008) Why should we spend 6 million dollars for HIV diagnosis in a country like Uganda that is able to afford to spend some $57, 000 on malaria prevention?

Who is legitimate to decide about the usefulness of such research? On the other hand, what if future research, that would really be useful, is banned, because of “useless” current research?

2.1.2 Ownership of information and products

Within the public, an undercurrent of fear is discernable in their concern that scientific developments could be misused (Gamble & Kassardjian, 2008, p.251). Scientists’ ethics and morals are under the microscope as there is a concern that scientists and science are untrustworthy and fallible.

A crucial issue that creates conflict is the ownership of information about significant findings such as human reproduction methods or health issues. Who should be responsible for setting down guidelines to use this information, given the moral and ethical issues involved? (Lazarowitz & Bloch, 2005, p.439) How would the guidelines and border lines of embryo selection, for example, be established? Who is responsible for setting those guidelines? Who should regulate cloning or the production of GMF? And what if, eventually, the use of new technologies becomes available, because of its cost, only to specific social classes?

2.1.2.1 Methods of science

In many cases the controversy, or parts of it, may arise regarding the procedures of science as well. Ethics in the society demand proper treatment of animals and humans, for example, regardless of whether they are subjects of research or not. Science is not exempt from ethics or other social values (Allchin, 1999, p.6) and the resolution of issues concerning science's products or procedures entails ethical reasoning (Ratcliffe & Grace, 2003).

The embryonic stem cell research, for example, is under public discussion and even the research holds promise for the treatment and cure of devastating conditions such as Parkinson's disease, Alzheimer's disease, diabetes, and spinal cord injury, there are conflicting beliefs of several groups that the destruction of human embryos in stem-cell research amounts to the killing of human beings (Sandel & Phil, 2004, p.207).

2.1.3 Understanding and interpreting the situation

Emotional intensity, cultural contexts, value assumptions, laws, and interests differ drastically from one conflict to the next. Yet, the vast majority of disputes have at least one common element: relevant facts (Schultz, 2004). In the context of socioscientific issues, information, data and knowledge claims possess central importance in understanding and interpreting controversial issues; to evaluate alternative positions, one must collect information about those options (Sadler, 2004, p. 527).

There are issues for which facts are not the central issue; they actually play a secondary role as the dispute is essentially over valuative, moral or other non-factual issues. Other entities such as feelings of entitlement, cultural and religious values, are perhaps more important and therefore the issue cannot be reduced to a factual debate (Schultz, 2004). Additionally, even if the discussion about the issue is related to science products or methods, the scientific information presented on those issues is rather a "readymade science". This science is characterized by a "stable consensus which scientists consider unproductive to challenge" (Bingle & Gaskell, 1994, p. 187 as cited in Kolsto, 2001a, p. 295).

However, the information presented to social groups is often incomplete, because of conflicting or incomplete scientific evidence and inevitably incomplete or conflicting reporting (Ratcliffe & Grace, 2003, p.2; Sadler, 2004, p.527). Knowledge claims or theories about such issues might not have been established by the scientific community yet; there are issues about which the science involved is "frontier science", "science in the making", "disputed science" and sometimes there is disagreement between the experts involved (Kolsto, 2000, p.652; Ratcliffe & Grace, 2003, p.21).

How can we tell the effects of genetically modified food on our health, if the consequences are to be met in a number of years after consumption of such foods? (Kolsto, 2001a, p.293) How can we decide about whether power transmission lines constitute a health hazard when different researches and institutions have been giving different estimates and evaluations of the possible risk? (Sadler, 2004, p.516)

When the issue comes to the public level, social groups and individuals make different decisions on aspects related to the selection of evidence, the interpretation of evidence, and finally the evaluation of evidence in terms of relevance and validity.

Disagreements upon the procedure of selecting, interpreting and evaluating information are shown up as epistemology interacts with the interests of the stakeholders (Geddis, 1991, p. 180). Scientists, citizens, or governments have different demands for evidence underpinning knowledge claims; those demands may vary as individuals and groups are influenced by different interests and values (Kolsto, 2000). Studies have shown, for example, that religious and ideological values appear to filter the influence of information disseminated by scientific institutions (Nisbet & Goidel, 2007). Finally, many conflicts are made worse because of information that is misinterpreted or misunderstood (Schultz, 2004).

2.1.3.1 The role of the public in evaluating scientific evidence

One question that arises in the context of evaluating scientific evidence is the role and status of the public in conducting such an evaluation. The question focuses on the ability of the public in the evaluation of experts' statements, when experts still disagree.

On the one hand, there is a view that the evaluation of scientific claims would not be possible to be done by the public, as lay people cannot adopt the same standards as scientists (Kolsto, 2001a, p.304). Still, a dominant perspective in the United States, the science literacy model, assumes that knowledge boosts public acceptance of the scientific worldview. Such a claim though if related to different pieces of research suggesting that public's knowledge is inadequate, might conclude that scientists should remain independent from societal control (Nisbet & Goidel, 2007, p.421).

Actually, there is a concern about the understanding of the concepts or scientific theories that are embedded in the subject. There are beliefs, even studies, that support the view that citizens lack the capacity to understand a scientific topic, describing lay people's interaction when entering the discussion as rarely if ever narrowly cognitive (Irwin, 2001; Jenkins, 1997 as cited Solomon, 1999, p.67).

Those views describe naïve citizens who rely on experts because they lack the motivation or time to be informed on one hand, and the capacity to process that knowledge on the other. Due to this expertise inadequacy, citizens -according to this view- might even imply that scientific knowledge is not relevant to the primary issues at stake. Science is presented as detached from the social, thus leaving citizens considering the debate to be really about morality or politics (Michael, 1996 as cited in Irwin, 2001, p.6).

On the other hand, there are sides that support that, when the public is engaged in a procedure of evaluating scientific claims, is actually asking epistemological questions concerning the underlying contextual pressures that might guide scientific research; the interpretation of those questions does not necessarily require an understanding of scientific concepts or theories (Kolsto, 2001a, p. 304).

If we accept that citizens have the right to be informed and evaluate scientific evidence then what information should made available to the general public about advances in science, like biosciences? (Irwin, 2001, p.6) For many people within the scientific community, there is a widespread belief that the general public is unable to conceptualize uncertainties associated with risk management processes: providing public with information about uncertainty would increase distrust in science and scientific institutions as well as cause panic and confusion (Frewer, et al., 2003). A real problem that might arise is that scientific developments could be banned because of fear and panic. But is it better leaving the public in the blind just because panic is going to be spread? How can we trust evaluation from the public when most people get exposed to information about biomedical and other issues only through stories publicized in the media? (Blok, et al., 2008, p.189)

Our society, after the crisis that the public had about its trust in science, enters a new era, where science and public could stand a dialogue in transparency. Citizens need and ask to be informed. In the discussion of health issues, for example, NGO’s in the US have called for the right-to-know-more: they demand that data about chemical use in manufacturing and products, not simply factory emissions, should be compiled and made publicly available (Iles, 2007, p.371). As science enters the public, a new type of science is generated: citizen science, a meeting point between different forms of understandings, opening up the possibility of cross-fertilization between them (Irwin, 1995).

2.1.3.2 Epistemological issues concerning scientific evidence

During the discussion of a controversial issue, scientific evidence, complete or incomplete, competing or not within the scientific community, becomes available to the public through different channels, but primarily by the media. In such cases, consciously or not, individuals perform evaluations of such evidence by asking several epistemological questions.

Epistemological views of individuals influence the way in which evidence is selected and evaluated, and is considered to have bearing on views of the nature of socioscientific issues (Zeidler &Keefer, 2003, p.13). Knowledge of the nature of science as an institution holding on one side epistemic values, but also vulnerable to contextual pressures, can serve as tools to interpret scientific statements, and help determine how results are interpreted and used (Sadler, et al., 2006, p.354, Kolsto, 2001b, p. 890).

Different epistemological questions addressed to the same piece of evidence, or different standards applied for providing answers to those epistemological questions, might be a cause for different views regarding the trust, validity and relevance of selected evidence.

The following paragraphs elaborate the characteristics of scientific knowledge and science as an institution that determines different questions and standards for the evaluation of scientific evidence.

2.1.3.3 The limits of scientific knowledge

In the discussion of controversial issues, different social domains impinge upon the decision making: religion, science, ethics, politics, law and others (Aikenhead, 1985). Science is a domain that has certain values that guide the actions of its members. These are particularly epistemic values, which guide scientific research: reliability, testability, accuracy, precision, generality, simplicity of concepts and heuristic power that define science's character as a distinct way of knowing (Allchin, 1999). Even if scientific knowledge has an exceptional status in the society there is controversy concerning this status: the limits of scientific knowledge are questionable among several domains, like religion for example. The neutral, disinterested and objective expert that has been promoted in many cases as the rational and authoritative arbiter of public disputes over scientific or technical issues has been eroded: scientific knowledge has obvious limitations in resolving issues of public controversy (Martin & Richards, 2005).

Additionally, multicultural concerns also raise the issue of the status of knowledge in various cultural groups. In the science area, common sense and local (traditional) knowledge are considered as inferior or worthless types of knowledge (Roth & Désautels, 2004, p.154). Those evaluations might deal with the dichotomy between beliefs and knowledge and ask whether the cultural knowledge about natural world, as it is assigned to various beliefs, could constitute knowledge (Southerland, et al., 2001, p. 326). The dichotomy between beliefs-values and knowledge create questions such as “what is fact”, “is a statement a fact or a belief?” Those questions are answered differently because of different epistemological orientations and additionally, because of different standpoints as the authority of reason in acquiring knowledge are concerned.

For example, the positivists declare that only facts derived from experiment and observation, could be called truth, and they reject all talk about values (ethics, morals, religion, philosophy) not only as “preferences without foundation” but as meaningless or “non-cognitive” babble (Harris, 2004, p.5). On the other hand, there are other perspectives that, in trying to answer the questions of “What is a fact?” and “For whom is it considered a fact, and why?” they do not talk of “proving”; proof means different things within different knowledge domains. Those perspectives rather discuss the underpinning meanings of a piece of evidence (Kolsto, 2001a, p. 299-300).

2.1.3.4 The social nature of scientific research

The authority that individuals or groups assign to science can become a source of conflict. Values that guide scientific procedures have given an authority to scientific knowledge above other forms of knowledge, as the conclusions of science themselves are accorded an image of value (Allchin, 1999, p. 11). Within the scientific community, objectivity and neutrality are highly valued (Kolsto, 2001a, p.299). There seems to be agreement on constitutive values to be an indivisible part of scientific inquiry (Aikenhead, 1985), but disagreement about to which degree contextual values trickle into science (Kolsto, 2001a, p. 301).

The authority of science is challenged. The view that science represents a uniquely valid approach to knowledge disconnected from social institutions, their politics and wider cultural beliefs and values is strongly challenged by research (Lemke, 2001, p. 297). Science is not value free; it is value-laden with contextual values (Casper, 1980; Longino, 1983; Mc Connel, 1982; Schurr, 1981; Ziman, 1980 as cited in Aikenhead, 1985, p. 457). Experts cannot guarantee their “objectivity” by their specialist access to some rigorous scientific methodology: scientific research is a contingent practice and is subject to interrogation of the assumptions that underlie its moment-to-moment decision-making process (Roth & Désautels, 2004, p.152).

Science, as a human enterprise, is embedded in the culture from which it emanates and is affected by and reflects the values and norms of a given society at a given time (Abd-El-Khalick, Bell, & Lederman, 1998; McComas, Clough, & Almazroa, 2000 as cited in Sadler, 2004, p. 355). As a result, scientific theories tend to be “contextualized”, i.e. consistent with the prevailing norms of both the scientific community and of the greater society (Kuhn, 1970; Hubbard, 1990; Harding, 1993 as cited in Sadler & Zeidler, 2006, p.263).

As Roth and Désautels (2004) cite, scientific knowledge can no longer claim epistemologically exceptional status but has to interact with other forms of knowledge on an equal footing in the decision making process (Roth & Désautels, 2004, p.154). Even if it holds an exceptional status in Western societies, science is still a way of knowing, not the only way of knowing (AAAS, 1993).

2.1.3.5 Science vulnerable to contextual pressures

The history of science provides examples of cultural prejudice based on scientific errors and unethical science practised by business and government as well (Sadler & Zeidler, 2006). When interpreting expert statements and their discussions over scientific knowledge claims, the consideration of epistemological factors serves as a tool for understanding and makes it easier to respect the views of antagonists (Kolsto, 2000, p.650). Examples of such epistemological factors are the impact of values or motives that scientists hold as individuals (i.e. funding), or values that science holds as community of practitioners, like peer recognition.

Companies are likely to make a fortune through the development of scientific techniques that can improve or save human lives. Pharmaceutical companies are under pressure to make profits. Scientists, on the other hand, are under competitive pressure to obtain grants and to publish. How far are science and technology compromised by the quest for profit? (Levinson, 2008). Science, in many cases, can be seen as a combination of business and politics (Cross & Price, 1996, p.779) striving to maintain elimination toward the influence of political and economical interests on their theories.

Scientists are not supposed to let personal or institutional interests have any impact on their scientific work. Even if there is no doubt that objectivity and neutrality are ideals for most scientists, these ideals are sometimes difficult to achieve (Kolsto, 2001a, p. 299). In cases when scientific knowledge is inconclusive, science is more vulnerable to contextual pressures, making it more value-laden. Scientists involved in debates on controversial issues tend to be more critical of the evidence the antagonists are offering, than of the evidence their own conclusions are based on (Collingridge & Reeve, 1986 as cited in Kolsto, 2001a, p. 299).

There is now a widespread public perception that experts can and do disagree with, and that their purportedly "disinterested" advice may be influenced by professional, economic, or political considerations (Martin & Richards, 2005).

2.1.3.6 The status of anecdotal evidence

The public uses its own knowledge base to produce its own evidence, known as “anecdotal evidence”. Anecdotal evidence is based on “popular epistemology”, as defined by Irwin (1995) and is concerned with local and specific situations, while science aims at universally applicable theories and explanations (Driver, et al., 1996).

The role of anecdotal evidence has evolved numerous debates involving lay and professional views about the issue. Citizens seem to highly value “anecdotal evidence”, as it has been shown to be of great relevance and importance in several cases (Irwin, 1995). Scientists question the status of anecdotal evidence and usually accept evidence that has been produced with standards that are highly valued in the scientific community. Evidence has to be public, inter - subjective, and open to validation for anyone interested (Trany, 1986 as cited in Kolsto, 2001a, p. 301). Scientists assign citizens’ value to anecdotal evidence to be caused by a lack of understanding.

Though not accepted by the scientific community, anecdotal evidence can point to the existence of a problem; it could be used as the input of information of the public to the scientific community that hold the tools to provide statistical evidence that is needed to distinguish between competing explanations of it (Kolsto, 2001a, p. 301). In cases of products and methods that are related to human health risks, non-governmental organizations are critiquing regulatory science, attempting to change standards of evidence and proof, and introducing data about product use. We could argue that in an ideal mode, under a very complex process of science-policy-political interactions that Krimsky (2000 as cited in Iles, 2007, p.377) explores, regulatory agencies, researchers, and environmental health institutes should expand their research to scrutinize health outcomes, related to the use of specific products not previously included in research.

On a different level, the synthesis of individual lay and professional views with research findings could point to some important factors that would have otherwise been missed. Synthesis of anecdotal evidence with that from scientific literature in widely debated public issues would help in filling the gaps in evidence base and in planning effect (Nagaraj, 2006).

Recognition of and demands for further investigations on potential health hazards have often come through workers in gas industries, plastic workers, textile workers, and so on, with asbestos workers as the best known example (Irwin, 1995, as cited in Kolsto, 2001a, p.301). Individuals and NGOs like consumer and environmental groups expand their role beyond of that of evaluating and criticizing scientific evidence to that of producing of technical knowledge. Iles (2007) describes the case where very little information was available on consumers' exposures of phthalates, a family of existing chemicals used in chemical manufacturing primarily as a plasticizer additive in PVC. In this case NGOs are taking on a new role of producing scientific and technical data that can feed into regulatory science and influence decision-makers as well as citizens and consumers This data can be merged with emerging scientific results that argue that some phthalate uses were "unsafe" (Iles, 2007, p.375-378).

However, the case is not always like that. Anecdotal evidence is often ignored by scientists. Professional and social groups and government bodies use scientists' authority, not only for providing evidence, but also to determine the focus of the study. As a result, what is perceived as technical ignorance by experts overlooks valuable forms of localized knowledge among networks of citizens, leading to feelings of alienation and distrust among the affected social group (Irwin & Michael 2003; Wynne, 1992 as cited in Nisbet & Goidel, 2007, p.422). Citizens feel fear that their concerns cannot be expressed and their observations and own conclusions, though unfounded, are not seriously considered. When it comes to public health issues, like the possible effects of the consumption of genetically modified foods, public concerns are arrogantly dismissed as irrational and emotional (Irwin, 2001).

Science no longer represents "enlightenment," but a force to be struggled against, especially when it comes to environmental and public health issues, where citizens' experiences may suggest the opposite when met with scientifically based reassurances (Kolsto, 2001a, p. 303).

2.1.4 Decision making about controversial issues

Controversial issues are not problems of scientists in the laboratory, or of politicians in the government board. There is always a decision to be made that affects the social. Controversial issues are problems of the society. Hess (2001) uses the term "Controversial *Public* Issues" stressing that some public either informs or makes a decision about such issues.

Even if the public is not always capable of acting on societal level, these issues include, apart from forming opinions, the making of choices at personal or societal level (Ratcliffe & Grace, 2003, p.12). Finding solutions and deciding upon such issues is not easy, as the issues are by definition complex, open-ended, often contentious dilemmas, with no definitive answers (Sadler, 2004, p. 516).

2.1.4.1 The role of values

The discussion of controversial issues requires the consideration of ethical issues and construction of moral judgments about scientific topics via social interaction and discourse (Zeidler & Keefer, 2003, p. 9). Political, economic, ethical, scientific and ideological values give an 'ethical' context for conflict resolution as they frame the ways groups of people ought to act in relation to controversial issues (Aikenhead, 1985, p.453). Those values also affect the risk evaluations, in a cost - benefit analysis about the issue (Ratcliffe & Grace, 2003).

Because we have different wishes, values and beliefs, society is loaded with these sorts of conflicts (Kolsto, 2000). Controversial issues are "moral": they are associated with the rightness or wrongness of an action towards such issues (Levinson & Turner, 2001, p.16).

As Bailey (1971) cites:

> *"A controversy is about human action and thus, is only understandable if valuative considerations are included. That is, any attempt to explain the controversy, to one self or to others, that leaves out value positions will fall short of being an acceptable explanation or a coherent understanding." (p.69)*

Reference to factual information, experiment, or evidence alone cannot settle controversial issues as political, economic, ethical, scientific and ideological values are interrelated in the decision making process (Bridges 1986; Wellington, 1986; Aikenhead, 1985).

Different groups offer different solutions to controversial issues as they are attached to different values (Aikenhead, 1985; Ratcliffe & Grace, 2003; Kolsto, 2000; Bridges, 1986; Demopoulos & Koulaidis, 2003; Sadler, 2004; Wellington, 1986). Value systems differ both in personal and group level in the society and among societies as well. Members of the same society share a common life within a variety of activities, institutions, and traditions that they 'agree' on standards that lay down within each other (Elliot, 1973, p. 53).

At another level, several sections of the society share a number of social activities and traditions and raise conflicting judgments to other different sections of the society. Moreover, even if several individuals, groups or nations hold the same values, they may assign different priority to the same value or different interpretation to the same value (Bridges, 1986, p.21).

Pajares (1992) explained that clusters of beliefs around a particular situation form attitudes, and attitudes become action agendas that guide decisions and behaviour. In other words, people act upon what they believe (as cited in Lumpe, et al., 2000, p.277). These differing views on an issue usually imply different emphases (based on a range of values) placed by individuals and groups on the needs of society and social groups and consequently, might affect the decision on the issue under discussion (Oulton, et al., 2004, p. 413).

Several studies designed to explore patterns of reasoning regarding socioscientific controversial issues have reported that ethical concerns are among the most important factors for individual decision-making in all ages and across a variety of issue contexts including genetic engineering, biomedical research, environmental problems, and animal rights (Sadler, et al., 2006, p. 354).

Participants who are engaged in socioscientific issues base their decisions primarily on personal values, morals, ethics, and social concerns rather than on scientific knowledge (Bell & Lederman, 2003; Nisbet & Goidel, 2007). Beliefs regarding the spheres of science, spirituality, business - technology, nature - environment, and family - society frequently emerge in the discussions of controversial issues (Small, 2003 as cited in Gamble & Kassardjian, 2008, p.246).

Decisions are based on identification of values and on personal criteria rather than on knowledge of scientific data, especially when more emphasis is placed on "science in the making" (Aikenhead, 2004; Fensham, 2002 as cited in Albe, 2008, p.3). Argumentation has been found not to differ among groups that hold different scientific backgrounds; groups in different educational levels, for example, tend to focus on similar, sociomoral themes as they negotiate socially complex, genetic engineering issues (Sadler & Flower, 2006).

There is a strong implication that when the issue concerns values, equally rational possibilities come up and that reason will not help in the decision of which is the right one (Bailey, 1971). As a result, a controversial issue cannot be solved by means of value-free evaluations or calculations, but has to be negotiated; because of values, there is no rational way by which we can come to consensus (Eliot, 1973). Therefore, we need politics and discussions to weigh values that in principle cannot be weighted (Kolsto, 2001a, p. 298; Elliot, 1973). As Eliot (1973) cites:

> *"The process of coming to view things in a different light is neither rational nor irrational; it is non-rational." (p. 61)*

2.1.4.2 The context of the decision making

An area of dispute is the framing of the decision to be made (Aikenhead, 1985). Within any issue there are many different types of question to address; additionally, people view the issue in different ways (Levinson, 2008). Interests, needs and values might frame the same problem under different limits and lead to different decisions. Not all sides of the society are involved in each issue (Aikenhead, 1985). However, framing the issue by one way or another, will lead to different decisions and solutions that leave out several groups. For example, in the genetically modified food discussion, there is still no single widely agreed ethical framework within which genetically modified crops can be evaluated (Reiss, 2001, p.180). Issues are framed and reframed as different people that inhabit different value systems both within and between cultures enter the discussion. However, whenever a decision is to be made at a collective level, this is taken under certain people, with certain needs, interests and values.

As a result, the definition of the problem to be managed is a controversial issue per se. How can the issue be defined? Who gets to decide what counts as a legitimate problem for discussion? (Irwin, 2001, p.4)

2.1.4.3 Macromorality and micromorality level

The context of the decision making is also situated in two levels: one of macromorality and one of micromorality (Zeidler, et al., 2004). In a macromorality level, usually the effort is not to provide a decision towards one direction or another rather than to provide a frame for decision making balancing different benefits, risks and duties (Dawson & Taylor, 1998, p.318). Reasoning about societal constructs - laws, duty and social institutions- rests in a different level rather than trying to resolve differences in a personal level, via argumentation and discussion during face to face interactions (Rest, et al., 1999). Macromorality level, though providing support for more complex moral judgments by examining societal conventions from a theoretical perspective, has been criticized for inattention to the micromorality questions that arise in individuals' everyday lives (Krebs & Denton, 2005 as cited in Ross, 2006; Rest, et al., 1999).

The distinction between those two modes of reasoning might produce different outcomes in a decision making procedure, but also explain the distance between people's beliefs and actions (Zeidler, et al., 2004). In real life people make moral decisions about themselves and others that matter; the consequences are real (Krebs & Denton, 2005, p. 647). Micromorality thus, describes the level in which people grapple with everyday issues rather than philosophize about morality.

2.1.4.4 The role of the public in deciding

Democratic ideology suggests that people must be able to influence policy decisions that affect their lives, being involved somehow in decision making about such issues (Dolbe, 1995; Irwin, 2001). Along with decline of public trust in the infallibility and neutrality of expertise has come a growing demand for greater public participation in scientific and technical decision-making and policy formulation (Martin & Richards, 2005).

The public interacts in controversial issues in many levels. Does the public inform (Hess, 2001), being informed, just “presented” to such issues, does it offer solutions, does it decide? (Hess, 2001; Demopoulos & Koulaidis, 2003; Crick Report, 1998) The answers to those questions define the level of democracy in a society - citizens’ rights to decide for themselves- but also describe the citizenship level; the citizen’s willingness to act in such a mode.

One of the problems arising when it comes to controversial scientific issues is the ability of the public to participate thoughtfully and effectively in the process of developing policy responses to such controversies. Many of the issues that society confronts today contain risk evaluations in the decision making process. One model of risk evaluations is based on the experts’ knowledge: through techniques of risk assessments, experts often come to define the boundaries of environmental problems as well as their proper solution. However, this tactic is widely believed to suffer from a lack of public understanding and legitimacy, thus leading to a “lay-expert discrepancy” (Blok, et al., 2008, p. 189).

Different views of the situation spark conflict at a political level. There are researchers, experts and government agencies which interpret the public's demands for participation in decision making as:

> *"endless demands from private interests and self-appointed representatives, who lack the requisite technical knowledge to assess decisions and thus making it impossible for the public to maintain a reasonable involvement in the decision making process." (Doble, 1995, p. 45-46)*

Those who believe that scientific knowledge is one of great importance for evaluating scientific claims, express their concerns in the light of research that reveals lack of understanding about basic science related to an issue, like genetics for example, (Lanie, et al., 2004), about the significant implications of this lack when it comes to the decision making process. Risk evaluation of the public is thought to be done in terms of fear and of the unknown, as the far-reaching benefits in areas of medicine and public health from recent biomedical research cannot be enhanced if people do not have an understanding of basic concepts and terminology (Burke, et al., 2002).

Expanding the sceptical of this technocratic view, decisions that would guide scientific endeavour could not be left in the hands of citizens guided by horror. Why do we have such a horror of cloning? Why is this technology seen as particularly unnatural whereas other non-natural technologies are readily accepted by society? (Levinson, 2008) Is it a matter of time? Why are we regarding GMF as "Frankenstein" food whereas we are not surprised by dozens of chemicals used in conventional food? Should we let "ignorant" citizens take decisions?

On the other hand, there is a widespread view that differences in risk perception must be understood at the level of social identities and not that of knowledge (Blok, et al., 2008). Studies have shown that citizens' considered judgments about controversial issues were generally in line with the views of the scientists and that differences that persisted seem to stem from different values, not from different levels of technical expertise (Dolbe, 1995). According to Dolbe (1995), those results suggest that the general public can reach a clear, understandable, logically consistent, considered judgment about scientifically complex issues, though this is underestimated by government and expertise bodies (Doble, 1995, p. 107).

Finally, there is a view that not only is the public able to engage in a decision making process, but its presence in policy making is essential. These views demand not only an "add on" participation of the public in decision making, but a direct engagement which would be a "normal and integral part of the process of decision making" (Irwin, 2001, p.2). At present, it is increasingly being recognized that participatory techniques for the involvement of stakeholders, ranging from ordinary citizens to business people, are needed - with particular emphasis on public trust and the articulation of environmental and social values (Kasemir, et al., 2000; Irwin, 2001).

Additionally to values and morals of public that have to enter the discussion, "civic epistemology" - "the practices, methods, and institutions by which the community identifies new policy issues, generates knowledge relevant to their resolution, and puts that knowledge to use in making decisions" (Miller, 2005, p. 406 as cited in Iles, 2007, p.171) - can help illuminate how environmental health is being used to identify product risks and change the regulatory science that decision makers use to control products (Iles, 2007).

Therefore, experts and policy makers may, because of the demands of the citizenry, be forced to learn how to communicate more effectively about scientific issues and involve the public in the decision-making process (Doble, 1995, p. 103). This requires much greater transparency and openness within decision-making. As the Royal Commission on Environmental Pollution (RCEP) (2001) cites:

> *"Those directly affected by an environmental matter should always have the accepted right to make their views known before a decision is taken about it. Giving them that opportunity is also likely to improve the quality of decisions; drawing on a wider pool of knowledge and understanding (lay as well as professional) can give warning of obstacles that, unless removed or avoided, would impede effective implementation of a particular decision. . . ." (As cited in Irwin, 2001, p.2)*

We live in the era of dialogue; things change and knowledge, values and morals are being assimilated in a new setting. This is a procedure that has always taken place; it is rather faster in our time. In this assimilation science and public, scientific knowledge and "civic epistemology" enter, or at least should enter, an arena of open dialogue: science, policy, and politics are enmeshed and interactive, not separate realms of cognitive and societal activity (Jasanoff, 2005 as cited in Iles, 2007, p.173).

2.2 Controversial issues and science curriculum

Previous paragraphs have elaborated the nature of controversial issues as a societal construct that involves science and the society interacting in levels of knowledge and decision making. The aim of this subchapter is to elaborate how this complicated construct might be a subject in school science classrooms.

The paragraphs that follow aim to shed light on perspectives related to the implementation of controversial issues in science education, not by mentioning all of them, but by trying to highlight the areas of conflict among them. Different frameworks will be presented according to the following areas that have been found as important, while analyzing them:

- The relationship that they assign to science curriculum and controversial issues teaching, and accordingly different pedagogical outcomes that they propose
- The nature of science that is promoted through them
- The role of values and moral development , and finally
- The role of emotions

By using the following classification of frameworks, I do not assume that the relationships of the dimensions mentioned above are static and definite. Actually, they fall under the interpretation of the writer. However, the way that the chapter is organized aims to shed light on how different pedagogical needs for including controversial issues in science education, or how controversial issues might contribute to scientific literacy, promote different pedagogical outcomes and views of scientific knowledge, but also are problematic either in philosophical or psychological grounds (is it right, is it achievable?). Additionally, a classification like this might be helpful in realizing what is going on in a science classroom, when a controversial issue is explored.

2.2.1 Science education for citizenship: Science view for thoughtful decision making

One of the frameworks proposed for the use of controversial issues in science can be described as "science education for citizenship" (Crick Report, 1998; Wellington, 2004). According to this perspective, teaching with or about controversial issues is done under the use of science as a lesson, unique and indispensable, that could make a significant contribution to citizenship education (Wellington, 2004, p.34; Crick Report, 1998, p.35; Ractliffe & Grace, 2003).

National curricula are called to meet the needs of preparing active citizens: those who are willing, able and equipped to have an influence in public life, citizens that should have the critical capacities to weigh evidence before speaking and acting (Crick Report, 1998, p.11). Students should get learning opportunities, which require the use of higher thinking skills, such as analysis, synthesis, critical reflection, and evaluation of their ideas about social and ethical issues (Lazarowitz & Bloch, 2005, p.442).

Pupils learn about how to make themselves effective in public life through knowledge, skills, and values (Birzea, 2005, p.910). *Knowledge* about scientific theories that embed the subjects under discussion, *skills* of enquiry and communication needed for the discussion of such issues, and responsible *action* and participation are the three pedagogical outcomes that fall on both areas: science and citizenship (Wellington, 2004; Ractliffe & Grace, 2003; Davies, 2004). Science education, thus, should enable students to develop skills such as

- the understanding and the ability to recognise bias
- the ability to recognise and evaluate argument,
- the ability to weigh evidence put before them, questioning and evaluating where information comes from, who put it there and how its presented (Wellington, 2004, p.34) and to look for alternative interpretations, viewpoints and sources of evidence (Crick Report, 1998, p.61) and
- the ability to identify objective scientific evidence as well as evaluating the advantages and disadvantages of different possible solutions to a problem based on the available evidence (Ractliffe & Grace, 2003, p.40).

The place of values according to this project could be described under a *moral - character education* in which social and moral responsibility should be developed progressively as pupils move through schooling (Crick Report, 1998, p. 32). The ultimate goal is to educate students who will act as informed, responsible citizens when confronted with such issues. Students, under the moral education notion, are called to develop some "qualities of mind" such as

- a willingness and empathy to perceive and understand the interests, beliefs and viewpoints of others
- a willingness and ability to participate in decision-making, to value freedom, to choose between alternatives, and to value fairness as a basis for making and judging decisions (Crick Report, 1998, p.59).

There are general statements of the report that refer to the moral development of the students (Crick Report, 1998, p.59) declaring that:

> *"Students should be helped, in particular, to reflect on and recognise values and dispositions which underlie their attitudes and*

actions as individuals and as members of groups or communities.” (p.41)

However, the emphasis given in the aims stated in the report is on the “duties” and “responsibilities” of students rather than self reflection procedures. The values are described as established morals and ethics situated in the community in an unproblematic manner, not recognizing the complexity of rearrangement of the social as an impact of scientific endeavour.

The stronger connection between science and citizenship education, as far as moral character education is concerned, seems to be the transmission of values of science to the students, according to this framework. Science education is viewed as a discipline where values such as the willingness and ability to apply *reasoning skills* to problems and the respect *for truth and evidence* in forming or holding opinions (Crick Report, 1998, p. 59) could be cultivated. Students should base their decisions on science, according to this framework, which is interpersonal, and rooted in a community of scholars, based on accumulated evidence, open to scrutiny and falsification (Wellington, 2004, p.36).

The nature of science presented in documents describing the “education for citizenship” framework, is rather an authoritarian one. Science is viewed as a place where “truth” can be directly connected to evidence and “reasoning skills” are seen to possess a vital role in the resolution of such issues. As Wellington (2004, p.36) argues, all the ethical and moral decisions we have to make about the distribution of resources, feeding the world’s population or preserving the ecosystem of the planet are grounded in the physical and natural world and therefore are grounded in science.

This framework, even if it offers a strong connection to traditional science curriculum and citizenship education, has several shortcomings. Firstly, it fails to deal with the social nature of scientific knowledge. How are students going to engage in controversy, weighing contrary scientific evidence when they are “seeking the truth” and not asking epistemological questions? How can the “science view” be applicable when scientists still disagree? One might argue that if science is presented as a discipline that holds the answer, there is a danger that science education would not prepare citizens to deal with real-world science, which is more often than not equivocal, reversionary and conflicting (Bell, 1995, p. 63, as cited in Gray & Bryce, 2006, p.179).

Additionally, the framework is problematic on psychological grounds as it leaves out students’ own values and interests - which are regarded as personal and unreliable - alongside values and methods of science. Methods like these present a “mystique” of science that makes it seem dogmatic, authoritarian, impersonal and even inhuman to many students (Lemke, 1990, p.12). This argument however does not seem to sound strong for those who believe that curriculum should be grounded on philosophical rather than psychological assumptions: what students like can never be the determinant of curriculum contnet (Hall, 2004, p.27).

The problems that might be encountered though in pedagogical level, could go beyond students’ dislike of science. Giving the “science view” of the problem (Wellington, 2004; Kolsto, 2000), requires isolation of issues of evidence in a whole network of values and interests that students bring to the classroom. If evidence cannot settle those issues alone, how should the science dimension be presented in the classroom? Which pedagogical decisions could make this possible?

One possible solution that Wellington (2004) offers and seems reasonable in some, but not all issues, is promoting key ideas that should influence our ethics that are science based. Science curriculum should actively promote an environmental ethic, a conception of human beings as being part of the environment and not apart from it, and a philosophy of education for sustainabiilty (p.38). Science education should promote a “global citizenship” and “enable students to develop the eclectic values of an educated member of society” from the global awareness perspective: students should learn about world problems, share the world and act in a worldwide perspective (Birzea, 2005, p.9; Lazarowitz & Bloch, 2005, p.438). A curriculum like that would promote science as a way of influencing morals and thus, guiding decisions that go beyond scientific evidence.

Finally, the frameworks’ manifest, the authority of scientific knowledge upon other forms of knowledge, is highly questioned if it fails to recognize the limits of scientific knowledge. Even if this argument gives a great strength in the relationship of citizenship and traditional science education, it is not applicable in issues where strong religion or emotional elements embed the issues under discussion. What would be the “science view” of cloning? Perhaps finding a reliable way to estimate the possible impacts of this endeavour and put it under the morals of sustainable development? Even if we agree, as science teachers, to do that, in the sake of promoting a science view, how could this be possible with moral agents in the classroom that might hold strongly religious beliefs towards one or another direction? Does this mean that we describe religion as a “dogmatic” way of thinking, based on belief and faith, and thus, inferior to “scientific”, reason guided, based on accumulated evidence way of thinking and therefore, try to remove students from one momentum to the other? Which is the level, or status, that those elements - religion, emotions, science- should be presented in the classroom? I would not say that “view from science” framework would give a definite answer to this question, even if one could argue that this framework would rather promote scientific authority upon other forms of knowledge.

Not even a “view from religion” would give such an answer. The view of science and religion as areas that hold the answers is problematic. If the answers were either on one discipline or the other, then no need for discussion. Why has the Greek Orthodox Church established a bioethics committee - that includes scientists also - if it already holds the answers? On the other hand, why do scientists not always make the best decisions for their own lives?

Concluding, I would say that helping students to see the science view of controversial issues is a vital part of introducing SSI accroding to this framework. If science teachers would not do it, who else would ? (Wellington, 2004) However, thinking scientifically about controversial issues implies a clear distinction beteween value and reason (Bailey, 1977), faith and science (Wellington, 2004), distinctions that might be evident only in a philosophical level, and also problematic when considering students’ moral and religious beliefs. Furthermore, presenting the science view would be problematic in cases where there is no consensus in the scientific community for such a view, and additionally might be epistemologically and pedagogically problematic if it is introduced in a way that does not recognize the limitations of science as a discipline.

2.2.2 Controversial issues for science education: Epistemological issues in focus

Other initiatives, derived from the need of science education to meet the needs of citizenship education, located in the science education area, have given different perspectives to the role of science in the resolution of such issues (Ratcliffe & Grace, 2003; Fullick & Ratcliffe, 1996; Kolsto, 2000). Even if the starting point is the need of science teaching to meet the needs of citizenship education, the argument that socio-scientific issues can make an important contribution in learning science is, perhaps, the greatest strength that frames the pedagogical decisions under this perspective (Zembylas, 2005, p.717).

Students consider socio-scientific issues in science lessons, developing skills of reasoning, communication and analysis, but they also engage in activities that aim to increase the appreciation of the strengths and limitations of scientific process and content in addressing the issue (Ratcliffe & Grace, 2003, p.35).

As in the previous framework, the emphasis of the science dimension of controversial issues is also evident (Kolsto, 2000; Ractliffe & Grace, 2003). An important goal of science teaching should be to enable students to interpret scientific information and to recognise, construct and evaluate arguments where the issue in question has a science dimension (Lewis & Leach, 2001, p.4).

Pedagogical activities aim to foster students' logical development by focusing on scientific problems in activities that will allow the evaluation of evidence as well as thought. Students should be able to ask for evidence and clarify whether a claim is supported by evidence at all, or whether it is merely a guess, an assumption, or personal opinion or impression (Kolsto, 2001a, p.309).

Additionally to the previous framework, socioscientific controversial issues are regarded as a fine opportunity for the teacher to initiate a discussion on the differences between knowledge claims from frontier sciences and established consensual scientific knowledge and on the different aspects of the nature and epistemology of scientific knowledge (Kolsto 2000; Ryder, 2001). The processes, which students should engage in during the discussion of socioscientific issues, are akin to those which scientists pursue "when making decisions regarding the justification of scientific knowledge proper" (Abd-El-Khalick, 2003, p. 58). Students, accordingly, are called to:

- recognize that measurements carry an inherent variability and, therefore, do not provide unequivocal access to a "true" value;
- appreciate that many scientific questions are not amenable to empirical investigation because of the number and complexity of variables which would need to be controlled in an experimental study, the long-time horizons involved, and/or restrictions on study design following from ethical considerations; and
- understand that since proof is often unattainable, decisions may need to be made on the basis of estimates of risk (Ryder, 2001).

Epistemological development of the students, under this perspective, is regarded as an essential skill for conflict resolution. Individuals capable of examining scientific knowledge critically can be considered scientifically literate in the decision - making sense (Aikenhead, 1985; Fleming, 1989; NSTA, 1982; AAAS, 1989 as cited in Kolsto, 2000). This argument serves not only citizenship aims, but also offers an opportunity to include epistemological issues in science curriculum. Knowledge of the human character of science, values in science, limits of science, and its tactics for decision-making are regarded as prerequisite knowledge for thoughtful decision-making (Aikenhead, 1985). Therefore, the focus is on issues like evidence and its relevance, and on questions for social information, like sources of claims and evidence, possible interests involved, competence of claim holders, and level of consensus among scientists (Kolsto, 2001a, p.304).

The notion of using controversial issues to promote scientific literacy has certain differences from the framework described as "science for citizenship education." In the first place, it emphasizes the "science part" and not the "science view" of controversial issues. This notion holds a dialectical move of science towards other domains of knowledge and beliefs. As Kolsto (2001a) argues:

> *"If we, through school science, want to lay a more tenable foundation for the education of future scientists and citizens, raising awareness, that science is but one of several social domains relevant to decision making on socioscientific issues should not be rejected." (p. 298)*

Under this perspective, new aims come alongside the teaching of controversial issues. Students should be able to:

- Understand the limits of science (Ractliffe & Grace, 2003).
- Understand that science is not the only relevant knowledge area for decision-making and that it may not even be the most important one (Koslto, 2000).

Engaging students in activities that would question scientific evidence would hopefully involve a dismissal of claims to "the best solution" and to primacy of scientific and technological aspects in one's decision base (Kolsto, 2000). Taking this argument further, other writers support the view that students should examine how power and authority are embedded in scientific enterprise (Zeidler, et al., 2005, p. 360) and realise that since scientific knowledge is vulnerable in contextual factors it can no longer claim epistemologically exceptional status but has to interact with other forms of knowledge on an equal footing (Roth & Désautels, 2004, p.154). This could not be a threat for scientific literacy, as if students are to fully understand the power and potential benefit of science, they must also be aware of its shortcomings and drawbacks (Sadler & Zeilder, 2006 p.280).

One problem that might be encountered in the application of the framework is that the issues under discussion include levels of conflict that go beyond contradicting scientific evidence. Consideration of socio-scientific issues requires more than just discussion about the justification of scientific knowledge, but needs to engage with the many multiple perspectives, which have a stake in the issue and embrace complexity and uncertainty in its approach (Gray & Bryce, 2006, p.176). Selecting a pedagogic approach that focuses only on the scientific disagreement would be problematic in cases where students' values and interests use hierarchies that do not necessarily deal with scientific evidence.

The resolution of this issue seems rather "literal" and rests in the level of "declarations", also. For example, Kolsto's (2001a) consensus model rest on the idea that:

> *"Such conflicts cannot be solved by means of value-free evaluations or calculations, but have to be negotiated; therefore, we need politics and discussions to weigh values that in principle cannot be weighted." (p. 298)*

In other examples, also, even if students are called to "clarify personal and societal values and ideas of responsibility" (Ratcliffe & Grace, 2003, p. 41) there is no clarification of how this can be done. The complexity of students' interactions with the values embedded in the issues for discussion is presented only under the "procedural understanding" goals of undertaking "ethical reasoning" in the decision making process.

Students are regarded as subjects for “moral development.” However, the aims presented that connect science education to controversial issues that fall under a knowledge - skills - attitudes scheme, create a profile of a student who is somehow “distanced” from the problem: a student who is able to “make distinctions between descriptive and normative statements” (Kolsto, 2001a, p.293) and “recognize how values and beliefs are brought to bear alongside other factors in considering socioscientific issues” (Ratcliffe & Grace, 2003, p.41). Whose values? Where is the place of students’ values and emotions? How are these going to be resolved in the decision making process?

2.2.3 Focusing on the ethical aspects of Science: Moral development of students

A third initiative for including controversial issues in the science curriculum derives from a need to infuse ethical aspects in science. The framework is based on the distinction between scientific understanding (what we know, we can do) and ethical judgments (what we believe we should do), which could contribute to the moral development of students (Fullick & Ratcliffe, 1996; Hall, 2004).

Two arguments might support the infusion of ethics, under this definition, in science education. The first one derives from deductive connections between science education and ethics: the goal of science education is the promotion of scientific literacy; scientific literacy includes the negotiation of SSI (socioscientific issues); SSI are value-laden; therefore, ethics should be a part of science education (Sadler, et al., 2006, p.354). Even if this argument supports the infusion of ethics with science education, it does not actually explain why SSI should enter science education, as it takes it for a granted need.

The second argument derives from the need for "humanizing" science education since traditionally it is not related to ethics and morals. Teaching has been described as "moral by nature" meaning the very essence of good teaching involves the ethical and moral development of young people (Loving, et al., 2003, p. 183). In traditional science classrooms, students are not exposed to moral, ethical, and human value discussions while learning science and technology.

> *"Students should be made aware that society became extremely sensitised to the need of ethics in human experimentation after the details of the Nazi atrocities, presumably performed in the name of scientific research, were made public" (Gottlieb, 1976 as cited in Lazarowitz & Bloch, 2005, p.438).*

Science education consequently, should be a place where moral development of students should take place, especially when it comes to science and technology applications in the social.

One problem regarding this framework is the dichotomy that presents between science and ethics. Science is defined as the process of rational enquiry, which seeks to propose explanations for observations of natural phenomena whereas Ethics is defined as the process of rational enquiry by which we decide on issues of right (good) and wrong (bad) as applied to people and their actions (Fullick & Ratcliffe, 1996, p.7). As Hall (2004) cites, nowhere in science do we find an injunction to pursue the intrinsically good: science holds methodological rules and not values (p.25). For Hall (2004), there is no good or bad science but there is just science and non science. According to this view, ethics needs to be used alongside scientific knowledge in order to make decisions about complex socioscientific issues:

> *"Scientists grapple with it in ignorance of a sound ethical dimension and those with knowledge and skills in the ethical field are ignorant of science" (Hall, 2004 p.26)*

The dichotomy of science and ethics describes an "objective" nature of scientific knowledge that leaves outside the place of values and ethics in the reasoning and other acts of scientists. This rests on a fact-value distinction that, as Wellington (2004, p.34) argues, is as old as the steam engine and about as absolute: the facts are value laden; values are fact laden. Any effort to preserve the "objectivity" of science by excluding values and ethics from the science classroom, when dealing with complex controversial issues, shelter students from the complexities of science as it is conducted in and applied to society (Hughes, 2000 as cited in Sadler, et al., 2006, p.353; Allchin 1999). Presenting the "science part" as unproblematic, could only be effective in issues that might not deal with contradictory evidence. Otherwise, as several scholars have argued, science education for citizenship ought to include content-transcending goals or topics as knowledge of the nature of science, limits of science and values in science (Driver, et al., 1996; Millar & Wynne 1988; Norris, 1995 as cited in Kolsto, 2000, p.650; Aikenhead, 1985; Allchin, 1999).

Another problem, regarding the application of the framework, refers to its applicability in a classroom with students morally and emotionally involved in the issue. Fullick and Ratcliffe (1996) introduce an "ethical enquiry" framework that involves interpretation, analysis and argument, critique and decision making for the resolution of socioscientific, ethical issues (p.10). The dichotomy between facts and values calls students to be aware of the "type of truth" of statements in a statement asking questions like:

- Are they *assuming* that it is true?
- Have they *defined* it as true?
- Is it true because they are unable to find a contradictory example?
- Have they demonstrated that it is true by providing relevant evidence? (p.10)

On the one hand, one would argue, how can we define "truth" in such complex issues, in a complete rational way that is presented in the above questions? Even if we agree on this level, how can students be distanced from a problem and analyze it from the level of others' rational and emotional procedures? Students, according to this framework, are called to avoid fallacies in such cases:

- when the same word means different things to different people
- when metaphors or other "tricks" of language are used
- when ideas are "disproved" by personal innuendo rather than logical analysis
- when truth is defined by an appeal to authority, arguing that if an expert says something is true it must be so
- when false assumptions are employed to make a case (Fullick & Ractliffe, 1996, p.12).

Even if those "fallacies" could feed a good discussion about an issue, the way presented here describes a student that keeps a "distance" from the problem. The student is assumed to be able to recognize "the common fallacies and sources of confusion that can arise in loose or over-emotional discussion" in a way that some other people are discussing and fell to fallacies and confusion and not the student herself. How is the student going to understand "common fallacies" if she falls in such "fallacies"?

Even though basic principles of the framework seem problematic, the framework is the only one that provides practical guidance on how value issues may be resolved. Focusing on ethical aspects, even if this is done under the dichotomy of science and ethics, might serve as an acknowledgment that they are both essential to the solution of problems (Hall, 2004, p.26).

Projects like the "Science, Ethics and Education Project", "highlight the importance of including and resolving ethical aspects in science, as an opportunity for a thoughtful, rigorous approach for inquiry" (Fullick & Ratcliffe, 1996). By proposing a structured framework, Fullick and Ratcliffe (1996) encourage open- mindedness and a willingness to listen to and respect the points of views of others by including steps in their framework that deal with the values and ethics embedded in the issue like:

- arguing priorities which should determine the choice between alternative judgments (values)
- deciding on a final judgment and the particular reasons for the choice (p.10)

The problem again is that the whole framework looks like a rational and simplistic one; students are thought to come up to decisions through a well - structured procedure. However, the argument that, "it makes no sense to suggest that value-issues of this kind must be capable of being resolved in a rational way" (Elliot, 1973, p.62) strongly questions the project's suggestion that decision making could be a process of rational inquiry and ethical inquiry that is presented as a rational one also.

On the one hand, one would argue that moral reasoning judgments entail prescriptive judgments of right and good applied to social situations (Kohlberg, 1986 as cited in Zeidler & Keefer, 2003) and therefore, moral reasoning is based on specific features of thought processes. However, those processes reflect the individual's interpretation of rules, principles (i.e. justice) in conflict situations (Zeidler & Keefer, 2003). Coming to a conclusion on matters of value is more than we can expect of a rational enquiry (Bailey, 1971, p.73). The process of coming to view things in a different light is neither rational nor irrational; it is non-rational (Elliot, 1973, p. 61). As Bailey (1971) argues:

> *"The open enquiry is not to seek truth, but only to demonstrate to the sceptical the equal validity of diverse views. This does appear to rest on not only a fact-value distinction but a reason-value distinction as well." (p.74)*

2.2.4 Socioscientific discourse for the cognitive, psychological, social and emotive growth of the child

One framework that addresses socioscientific discourse and connects the complexity of the socioscientific controversial issues and science teaching in terms of the psychological, social, and emotive growth of the child, is the model of Zeidler and Keefer (2003) that derives from a cognitive-moral reasoning perspective.

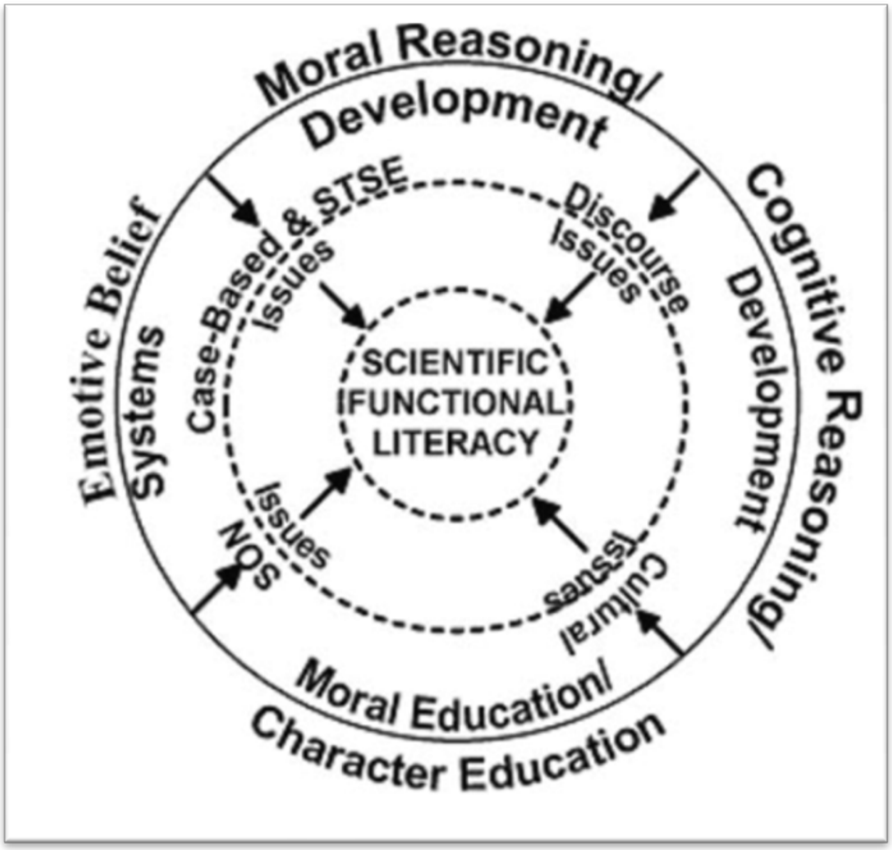

Figure 1: Socioscientific elements of functional scientific literacy (source: Zeidler and Keefer, 2003, p.362)

The main difference of this framework from the others presented before is the relationship that it assigns between functional scientific literacy and child development. Functional scientific literacy, according to the framework, “falls short of the mark if it ignores the fundamental factors aimed at promoting the personal, cognitive and moral development of students” (Zeidler, et al., 2005, p. 362).

Socioscientific controversial issues under this framework are not considered as a context that science uses in order to promote specific knowledge, attitudes, and skills. The term refers rather to a distinctly developed pedagogical strategy that focuses specifically on empowering students to consider how science-based issues and the decisions made concerning them reflect, in part, the moral principles and qualities of virtue that encompass their *own* lives (Zeidler, et al., 2005, p. 359). Students are not thinking *about* controversial issues and deciding what *should* or *should not* be done under a notion of macromorality (Rest, et al., as cited in Zeidler, et al., 2005, p. 359). They engage in the resolution of socioscientific controversies in a level of micromorality: their emotions alongside their beliefs are considered as important in the decision-making procedure. From these perspectives, socioscientific issues may be equated with the consideration of ethical issues and construction of moral judgments about scientific topics via social interaction and discourse (Zeidler, et al., 2005).

Actually, this could be described as the main difference of this framework from the others. It positions the resolution of the issues in the micromorality rather than in the macromorality mode, giving a place to the emotive belief systems of the child under a psychological, and not a "fallacy" ground. As Zeidler, et al. (2005) cite:

> *"Once this distinction is made, it exposes a more robust conceptualization of the complex relationship that exists between moral reasoning and action and has implications for decisions related to pedagogy." (p. 363)*

The framework is psychologically grounded: as there is empirical evidence suggesting the importance of emotions in the resolution of SSI (Zeidler & Schafer, 1984; Sadler & Zeidler, 2004), an emotion-based morality and care (Belenky, et al., 1986; Gilligan, 1987; Noddings, 1984 as cited in Zeidler, et al., 2005, p. 365) emotions should not be left out of scientific decision making. Additionally, the framework questions the Kohlbergian paradigm, which suggests that emotive decision-making represents inherently underdeveloped moral reasoning, citing a piece of research that indicates that evaluative distinctions among emotive and other forms of reasoning in terms of students' decision-making adequacy were unfounded (Zeidler, et al., 2005, p. 365). The dichotomy of emotion and rationality is questioned, as individuals might rely on emotions for the resolution of SSI, but that informal reasoning based on emotion is often equivalent to strictly cognitive approaches to decision making in terms of logical constructs such as internal consistency and coherence (Sadler & Zeidler, 2005).

Consequently, the teacher is not “seeking the truth” but must suspend both his own judgments, and encourage his students to do the same, until arguments are imaginatively and sensitively explored (Elliot, 1973, p.60). Students are called to frame their positions, and consider how belief convictions influence *their* emotions and moral commitments to moral issues. The instruction has a meta-cognitive character that helps students to listen seriously to others and reconsider their views rather than treating the whole event as an elaborate game or contest (Cotton, 2006, p. 238).

Nature of science issues are not only seen as a way of engaging students in authentic science episodes and gaining epistemological understanding, as perceived in Ractliffe’s and Grace’s (2003) knowledge-skills-attitudes scheme, for example, but also as a factor that influences the way in which evidence is selected and evaluated, and is considered to have bearing on students’ pre-instructional views of socioscientific issues (Zeidler & Keefer, 2003, p. 13). Scientific knowledge is regarded as personally relevant and socially shared: it therefore, relies on careful analysis of cases involving considerations of data, evidence, and argumentation that may be in conflict with one’s existing conceptions regarding various socioscientific moral and ethical issues (Zeidler, et al., 2005, p. 370).

Using elements from the previous frameworks, as far as the nature of science is concerned, supporters of this framework assume that individuals who progress through the higher stages of moral development, make decisions with perspectives more distant from the primitive reliance on an immediate authority figure, even if this figure is science. Students should have the skills to judge the merit of scientific activity and discovery independent of the authority the name carries (Sadler & Zeilder, 2006, p.280). While this seems contrary to what would count as scientific literacy, according to the framework of “science education for citizenship”, the authors argue that they are not trying to recommend that the aim of science education should be to tear down science. They are however, suggesting that students should be given the opportunity to free themselves from blind reliance on science, an ability that requires moral skills (Zeidler, et al., 2005, p. 358). That’s why they suggest that moral issues connected to science, such as the discussion of historical instances when the power of science was over-used or abused, should be explored within science classrooms (Sadler & Zeidler, 2006, p. 263).

Comparing this framework to the others, I detect a main difference: the framework is not established on the grounds of citizenship, science, or moral education, but is rather established on psychological grounds of how all those elements could contribute to the development of the child under a “functional scientific literacy”. Under scientific literacy several elements like the moral development of the child, epistemological and cognitive development along with student’s feelings and personal values are brought together, in a single framework. The effort is not to move students to one or another direction, but to engage students in self reflection procedures: this line of thought better fits to the argument that the role of education should be to encourage independent thought and not to promote a specific world-view, moral or scientific (Aldrich-Moodie & Kwong, 1997 as cited in Cotton, 2006, p.68). However, this argument would strongly be challenged by those who support the view that science education should promote the science view of the problem, thus promoting the scientific, thoughtful thinking, whereas supporters of the moral development would also argue that self reflection procedures might drive to an endless relativism and would never have an impact on the moral development of the students.

An additional level where this framework could be problematic is the selection of a didactical proposal that could fit under its philosophical description. Having all those elements co-existing in a single framework creates questions as to how NOS issues and cognitive reasoning/development could go alongside moral development, while respecting emotive belief systems. No one assumes that all these elements could be found in a single lesson. However, how all these elements might co-exist in a single lesson, remains an issue. As the proposals of this framework cite:

> *"It would seem, then, that opportunity to engage in informal reasoning through argumentation allows for the evaluation of evidence as well as thought, but finding appropriate pedagogical strategies to seamlessly integrate such dynamic social interaction in the science classroom remains a high priority." (Zeidler, et al., 2005)*

Summarizing this chapter, I would suggest that the notions for implementing controversial issues in the science curriculum have common but also conflicting elements. Teaching controversial issues in science education is set under different perspectives that describe different pedagogical outcomes from their instruction. Those perspectives, though overlapping, are sometimes conflicting in a multileveled and multilayered construction. Different views of the relationship and status of science and society impose different descriptions of the nature of socioscientific issues and assign different tools that a citizen should hold for the participation in the discussion and decision making about those issues. Additionally, different perspectives about science education in general create different relationships between socioscientific issues education and science education.

The notion of including controversial issues in the curriculum, as a distinct area that uses science education to achieve socioscientific education in the light of citizenship education, raises questions about the place of the curriculum where those subjects should be elaborated and the impact in science curriculum that such a notion holds. On one edge, one can see the humanizing of the science curriculum- using controversial issues *for* science education- and on the other the scientific literacy of the public in order to be able to engage in thoughtful decisions about controversial issues: the use of science for the resolution of controversial issues. Both edges share similar but also conflicting elements. Finally, there are views that perceive controversial issues as a pedagogical method that could contribute to the functional scientific literacy that includes beyond cognitive and moral development, the exploration of emotional belief systems of the child.

2.3 Argumentation as a process

This sub-chapter aims to provide an overview and discussion about different perspectives for analysis and evaluation of argumentative talk, outside classroom settings. It also aims to critically use this literature to support an analysis scheme, the typology of argumentative dialogues (Walton & Crabbe, 1995), which has finally been used for the analysis of classroom talk regarding the description of the dialectical context that was created by the discussion of a socioscientific issue.

The definition of the dialectical context has to be related to argumentation theories, since the nature of the issues and the talk performed in the classroom had an argumentative nature. A first distinction among definitions that argumentation theorists provide is that of process and product. Some definitions refer to "argumentation" or "argument" as the process of arguing, which is defined accordingly in different disciplines. Others refer to the product of the process, the "argument", which rests on a different level as a construct, than the discussion that has generated it, does.

Definitions of argumentation as process and product should not be seen as conflicting but rather as complementary (Walton & Godden, 2007). Endorsing this view, we study argument as a complex process, called *argumentation* and situate *argument* as one of the products within this process, or outputs of the process. Studying argumentation as a process was the method that had provided the means to describe the dialectical context of the study. The conceptualizations about argumentation as a process are presented below.

2.3.1 The beginning of argumentation: A question or doubt: The disagreement space

Aristotle in his Rhetoric suggests that rhetorical talk consists of three distinct parts: the issue, the arguer, and the audience.

All dialogues arise from a problem, difference of opinion, or question to be resolved that has two sides that constitute the issue of the dialogue (Walton, 1989, p.10). Those arguing have a position about whatever the subject (issue) that is being argued is (Bricker & Bell, 2008). The conflict or difference (stasis) that is the origin of the argument could be of different kinds: it could be a conflict of opinion, an unsolved problem, an unproven hypothesis, or even a situation where both parties are blocked from further actions they are trying to carry out (Walton, 1990, p.412).

Those definitions use the terms, “thesis”, “view”, “difference of opinion”, and “standpoint” related to the “issue”. Mbasakos (1999) places all those entities in a “disagreement space”. If we set the “issue” in “space” then to take a standpoint and argue to back a thesis, means to “view things from a specific perspective”, as we do for every object in a related physical space. Respectively, if we accept that there are many such perspectives to view an object, what has been gained from taking a “position” towards the object, loses a perspective taken from a different “stand’, “thesis” or “position” (Mbasakos, 1999, p.15). It is remarkable that all those words - stand, thesis, position - represent where we physically stand towards an object, whereas the “view” has a meaning of what can we actually see from where we stand. It is also remarkable that the same meanings are found in both languages, English and Greek.

The agents and their standpoints towards the issue construct the "disagreement space". As Van Eemeren and Houtlosser (2000) cite "the disagreement space is a structured set of possible standpoints associated with an act, issue" (p.5).

The disagreement space constitutes therefore the "place" where the communicative event of argumentation takes place. At the same time though, the definition of such a space defines accordingly the nature of argumentation as a dialectic practice (Leitao, 2000a; Mbasakos, 1999). Since a position determines the angle and the way that someone views the issue, an argument is by definition defensible (Mbasakos, 1999). Respectively, the discipline of dialectics is distinguished from that of analytics since it is defined from the possibility to stand on the other side and therefore, argument is classified as being different from that of syllogism or proof (Mbasakos, 1999, p.15).

Furthermore, disagreement serves as a means of identifying argumentation. Argumentation requires that at least two opposite positions be distinguished, which are dialectically construed as the position of a proponent and that of an opponent (Leitao, 2000a). As Van Eemeren et al. (2002) cite "an analysis of argumentation must begin by identifying the main difference of opinion" which arises when one party's standpoint meets with doubt from another party (p.5).

Consequently, the notion of standpoint is one that draws a distinction between argumentation and other forms of discourse, such as explanation, elaboration, and clarification (Van Eemeren, 2002 as cited in Bricker & Bell, 2008, p.481). Explanations, elaborations, and clarifications are used when discussing matters that are already accepted, whereas argumentation is "always brought to bear on a standpoint that has not yet been accepted" (Van Eemeren, et al., 2002, p. 43). Therefore, to identify a passage and classify it as an argument, as opposed to different speech acts like explanation, or from different kinds of discourse like informative discourse one has to draw a distinction on the basis of how the proposition put forward has been advanced as part of the dialogue (Walton & Godden, 2007, p.7; Goldman, 1994, p.31).

2.3.2 The agents

Argumentation involves, by definition, two parties: a proponent and an opponent; an arguer and an audience, real or potential (Leitao, 2000b; Rieke, et al., 2008). The term “audience” is used to include all argumentative situations ranging from interpersonal interaction between two people to talk radio or chat rooms on the Internet, from readers of letters to the editor to those who watch C-SPAN (Rieke, et al., 2008). ”Audience” might include entities such as a person, or an unspecific addressee - whether an institution, a body of beliefs, or the universal audience (Perelman & Olbrecht-Tyteca 1969). There are even cases where the audience is a “virtual other”, which represents an internal construction who anticipates some of the reactions which might come from an external audience (Leitao, 2001, p.333).

In a larger scale, where the “controversy” as a social phenomenon takes place, “spheres” of people are the agents of argumentation. Spheres, according to Rieke et al. (2008) are collections of people in the process of interacting upon and making critical decisions within which rules of interaction were developed and enforced, values were established, acceptable reasons were identified, and the appropriate decision makers emerged over time (p.5).

The dialectical roles of proponent and opponent in argumentation are described in terms of their commitment to their initial position. For pragma-dialectical theory, for example, the proponent is expected to advance a viewpoint and to defend it against counterarguments and the critical questioning raised by the audience, who takes the role of opponent (Leitao, 2000a). Not all perspectives though assign proponents and opponents such a static role. Elements of argumentation might be modified in many ways: new actors (human or otherwise) may be introduced, others may be discarded, positions may change, more resources may be rallied to increase support for or to refute a claim (Fountain, 1988, p.122). Argumentation is seen therefore, as a form of discourse that has a unique potential to set off processes of changes in view (Miller, 1987 as cited in Leitao, 2000b).

Additionally, the roles of proponent and opponent depend on the nature of the dispute. Not all disputes have an asymmetrical case where one party puts forward a claim, and the other party questions it (Walton, 1990, p.412). If the other party is not only doubtful but adopts an opposing standpoint then the difference of opinion is mixed, and if there is more than one proposition involved, the difference of opinion is multiple (Van Eemeren, et al., 2002, p. 3). As a result, proponents' and opponents' roles are interchangeable.

2.3.2.1 Argument: In dialogue or not?

A first issue that comes up as we define the agents of argumentation is the role of dialogue as a prerequisite for the existence of argumentation. How can argumentation be explained in cases that the "other" provides arguments to an audience that is not there to refute its position?

Argumentation only exists as a form of exchange between an arguer and an audience who prompt each other's discursive actions (Leitao, 2000a). In the case of the "virtual" anticipation, the audience anticipations are raised by the proponent, and thus confronted.

Walton (1990) defines dialectical reasoning, as opposed to monological, as the interactive reasoning that occurs where “there are two participants reasoning together and the reasoning of each participant contains steps derived from the reasoning of the other” and, accordingly, assumes that the reasoning that occurs in argument can be called dialectical reasoning (p.412). However, it is not clear whether this reasoning always takes place in dialogue. If we accept this definition, then reasoning about others’ possible anticipations and arguing about them, could be classified as dialectical reasoning.

Goldman (1994), on the other hand, describes this type of argumentation as a non-dialectical one. According to his definition, this type of talk occurs when one party asserts a proposition that according to the informer might not suffice to apprise or convince the audience of its truth and therefore does not only assert it, but backs it up with reasons or grounds as well. What is performed then is a “reasoned-backed” assertion which Goldman classifies as a type of informative rather than argumentative discourse (p.30).

The difference between Walton (1990) and Goldman (1994) rests on the unit of analysis: Walton deals with reasoning. Accordingly, he defines reasoning as dialectical when possible anticipations are taken into account. On the other hand, Goldman refers to the discussion; dialectical includes two parties and thus a single party that backs its assertions is seen as arguing “non-dialectically”.

The issue of defining argumentation as situated in dialogue, or not, is important for the purposes of this study, as the mode of talk in which students and teachers are engaged defines the context in which different entities come up. Taking this discussion into account we might conclude that argumentation could be dialogical or monological - in a discussion level, but always dialectical in a reasoning level - it always needs disagreement.

2.3.3 Goals of participants and typologies of dialogue

Argument is a social operation, which is oriented to context and to purpose (Mork, 2000). The notion of argumentation, as cited in pragma - dialectics, is a goal-directed form of interactional activity and entails both the content of argumentation and the discourse structure within which it evolves, which are sensitive to the goals the arguers pursue in specific contexts (Van Eemeren, et al., 1987 as cited in Leitao, 2001; Walton, 1990, p.411).

According to Costello and Mitchell (1995) an argument can be understood as a means for diverse goals: to put forward a position in preference to others, to discover, a perhaps shared perspective, to arrive at a decision, to publicize, to persuade and to win (as cited in Mork, 2000). There is however, an issue that highly concerns any kind of argumentative talk analysis: if argumentation is defined by the presence of a standpoint that has to be defended, a self standing goal, how can discovering a shared perspective be argumentative? Or how can arriving to a decision be understood in terms of defending a position or a decision? I will leave this question open, and try to refine the aspects that relate to its answer by looking at different classification schemes about types of argumentative and non-argumentative talk.

Walton (1990, p.390) describes different types of argumentative talk, by providing a classification scheme based on the goals on argumentation and the initial situation that has sparked the dispute (see table 2).

Type of Dialogue	Initial Situation	Goal	Benefits
1. Critical Discussion	Difference of Opinion	To Convince Other Party	Understand Positions Better
2. Debate	Adversarial Contest	Persuade Third Party	Clarification of Issue
3. Inquiry	Lacking Proof	Prove or Disprove Conjecture	Knowledge
4. Negotiation	Conflict of Interest	Maximize Gains	Settlement and Consensus
5. Planning Committee	Collective Action Required	Joint Plan or Decision	Airing of Objections
6. Pedagogical	Ignorance of One Party	Teaching and Learning	Spread of Knowledge
7. Quarrel	Personal Conflict	Hit Out Verbally	Venting of Emotions
8. Expert Consultation	Need for Expert Advice	Decision For Action	Second-hand Knowledge

Table 2: Eight types of argumentative talk (source: Walton, 1990, p. 390)

This typology has been based on the initial situation, the goals of the participants and the benefits that could be described as the "desired outcome" of the dialogue.

2.3.3.1 Critical discussion-persuasion dialogues

In a critical discussion, the analysis starts from the assumption that the difference of opinion is approached in a reasonable way and that "those involved are assumed to view it as an occasion for overcoming doubt or opposition and expect each other to deal with this doubt or opposition by advancing reasonable arguments" (Walton, 1990; Van Eemeren & Grootendorst, 1992). However, this is an ideal construction since the pragma-dialectical model of a critical discussion is, in fact, a description of what argumentative discourse would look like if it were solely and optimally aimed at resolving a difference (Van Eemeren & Houtlosser, 2000), a situation that does not fit always in what happens in a real argumentative discussion.

Additionally, even if arguments are put down in order to convince a “reasonable critique”, any interlocutor aims at getting the best of the discussion: as a protagonist he aims at persuading the antagonist of the acceptability of his standpoint while an antagonist will try to convince the protagonist to withdraw from defending his standpoint (Van Laar, 2006). The issue that arises is clear: how can the goal of persuading another party, the rhetorical aspect, be compatible with a discussants’ commitment to reason?

Walton and Krabbe (1995) in their typology of dialogues have solved this problem by adopting the term “persuasion dialogue”, a broader term that might include critical discussion in an ideal situation, thus being able to create a descriptive and not normative typology of dialogues.

2.3.3.2 Expert consultation and pedagogical talk: argumentative?

Expert consultation and pedagogical talk are referred as “types of argumentative talk” but not as types of “dialogues”. Walton (1990) has assigned to pedagogical discussion and expert consultation an argumentative character since the teacher has access to knowledge and his role is to impart that knowledge to the student and accordingly, a layperson consults an expert in a skill or domain of knowledge in order to obtain advice on a decision or a problem (p.414).

It is not easy though, based on these definitions, to justify pedagogical talk, or expert consultation as argumentative, since there is no opposition apparent in the procedure of pedagogy or expert consultation either. Pedagogical talk might be described best as explanatory or as “non-dialectical”, “informative discussion” as

Goldman (1994) defines it, which gets the form of argument, as the informer grounds a proposition based on an impression of possible refutation from the audience (p.31).

As Walton (1992, p.112) cites in a later work on classification of types of dialogue, this classification is not complete and the types of dialogues do not all rest on the same level ; actually some are subtypes of others (p.111) (see Figure 2).

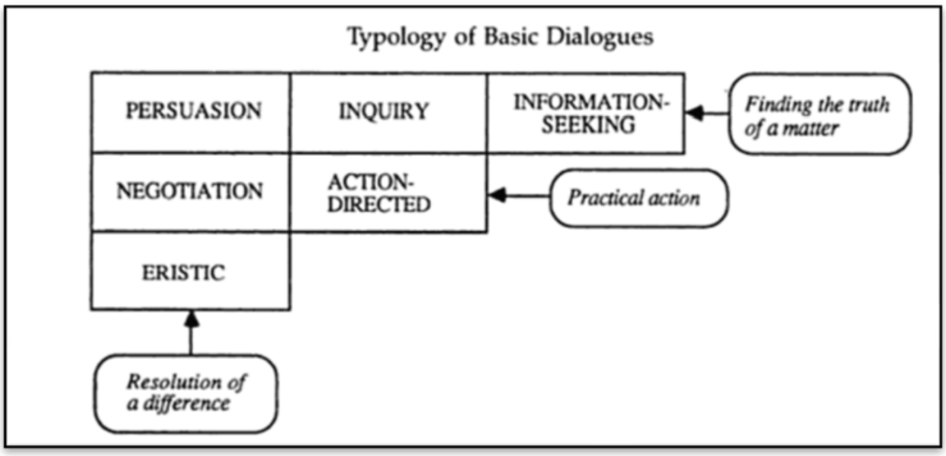

Figure 2: Typology of basic dialogues (source: Walton, 1992, p.112)

Walton, in this later work defines as “argumentative dialogues” only persuasion, negotiation and eristic dialogues that aim at the resolution of a difference. An eristic dialogue starts from an antagonism and the goal of each party is to defeat the adversary (Walton and Krabbe, 2005, pp. 76-79).

He argues that “in some types of dialogue, argumentation is the main function that holds the thread of dialogue together and gives it its special character as a type of dialogue, whereas in other types of dialogues, argument is peripheral - it is not the main engine that moves the dialogue along (Walton, 1992, p.111).

According to this new classification, pedagogical talk, or expert consultation and interview are classified as information seeking dialogues, where one participant seeks the answer to some question(s) from another participant, who is believed by the first to know the answer(s) (Mc Burney & Parsons, 2002).

2.3.3.3 Persuasion, rhetoric and argumentation

The issue that has been stated in the very first paragraphs of this subchapter is still there: Walton (1992) classifies persuasion dialogue as one that aims to resolve the difference and to arrive at truth, whereas he does not assign any need for truth in negotiation or eristic dialogues.

However, there is a view that persuasion, or rhetoric as an art of persuasion, is incompatible with truth providing. The first level of objection rests on the goals of the participants. The criticism of rhetoric as synonymous with the act of persuasion and its incapability of providing truth is not new. A man who uses rhetoric appears to have something to hide and uses his talk for selfish aims and unjust purposes (Nichols, 1987, p.657). Socrates, who has carried Aristophanes' criticism of rhetoric to philosophic grounds, has argued that rhetoric is not based on the truth (Nichols, 1987, p.658). Rhetoric in this sense is not a means to convey knowledge; it is rather a tool used by those who would distort the truth for their own purposes (Van Eemeren & Houtlosser, 2000).

In the other edge of rhetoric as seeking for truth, one might locate negotiation, in which the goal is not to show that a proposition is true or right, based on evidence, but the goal is to “get the best deal” (Walton, 1990, p.414). The goal of negotiation has nothing directly to do with finding the truth or with defending or maintaining one’s principles. It is outright self-interest (Walton, 1996b, p.187). The same stands for quarrel (eristic dialogues) where the goal is to hit out verbally at the other, a procedure that is characterized by an almost total absence of logical reasoning and by heightened emotions (Walton, 1990 p.414).

Aristotle (Rhetoric*)* has defended rhetoric and its relation to truth and reason, but Kennedy (1991) in his writings distinguishes two types of rhetoric: one making moral and logical demands on a speaker and one looking more towards success in debate (Kennedy, 1991 as cited in Van Eemeren & Hootloser, 2000). Rhetoric therefore, is not a practice that uses any available mechanism of persuasion, but as Siegel (1995) states “argumentation - whatever else it may be - is aimed at the *rational* resolution of questions, issues and disputes” (as cited in Driver et al, 2000, p.292). However, this definition of rhetoric is a normative but not a descriptive model of persuasion discussion, as I have already mentioned.

As Aristotle (Rhetoric) says “by appealing to anger, envy, and pity, rhetoricians move the judges to the decision that they desire, but allowing judges to decide cases on such a basis, is like measuring something with a crooked ruler (as cited in Nichols, 1987, p.659). However, if the ideal of an art of persuasion is rhetoric, as described by Aristotle, persuasion is not, because it is practised by real interlocutors and not ideal ones.

The second level of objection relating to persuasion as a means of arriving to truth deals with the incompatibility of the goals of the participants in terms of reasoning procedures. Even if we accept that persuasion dialogue can be performed as an agreement between two ideal interlocutors, who are knowledgeable, reflective, open and dialectically acute (Goldman, 1994, p.35), we still cannot explain how one might persuade about a position and still be seeking the truth for that position. As Scott (1965) cites, “it would be absurd for anyone who begins with the attitude that he possesses "truth", to embark on any genuine enterprise of cooperative critical inquiry" (p.15).

Supporting this line of reasoning, Mbasakos (1999) suggests that dialectical argumentation does not form any new syllogism and those who argue do not learn anything new from the reasoned process of providing premises to support a claim. "Dialectics does not produce truth; it already knows it with different ways and from different sources. It uses logic though, not for seeking the truth, but to convince" (Mbasakos, 1999, p.31) It is questionable, therefore, to assign "finding the truth" as one of the goals of persuasion dialogue. Since persuasion deals with issues of beliefs and actions and not only issues of fact, arguments used in philosophical discussion are not proofs but means to help someone see things he had not noticed before (Levison, 1964, p.261).

How can then truth be created or grasped? One way to accept Walton's (1992) view of persuasion as seeking for "truth", in other words regard persuasion as epistemic, is the following: as Scott (1994) assumes, when the speaker and the audience open themselves and exchange views, they come to an understanding that is different from either's beginning position. In that sense no absolute "truth" is defined, rather than knowledge contingent on the experiences of the community. This description is even compatible with theories that accept that such a "truth" exists and is held partly and differently by members of the community.

As Aristotle demonstrates, there is no "common opinion", for common opinion is composed of different and even contradictory viewpoints. Those viewpoints however, in different ways grasp some elements of the truth (as cited in Nichols, 1987, p. 669).

If we accept this view of persuasion as truth seeking (but not necessarily truth providing) we have to distinguish between two phases of persuasion: the first refers to “when the speaker and the audience open themselves and exchange views” (Scott, 1994), and support views, we would add, and when because of this process they change their views, “in an attempt to find a fit among one’s beliefs, other individuals’ beliefs, and the problem solving task at hand” (Laudan, 1984 as cited in Zeidler, 1997). This is not a linear process. It might not even be conceptualized by the participants: “skilled argument” as a product of discussants, moves in some directions and has goals of its own beyond the roles of individual participants (Berelter, 2002 as cited in Kuhn, 2007, p.115).

The issue stated at the beginning of this chapter - if arguing about a position and inquiring are compatible- seems to be resolved in a micro-level and macro-level of analysis of persuasion, or argumentation as a means of persuasion: in a local, micro-level the context is argumentative-persuasive, if a proponent cites a position and supports it.

However this act might be performed in a macro-level context, where possible positions might be collected, analyzed and evaluated within the aim of arriving to a “common best conclusion”. In this case, the role of the argumentative process is to encourage and explore alternative interpretations (perspectives), even in a monologue where a single “discussant” takes alternative views and cites conflicting arguments in an effort to arrive at a decision.

This process though, seems to resemble inquiry or deliberation rather than persuasion. In this sense, argumentation is a form of inquiry: both individually and collectively, then, people advance their interests and objectives through argument and in the process enhance their knowledge, either intentionally or not. (Kuhn, 2005, p.113)

The discussion above might convince one in the direction of accepting persuasion dialogue as one that might “seek for truth”. However, the relationship between inquiry and argumentation-persuasion needs further exploration if they are going to be classified as different types of dialogue.

2.3.3.4 Inquiry

Inquiry is a “hierarchical procedure of reasoning where the premises are supposed to be better known or established than the conclusion to be proved from them” (Walton, 1990, p.414), and consists of a cumulative type of dialogue. What makes inquiry differ from persuasion dialogue is the absence of the conclusion, the position, as a pre-existing entity that drives the discussion. In a persuasion dialogue an opinion is expressed from the beginning and the goal is to “prove” that one opinion is more plausible than another, whereas the inquiry is based on an initial position, but the position here has a certain degree of lack of knowledge that must be overcome (Walton, 1990, p.415). This definition of inquiry draws the distinction line between inquiry and argumentation.

For a dialogical exchange to turn into genuine argumentation, the participants must propound and justify their viewpoints while leaving room for these views to be examined in the light of the opposing claims and critical questions posed by the audience (Van Eemeren & Grootendorst, 1992; Freeman, 1991 as cited in Leitao, 2001). Therefore, since argumentation is defined and distinguished from other types of talk from the presence of opposition, inquiry cannot be described as an argumentative - persuasion talk, as opposition is not evident, at least in the beginning stages of it.

Another difference between inquiry and argumentation for persuasion is evidential priority, for the inquiry "is strongly directed toward deriving conclusions from premises that can be well established on solid evidence whereas in persuasive dialogue the best one can hope is plausible commitment to an opinion based on reasoned (but not conclusive) evidence" (Walton, 1989, p.7). This difference of inquiry and argumentation for persuasion is therefore attributed to the factual nature of inquiry: inquiry is a knowledge building procedure. Therefore, inquiry seeks out proof, or the establishment of as much certainty as can be obtained by the given evidence. However, argumentation seems to be a part of a factual inquiry.

Inquiries come up to explanations that are presented to a community of peers so they can be critiqued, debated, and revised (Driver, et al., 2000; Duschl, 2000; Sandoval & Reiser, 2004; Vellom & Anderson, 1999 as cited in Sampson & Clark, 2008, p.450). In this sense, the knowledge building process becomes a persuasive process through which scientists attempt to persuade others of the validity of their claims. Within the process scientists build arguments that are informal, material, contextual, and controversial (Prelli, 1989, p.5 as cited in Bricker & Bell, 2008, p.482) and are criticised through standards of reasonableness (versus the truth of argument) as well as through what community will count as claims in the first place (Bricker & Bell, 2008 p. 482). The acceptance of explanations in scientific domains therefore, is based not only on logical or empirical criteria but on whether an argument is capable of persuading other members of the community (Forman et al, 1988).

This view of inquiry situates argumentation within inquiry. There are scholars who state that this view of argumentation is not compatible with its persuasive nature, citing that argumentation in this sense is used to solve problems and advance knowledge (Duschl & Osborne, 2002) rather than as an effort to justify or refute a standpoint (Van Eemeren, Grootendorst, & Henkemans, 2002, p. 38 as cited in Sampson & Clark, 2008, p.456). In this line of reasoning, Meiland (1989) cites that argumentation for the purposes of inquiry, differs from argumentation for the purpose of persuasion in two ways:

1. Argumentation for persuasion usually does not develop objections to the position or to the arguments given to it, but if one's purpose is inquiry, one must consider objections; otherwise, one will not create a sufficiently severe test of the argument in question (p. 188).
2. In inquiry, one might reach no conclusion about the position or hypothesis being investigated - one might find good reasons from both sides or enter a really complex investigation- but such a situation would not be possible in a case of persuasion. In persuasion, the conclusion which is the focus of the persuasion has been identified first, and the whole point of the process of argumentation is to establish that conclusion (p.189).

Meiland (1989) tries to defend the view that although persuasion is a purpose of argumentation on some occasions, we must recognize that argumentation can and does have the purpose of inquiry (p.185). How can this be compatible with the "position defending" definition of argumentation? The "level" distinction, mentioned earlier, that could explain how discussants can argue but also arrive at "truth", is one that explains how discussants can do this intentionally. Discussants hold beliefs about minor sub-issues and use arguments to evaluate and process those issues in order to arrive at an unknown position. In this case what is to be defended is not the major issue at hand, for which there is still no answer, but other issues. Arguments, therefore, represent the substance of what is conveyed by the community and as

Yerric (2000) cites "constructing arguments is about the journey not the final destination" (p.814).

What happens though when the issue at hand is not factual? How can inquiry be performed in a policy issue? How can deliberation be considered as inquiry?

2.3.3.5 Planning committee and deliberation

Walton and Krabbe (1995) define deliberation, as a special type of dialogue, as shown in table 3 below.

TYPE	INITIAL SITUATION	MAIN GOAL	PARTICIPANTS' AIMS	SIDE BENEFITS
1. Persuasion Dialogue	Conflicting points of view	Resolution of such conflicts by verbal means	Persuade the other(s)	Develop and reveal positions Build up confidence Influence onlookers, Add to prestige
2. Negotiation	Conflict of interests & need for cooperation	Making a deal	Get the best out of it for oneself	Agreement, Build up confidence Reveal position Influence onlookers Add to prestige
3. Inquiry	General ignorance	Growth of knowledge & agreement	Find a "proof" or destroy one	Add to prestige Gain experience Raise funds
4. Deliberation	Need for action	Reach a decision	Influence outcome	Agreement Develop & reveal positions Add to prestige, Vent emotions
5. Information-seeking	Personal Ignorance	Spreading knowledge and revealing positions	Gain, pass on, show, or hide personal knowledge	Agreement Develop & reveal positions Add to prestige, Vent emotions
6. Eristics	Conflict & antagonism	Reaching a (provisional) accommodation in a relationship	Strike the other party & win in the eyes of onlookers	Agreement Develop & reveal positions Gain experience, Amusement Add to prestige, Vent emotions

Table 3: Typology of dialogues (source: Walton and Krabbe, 1995, p.66)

The planning committee (a term that has been replaced by deliberation in latest typologies of Walton & Krabbe, 1995) type of dialogue, often involves logical reasoning and persuasive debate (Walton, 1989, p.425). However, Walton (1989) regards it as a different type of argumentation since the conclusion reached through this type of dialogue should use practical reasoning by reaching agreement on common goals and the best means to implement them (p.414). Goldman (1994) does not agree that a discussion aiming at a consensus can be a critical discussion since, if a consensus was the sole aim, norms of argumentation should discourage argumentation appropriate to upset a pre-existing consensus (p.33).

The persuasive nature of deliberation is evident since the best course of action for a group may conflict with the preferences or intentions of each individual member of the group. Additionally, not every single participant has all the information required to decide what is best for the group (Mc Burney & Parsons, 2002).

However, as Meiland (1989) supports, deliberation might resemble inquiry when a group of people get together to come to a conclusion, with none of them initially having any belief of which he or she wants to persuade the others (p.189). Even if this situation is ideal as Meiland (1989) admits, and might be applicable in cases of inquiry purely for the sake of knowledge, it might even happen in cases where groups come together to try to solve a problem. The process is described as follows:

> *"In such cases, perhaps no one persuades anyone or tries to do so, but people do become persuaded in the course of the discussion. It might even happen that one person gives an argument which he does not believe and with which he is not trying to convince anyone - he gives it perhaps as an argument which should carry little weight, just to get that argument out of the way - but which in fact convinces another person." (Meiland, 1989, p.200)*

Lucaites, et al. (1999) seem to endorse this view of deliberative rhetoric as inquiry: deliberative rhetoric is a form of argumentation through which citizens test and create social knowledge in order to uncover, assess and resolve shared problems (p.251). In this sense deliberation is an inquiry process for solving social problems: argumentative endeavours characteristically involve, among others, the creative resolution and the resolute creation of uncertainty (p.250). Deliberation does not hold the conclusion from the beginning and it might not hold it even in the end of the process, because, even if the reasons tested were good or bad reasons, one might never be sure whether we have discovered and tested all the relevant arguments (Meiland, 1989, p.193). The basic steps of an argumentative process of inquiry, according to Meiland (1989) are as follows:

- Determining a question or problem to be inquired into;
- Formulating a hypothesis or position on the question or problem;
- Constructing an argument for the hypothesis or position;
- Developing objections to the argument for the hypothesis or position;
- Devising replies to these objections (p.187)

One objection to this view of deliberation would be the fact that in our lives we reach most of the judgments we make without deliberating on them at all (Wright, 1995) and thus, we are sceptical to the claim that one could enter a deliberation without holding any belief about an issue. Actually, we perform judgments before deliberating. However, if we do deliberate even after an initial "blind" judgment, deliberation acts as a form of reflection (Meiland, 1989, p.569). Meiland (1989) also assigns to this type of reflective deliberation the nature of inquiry: one might conduct inquiry into beliefs that he already holds. The process of inquiry in this case aims at testing those beliefs by testing the reasons one does or can have for having those beliefs (p.192)

Summarizing the discussion so far we might conclude that:

- Inquiry as a process that seeks "truth" as an existing entity, or as a community constructed entity, includes argumentation.

- Argumentation can be used both to persuade, but also seek the "truth". Because of argumentation people come to the "truth" as they share viewpoints that grasp different parts of it, or collectively construct it.
- Argumentation about inquiry is different than persuasion, as it considers objections and does not hold the conclusion from the beginning.
- Argumentation about inquiry rests in a lowest level related to the inquiry issue at hand.
- Inquiry is not restricted to factual issues, but could be used for solving social issues: in this case deliberation can be regarded as a form of social inquiry.

After those issues clarified I suggest that Walton's and Krabbe's (1995) typology of dialogues (table 3) could be used to grasp the dialectical context of the study, since it entails elements that could describe argumentation as a process: the agents of the process and their goals towards the discussion. Furthermore, the application of the typology is extremely helpful for identifying and analyzing argumentation.

Actually, the selection of Walton's and Krabbe's (1995) typology of argumentative dialogues was a mutual interaction between relevant literature and instances from classroom data, and as will be further elaborated in the data analysis and results chapters, this typology has been broadened so as to include other categories that had emerged.

Another issue that had to be elaborated though was one of analyzing the products of argumentative process, the arguments. The conceptualizations used for perceiving arguments as products are elaborated below.

2.3.4 The products of argumentation

Argument is defined as a piece of reasoned discourse, a product, which consists of something linguistically expressed through a set of statements of which at least one is offered as a justification for another (Leitao, 2000a, p.333); a set of propositions founding a text of discourse; a series of premises one of which is chosen as the conclusion while the others represent premises logically supporting that conclusion (Walton & Godden, 2007, p.6; Walton, 1990, p.408).

2.3.4.1 Argument as syllogisms

Aristotle defines a syllogism as a discourse in which, certain things having been laid down, something different from the things laid, down follows of necessity in virtue of the fact that these are the case (as cited in Kolbel, 2008). Certain things that are laid down are the premises and the different element that comes out is the conclusion which follows those premises. One classic example of a syllogism is:

Major Premise: All men are mortal

Minor Premise: Socrates is a man

Conclusion: Therefore Socrates is mortal

In this sense an argument is a type of syllogism, since the premises that construct an argument are put down, and the product-claim that comes out of them is different than the premises that have constructed it. In its simplest form an argument needs a conclusion, a claim. This claim is supported at least by one premise (Freeman, 1991).

Arguments as syllogisms are classified on different criteria. According to the relationship between the premises and the conclusion, arguments could be classified as serial, divergent, linked or convergent (Freeman, 1991, p.2) (see Figure 3).

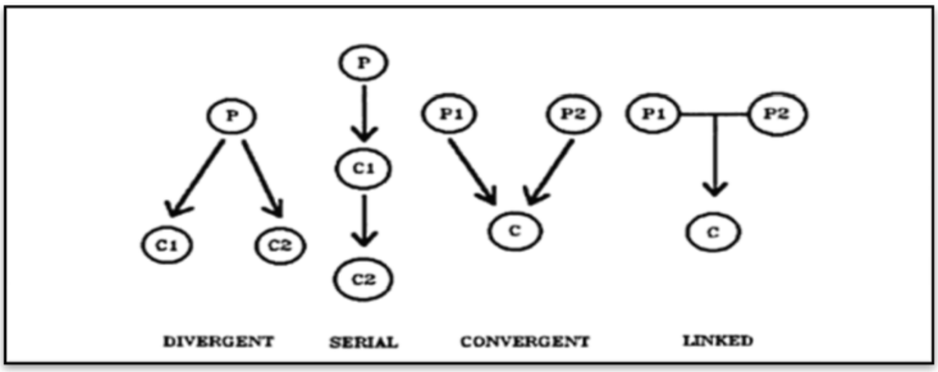

Figure 3: Types of arguments according to the relationship between premises and conclusion (p: premises, c: claim) (source: Freeman, 1991, p.2)

Convergent and linked arguments are types of single arguments, whereas serial and divergent refer to relationships between arguments. Where several premises are required together to support a claim argument structure is referred to as ‘linked’, and where multiple premises act independently, the structure is referred to as ‘convergent’ (Reed, et al., 2007, p.88). Accordingly, when two claims share the same premise, their relationship is referred to as ”divergent” whereas when one claim becomes a premise for a second one, their relationship is described as “serial”.

2.3.4.2 Form of arguments: Arguments as probative

Logic is the field that studies the evidential relations between premises and conclusions (Jason, 1994, p.15). The argument is analyzed in terms of how premises are capable of supporting the conclusion or vice versa, what is to be tested is arguments’ capability to provide truth, given the truth of the premises. In this line of reasoning, arguments are probative types of talk, and what is to be tested is how they preserve, or provide “truth" (Leontsini, 2006). Arguments are classified as deductive, when the truth of conclusion is probable, inductive, when the conclusion is possible and abductive when the conclusion is plausible given the premises.

In a deductively valid argument, if the premises are true, the conclusion must be true, meaning that the conclusion follows the premise by deductive validity of the argument (Walton, 1989, p.110). Validity is a conditional concept: it is the relationship between the truth or falsity of the premises of an argument and that of the conclusion (p.117).

The validity of an argument is judged on whether one produces the correct syllogistic form in accordance with the governing rules of formal logic (Bricker & Bell, 2008, p.477). Evaluation of arguments as valid or not, depends on the forms they have, according to their logical structure. Examples of such argument forms are Modus Ponens (If A then B, A., Therefore, B.), Modus Tollens, (If A, then B, not A, Therefore, not B), Hypothetical syllogism (If A then B, If B then C, Therefore, if A, then C), Disjunctive Syllogism (Either A or B, Not A. Therefore, B) (Walton, 1989, p.118), Categorical Syllogisms (All A's are B's, All B's are C's, Therefore, All A's are C's) (Copi & Cohen, 2007). Apart from categorical, hypothetical, categorical and disjunctive syllogisms, arguments based on mathematics or other axiomatic disciplines, or arguments based on definition of a term are forms of deductive arguments. Inductive arguments are distinguished from deductive arguments by the fact that they lack the ability to guarantee their conclusions (Hughes & Lavery, 2004, p.197).

The conclusion, given the premises of an inductive argument, is probable, and not certain. A functionality difference between deductive and inductive arguments is that the ability of a valid deductive argument to guarantee its conclusion derives from the fact that deductive argument draws out information that is already contained in the premises whereas inductive argument provides conclusions whose content exceeds their premises (Salmon, 1984; Hughes & Lavery, 2004). Inductive arguments are classified by different schemes - arguments from example, statistical generalizations, arguments from effect to cause etc (Salmon, 1984).

Peirce (1990) has introduced a third type of argument, in terms of "truth preserving": abductive arguments. He uses the following examples (Peirce, 1990, as cited by Flach, 1996, p.2) to show the difference between deductive, inductive and abductive form of arguments:

Type of arguments	**Truth preserving (as cited by Walton, 2001 p.142)**	**Example from Peirce (1990 as cited in Flach, 1996 p.2)**
Deductive	In a deductively valid inference, it is impossible for the premises to be true and the conclusion false.	All the beans from this bag are white. Those beans are from this bag. Therefore, those beans are white.
Inductive	In an inductively strong inference, it is improbable (to some degree) that the conclusion is false, given that the premises are true.	These beans are from this bag. These beans are white. Therefore, all the beans from this bag are . white.
Abductive	In an abductive weighty inference, it is implausible that the premises are true and the conclusion is false (The abductive type of inference tends to be the weakest of the three kinds).	All the beans from this bag are white. These beans are white. These beans are from this bag.

Table 4: Arguments as probative: deductive, inductive and abductive

This classification though, has little to say about reasoning schemes employed on different occasions. For example, there is a view that induction is not reasoning at all, whereas abduction and induction are (Peirce, 1990 as cited in Flach & Kakas, 2000a, p.3). Even though deduction, induction and abduction are terms that will dominate in the discussion about reasoning and argumentation, they are not enough to capture the complexity of it. Reasoning and argument was a vital issue that has to be elaborated within this study since the description of the reasoning used when forming specific forms of arguments could be used to grasp the epistemic part of the lesson. Section *2.4 (Reasoning and Argumentation: a justification of a typology of argument schemes)* of this chapter is devoted to such a discussion.

However, before the presentation of this chapter I need to refer to another level of perceiving arguments as products: the use of arguments as propositions in a meta-level discussion, an issue presented in the following paragraphs.

2.3.4.3 Argumentative discussions as complex structures: Arguments as propositions

Argumentative discussions are complex constructs. In the simplest case, the argumentation is limited to mentioning one positive or negative effect, but more extensive forms of argumentation provide a detailed consideration of the various advantages and disadvantages of a number of alternatives, in which the feasibility, acceptability and cost of an action are taken into account (Meiland, 1989, p.187). Real debates about war, social security and climate change, for example, never consist of isolated arguments. The central positions of these debates are typically supported or attacked by multiple arguments which in turn are themselves backed or challenged by further arguments (Betz, 2009, p.234).

Subsequently, a position, or thesis expressed as a claim may be linked to a series of other claims that constitute a case. When a claim is used to justify another claim, it is called *a sub-claim* (Rieke, et al., 2008, p.7). This chain of arguments, claims, and sub-claims builds a case which creates for everyday language a third meaning for the term “argument” (beyond that of the process of argumentation and the single product of a syllogism-argument). As Walton (1990) describes, an “argument” is not just a localized step of inferences, but instead, it is a long thread or fabric that runs through and holds together an extended discourse or argumentative text, being a linked sequence of sub-arguments, ranging over even an entire book, for example (Walton, 1990, p.410).

The series of arguments is getting more complicated as attacks enter the debate. An objection, if fully stated, is an argument, and so is each reply: objections and replies are themselves arguments, meaning that each objection and reply can become the beginning and the focus of new lines of argumentation which (when the purpose of argumentation is an inquiry) aim at testing the strength of the objection or reply in question (Meiland, 1989, p.187).

Wooldridge et al. (2005) refer to two widely used notions of attack as found in the field of logic: the *rebuttal* (where the conclusion of one argument is logically equivalent to the negation of the conclusion of the other) and *undercutting* (where the conclusion of one argument is logically equivalent to the negation of some element of the support) (p.46). Toulmin's (1958) view of rebuttals however includes undercuttings for warrants, as he regards as rebuttals arguments that defeat the conclusion, the applicability of the warrant and the authority of the warrant (as cited in Erduran et al., 2007, p.65).

Verheij (2005) however, even broadens the term of rebuttal and cites five different types of rebuttal using Toulmin's (1958) argument structure: an argument against the datum, an argument against the claim, an argument against the warrant, an attack on the connection between data and claim, and finally, an attack against the warrants' applicability (Verheij, 2005, as cited in Erduran et al., 2007, p.64.) The different types of attacks are shown respectively in the Figure 4 (c: claim, w: warrant, r: rebuttal, d: data).

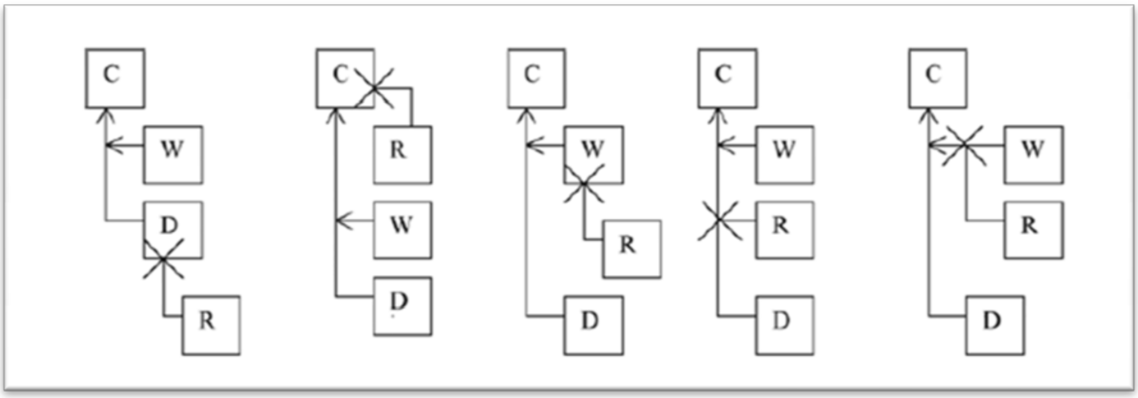

Figure 4: Kinds of rebuttals (source: Verheij, 2005 as cited in Erduran et al, 2008, p.64)

Erduran et al. (2008) note that all the statements (data, warrants) can be considered as claims in themselves; what makes them rebuttals is that they are positioned to be data or warrant relative to the main claim that creates a force for the generation of the subsequent elements, thus being considered as “nested”: data of one argument counts as a claim for another argument (p.58).

One issue that comes up in such nested arguments is the calculation needed for determining the force of support or rebutting of a single claim, given the initial thesis which has sparked the dispute. Additionally, as the discussion moves further, there is a possibility of one contradicting even his or her own self. As Betz (2009) cites:

> *“Given such a variety of conflicting, supporting and attacking arguments, can the central thesis still considered be well justified, or true? Supposed I wanted to claim t, what else would I have to maintain in order not to contradict myself? Is my position coherent in the light of all these arguments at all?” (p.284)*

Interlocutors seem to develop several mechanisms for dealing with such a complexity. One such mechanism is to use meta-statements describing the “position” in the discussion where they are: when discussions are lengthy, meta-statements serve monitoring functions, such as summarizing where the person "is" in the argument, planning where the person is "to go," and question asking, which is an information gathering or clarification function (Voss, Greene, Post, & Penner, 1983 as cited in Means & Voss, 1996, p.143).

A more sophisticated “economy” mechanism is one of transferring arguments to the level of propositions. Instead of referring to argument as reasons and the view that they are given to support, we refer to arguments as the reasons alone (What is your argument for that view?) (Wright, 1995, p.565) When arguments are treated as propositions calculation is enhanced. The process is described by Wright (1995) as follows:

> *“We regularly ask for arguments, give them unsolicited, complain of their lack or about their quality, and weigh them in making up our minds. We may denounce a view as unreasonable or irrational if its holder has no argument to give for it.”(p.565)*

This process is referred to argumentation theory in the context of evaluation of criticism of arguments: argument evaluation can be done seriously only if one gives reasons supporting the claim that evaluates the argument. Such an evaluation is an argument about argument: it is a meta-argument (Finocciaro, 2007).

The level of treating arguments as propositions is defined as a “meta-dialogue” and it is distinguished from forming arguments at a first place, which is defined as a “ground level” one. Krabbe (2003) accordingly names as a “ground level dialogue” any dialogue that is not a meta-dialogue (p.641).

The notion of meta-argumentation is better established in the branch of computer science that studies argumentation and reasoning. Wooldridge et al. (2005, p.46) describe a meta-arguments hierarchy as presented in Figure 5:

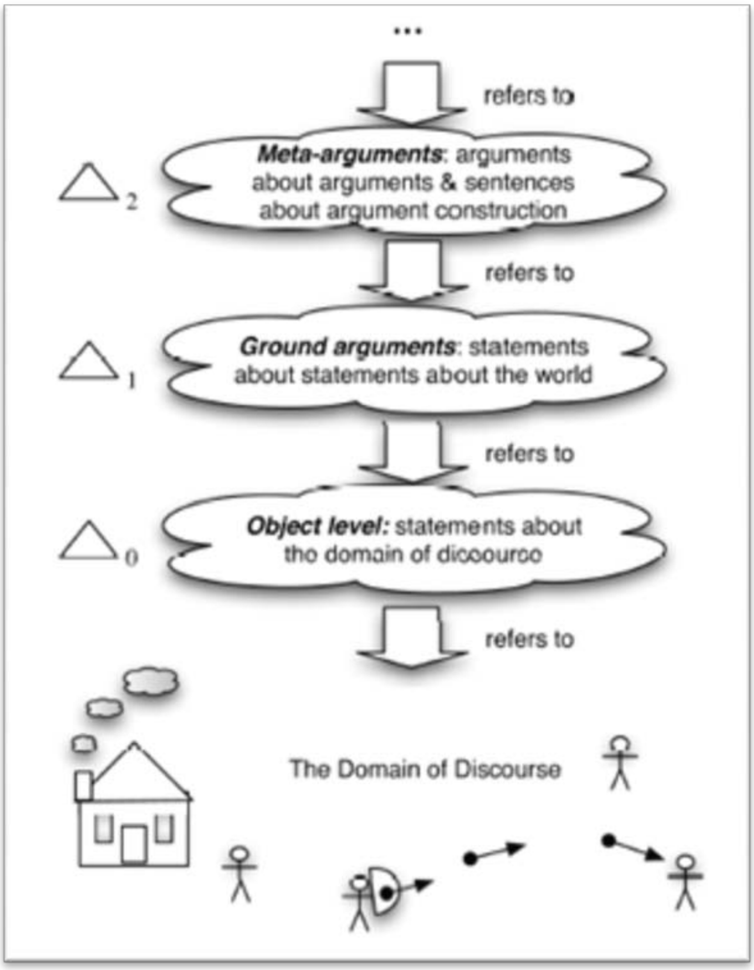

Figure 5: A hierarchy of arguments (source: Wooldridge et al. 2005, p.46)

The hierarchy is explained by Wooldridge et al. (2005, p. 46) as follows.

Level	Description
Object level Δ0	Does not contain arguments at all. It consists of statements about the domain of discourse and defines interrelationships between the entities Example of legal setting: *Δ*0 (object level) consists of the established facts of the case, (such as evidence that may be introduced), as well as non-logical axioms about the domain.
Ground Arguments Δ1	Arguments exist for the first time as first class entities of the hierarchy. They consist of a conclusion and some supporting statements, with a logical consequence between them. At this level also, we can make statements that are about object-level statements, for example, we can assert that a particular structure represents an acceptable argument
Meta Arguments Δ2	The main construction used in Δ2 is that of argument referring to an argument. Properties of arguments that involve referring to the axioms or procedures via which we in fact establish that they are arguments may be captured in this level of argumentation.

Table 5: A hierarchy of arguments (source: Wooldridge et al., 2005)

Meta-arguments therefore, argue about arguments: they argue about them as being valid or invalid, fallacious or not, good or bad (Finocchiaro, 2007, p.456). Relating this discussion to the relationship between argumentation and inquiry, one might place the processes of inquiry of discovering arguments that are relevant to a position as belonging to the ground level. Accordingly, when those arguments are criticized for their strength or weakness of those arguments we proceed to the level of meta-argumentation.

The conceptualizations cited above are helpful for describing the dialectical part of a lesson. However, as arguments are extracted as products of the talk one needs to analyze them in terms of content so as to gain information about the reasoning behind the argument and the epistemic practice performed. The next part of this chapter deals with this issue: to find a way to describe reasoning alongside epistemic practice that is performed when agents of the discussion cite down different forms of arguments.

2.4 Reasoning and argumentation: a justification of a typology of argument schemes

The purpose of this subchapter is to justify the use and modification of Schellens' (1985) typology of arguments as an efficient tool that has been used to describe epistemic practice performed in the lessons and the rejection of other relevant typologies found in the literature.

The effort is not to list all typologies; it is rather an effort to capture elements from typologies - since classification of argument schemes show striking similarities, use common sources (Whately, 1965 as cited in Garssen, 2001, p.94) and have influenced one another. Those elements are to be criticized under moral and scientific reasoning theories, and be used to create a coherent argumentation scheme that could effectively serve the purposes of this study: capture and describe different types of reasoning - moral, cognitive-scientific, emotional-that might occur in a socioscientific discussion. By doing so I adopt Blair's (2001) account of "no correct" typology, but also Garssen's (2001) account that "a typology is theoretically adequate if it lives up to the goal it is designed to serve" (p. 94).

2.4.1 Arguments as products of reason

Arguments capture many types of inference mechanisms, and combine to form chains of reasoning (Moulin, et al., 2002, p.185). Reasoning in argumentation has been described under different classification schemes by several scholars (Hastings, 1963; Schellens, 1985; Van Eemeren & Grootendorst, 1992; Freely & Steinberg, 1965/2008; Walton, 1996, 2008). Blair (2001) has stated that since systems of classification are relative to their purposes there can be no "correct" typology of reasoning schemes, and the only pertinent question is whether any particular classification successfully or optimally fulfils its purpose (as cited in Godden & Walton, 2007, p.240).

When we extract arguments as products of argumentation we actually treat them as products of reason. Reasoning, in a comprehensive definition, can be defined as a "mental activity that consists of transforming given information, called the set of premises, in order to reach a conclusion" (Galotti, 1989, p.333 as cited in Cole Wright, 2004). Some other definitions broaden this one by including the making or granting of the premises as part of the procedure: "Reasoning is the making or granting of assumptions called premises (starting points) and the process of moving toward conclusions (end points) from these assumptions by means of warrants." (Walton, 1990, p.402) In this sense one might assume that reasoning is identical to forming arguments. However, reasoning can be used in different speech acts, or contexts of discourse and thus “argument” and “reasoning” are conceived as non-equivalent terms: reasoning is used in argument (Walton, 1990, p.403) and arguments are defined as “the intentional explication of the reasoning of a solution during its development or after it” (Krummheuer, 1995, p. 231 as cited in Forman, et al., 1988).

2.4.2 Distinction between Theoretical and Practical Reasoning

A very first distinction of reasoning in arguments rests on the level of theoretical reasoning on one hand, and utility (Kincannon, 2003 as cited in Cole Wright, 2004), practical (as cited in Thornton, 1982 p.59; Walton, 1989, 1990), pragmatic (Schellens, 1985), or instrumental (Van Eemeren & Grootendorst, 1992) reasoning on the other.

The distinction rests on the nature of the conclusion: inference and reasoning are regarded as psychological processes leading to possible changes in belief (theoretical reasoning) or possible changes in plans and intentions (practical reasoning) (Harman, 1986). Theoretical reasoning, therefore, is concerned with what we ought to believe, whereas practical reasoning is concerned with figuring out what we ought to do; it seeks out a prudential line of conduct for an agent in a particular situation (Thorpe, 2008; Wallace, 2003 as cited in Cole Wright, 2004, p.23; Walton, 1990, p.405; Aristotle as cited in Thornton, 1982 p.60).

Aristotle affirms that the conclusion of the practical syllogism is an action. By citing this definition he is not contrasting action with choice, but the practical with the theoretical:

> *“When the two premises are combined, just as in theoretical reasoning the mind is compelled (ananke) to affirm (phanai) the conclusion, so in practical reasoning one is compelled at once to do it (prattein)” (as cited in Thornton, 1982 p.59).*

Not all typologies infer to pragmatic argumentation as a distinct category. One of the reasons for doing so is that they use as the criterion of their classification the type of the warrant from premises to conclusion, instead of the nature of the conclusion. For example, Freeley and Steinberg (1965/2008, p.175-177) include examples of practical reasoning as analogical reasoning, or reasoning by example, categories that can both be applied to theoretical reasoning as well. Pragma dialectical theory (Van Eemeren & Grootendorst, 1992) does not concern arguments that point to an action as different from theoretical ones, as their classification criterion refers to the process of how each scheme is to be evaluated: causal relationships are evaluated differently than symptomatic relations for example. Pragma dialectical theory actually reconstructs pragmatic argumentation as a type of causal argument in the case of a means end practical syllogism, and as instrumental when it comes to reasoning from consequences.

Hastings (1963), on the other hand, includes pragmatic argumentation in his scheme as a case of argument from definition, from principle to application. Even if elements of such considerations might be included in a typology of pragmatic argumentation, I have two main reasons for including pragmatic argumentation - practical reasoning- as opposed to a theoretical one, in a higher level hierarchy - a distinction made by Schellens' typology (1985):

1. Practical reasoning does not deal with matters of fact and their explanation, but with matters of value, of what it would be desirable to do (Wallace, 2008). When agents think practically they also think of themselves doing the action. Since desires are interfering, the kind of reasoning implemented gets complex. Actually, there is not a consensus among scholars which inference mechanisms are implemented in different types of pragmatic argumentation;

even if practical reasoning is propositional in expression, there is a complication in describing the inference behind the syllogism as identical to it. There are even views that confront the existence of “reasoning” when referring to pragmatic argumentation.

For example, Hume (1973) argues that since our passions, volitions and actions are not susceptible to any agreement or disagreement either to the real relations of ideas, or to real existence and matter of fact, they can never be the object of our reason (as cited in Mintoff, 1998). An extended discussion about the place of reason and passions in moral practical judgment can be found in Appendix A of this study. Theoretical conceptualizations regarding moral reasoning had indicated that there is a disagreement about the place of reason when actions are involved. Practical judgments, moral or not, cannot be classified alongside theoretical ones since they entail beyond cognition, emotion and volition as well. Given this disagreement, the safest path to take is to assimilate practical “reasoning” as a different category than theoretical reasoning.

2. Scientific reasoning, either deductive, inductive, causal, analogical etc, is a type of theoretical reasoning. It deals with facts and explanations of facts (Wallace, 2008). If we understand theoretical reasoning as concerned about questions of explanation and prediction of facts, we have to distinguish it from pragmatic argumentation that deals with values, desires and passions. One of the purposes of this study deals with such a distinction: situating socioscientific discussion about an action to be taken, within science education that includes, among others scientific reasoning, which is a type of theoretical is reasoning. A classification scheme that does not distinguish between practical or theoretical argumentation but classifies them as "causal" or "analogical" reasoning, like pragma dialectical theory, will need further elaboration to determine the scientific thinking that takes place. For methodological alongside epistemological reasons, therefore, this study distinguishes pragmatic from theoretical argumentation in a first level classification system of argument schemes.

Since among different typologies that have been studied (Hastings, 1963; Schellens, 1985; Van Eemeren & Grootendorst, 1992; Freely & Steinberg, 2008; Walton, 1996, 2008), Schellens' typology is the only one that makes a distinction between pragmatic and theoretical reasoning argument schemes, this study has taken Schellens' typology as the departure point for argument schemes used for analysis. Both the typology and the modifications made are presented in the following paragraphs.

2.4.3 Argument schemes for practical reasoning

In his typology of reasonable argument forms Schellens (1985) distinguishes between two types of pragmatic argumentation, based on the role of the consequences of the behaviour: one relates to the *probability* of consequences and the second in the *desirability* of the consequences. Schellens and De Jong (2004) recognize another type of pragmatic argumentation in which the desirability of the behaviour is considered separately from its consequences; the behaviour in this case can be advocated on the basis of an appeal to rule-based argumentation in which the conduct is judged on the basis of one or more relevant rules of conduct.

Practical reasoning therefore, is found in three types of syllogism that can be reconstructed as three different types of argument schemes: means end syllogism, reasoning from consequences and rule case syllogism. Each type of syllogism-scheme represents different worldviews and philosophical considerations regarding practical and moral reasoning. The following paragraphs further explore those three practical argument schemes.

2.4.3.1 The structure of a means-end syllogism

Reasoning that is based on the *desirability of the consequences* resembles what Aristotle defines as a means-end syllogism: practical reasoning (deliberation, bouleusis) starts from an 'end' which is wished for (boulesis) and terminates in a choice (proairesis). The action chosen is the agent's starting point in attaining, or partly attaining, the “end” (as cited in Thornton, 1982, p. 52). What an agent happens to want constitutes his ends; reason then calculates how those ends are to be achieved (Price, 2008 p.2).

If we reconstruct this type of reasoning as a syllogism, then the major premise of the practical syllogism indicates that the agent desires something, has a goal, wish or desire (Aristotle actually cites that the agent desires something that is “good”). The minor premise of the syllogism indicates a way in which this desire may be realized (Thornton, 1982 p.58). The conclusion of a practical inference states that the agent ought (practically) to carry out the action cited in the second (minor) premise (Walton, 1990).

We might represent this pattern of reasoning, which is called “instrumental”, or teleological (Thorpe, 2008), ta pros to telos, (Aristotle, as cited in Thornton, 1982 p.58) as follows:

> *“1. Promote end E.*
> *2. Action A promotes end E.*
> 3. *Perform action A.”* (Thorpe, 2008. p.161),

or in an example:
"1.I should be healthy (goal, end)
2. If I take this medicine, I shall be healthy (means)
3. *Therefore, I should take this medicine (conclusion)" (Thornton, 1982 p.56)*

The relationship between the means and ends varies. Walton (1990, p.407) describes two types of practical inference: a necessary-condition scheme and a sufficient condition one, as shown in the following syllogisms (where a is an agent, A is an action, and G is a goal):

Necessary condition practical inference

G is a goal for a.
Doing A is necessary for a to carry out G.
Therefore, a ought to perform A.

Sufficient condition practical inference

G is a goal for a.
Doing A is sufficient for a to carry out G.
Therefore, a ought to do A."(Walton, 1990 p.407)

2.4.3.1.1 Means end and theoretical reasoning

Means end is an "instrumental" type of reasoning, one of calculating which means would bring us the desired end. However, it is not a theoretical type of reasoning: instrumental reasoning is practical in the following basic sense: it tells us what to intend, not just what to believe (Brunero, 2005). However, there are several instances of theoretical reasoning that could either enable the calculations performed for this kind of reasoning, or act as supporting or countering such reasoning.

Thorpe (2008) makes a useful distinction between theoretical and practical forms of reasoning when running a means end syllogism. Deciding whether specific means are ways of realizing ends, and whether they are sufficient or necessary for those ends, requires reasoning that is distinguished from practical reason. When a person runs a means end syllogism, she figures out what she ought to do; however, when figuring out what the case is and which actions further realize a given goal, end or desire, she actually calculates: she reasons in a theoretical level. An example of such a calculation is one of an economist who can figure out whether tax cuts better distribute the wealth without having any interest in acting on this information (Thorpe, 2008, p.161).

2.4.3.1.2 Means end and moral reasoning

In a means end syllogism, the end to be promoted can be viewed as connected to a moral principle (Cole Wright, 2004). In this sense, pragmatic argumentation of a means end type might not be sufficient for persuasion by its own: it needs to be supplemented by other forms of argumentation such as ethical argumentation referring to the desirability of the course of action from an ethical perspective (Feteris, 2008, p.492). Ends therefore, have to be situated in a system of principles and be supported in a process of rule based argumentation in which it is argued, on the basis of an evaluation rule, that the end is desirable (Jan Schellens and De Jong, 2004). As Aristotle argues:

> *"He who persuades must show that those things to which he exhorts are just, lawful, expedient, honourable, pleasant and easy of accomplishment. Failing that, when he is exhorting to that its execution is necessary…It is for these qualities …that those who seek to persuade or dissuade must look."*
> *(Aristotle, as cited in Kock, 2006 p.254)*

Kock (2006) assumes that by doing this Aristotle provides a useful warrant typology for practical reasoning. The categories that Aristotle actually uses are the following:

1. Just (dikaia)
2. Lawful (nomima)
3. Expedient (sympheronta)
4. Honourable (kala, or "noble")
5. Pleasant (hedea)
6. Easy of accomplishment (rhaidia) (as cited in Kock, 2006)

Apart from moral evaluation of the end, the means could be set under moral evaluation also; in this sense a means end syllogism could be regarded as moral by itself, if the principle "The end justifies the means" is applied. In this sense, if a means end syllogism has to be evaluated for its morality it would be classified as consequentialism since the morality of an action is evaluated through its consequences.

In the cases that this principle is not applied, then alternative means might be put under moral evaluation for selecting the action which is less morally problematic.

What is concluded from the previous paragraphs is that means end reasoning, a kind of practical reasoning, represents a moral stance, consequentialism - by its own - if it is used to justify the morality of an action - but might be also be the starting point for evaluating ends and alternative means.

2.4.3.2 Reasoning from consequences

In argumentation from consequences, a position on the desirability of a given action is advocated on the basis of its advantages and/or disadvantages (Schellens, 1985, pp. 153-178; Walton, 1996, pp. 75-77 as cited in Jan Schellens & De Jong, 2004 p.299).

This kind of reasoning involves an attempt to decide what will be the wisest choice as far as the future is concerned, but as the future is never certain, practical reasoning involves presumptions in the form of hypothetical guesses about consequences of the action under deliberation (Walton, 1990b p. 139). Walton (1996) regards this type of reasoning from hypothesis or supposition to the consequences, as a modus tollens kind of deductive inference:

> *"If you the respondent bring about A then B will occur.*
> *B is a very good/bad outcome, from your (the respondent's) point of view (or desirable/undesirable, as constructed by Van Schellens and De Jong, 2004).*
> *Therefore, you (the respondent) should not bring about A."*

When reasoning from negative consequences it is evident that this type of reasoning is different from means end syllogism; however it is not easy to distinguish between means end syllogism and reasoning from consequences when the consequences lie on the positive side of the issue. For example, how could we decide if a certain consequence is an "end", by what means can we tell if the conclusion refers to the desirability but not to the probability of behaviour?

Pragma dialectical theory, actually, does not set clear boundaries between those two, as it reconstructs reasoning from consequences as a syllogism based on a causal relation: it is argued that a particular action X is desirable or undesirable because it "causes" certain desirable or undesirable effects (Van Eemeren & Grootendorst, 1992). From a pragma-dialectical perspective, therefore, the basic form of reasoning from consequences is similar to a means end syllogism causal scheme that can be represented as follows:

> *"1. Action X is desirable*
> *1.1.a Action X leads to Y*
> *1.1.b Y is desirable*
> *Underlying this scheme is also the following implicit premise:*
> *1.1c 'if action X leads to Y and Y is desirable, then action X is desirable" (Feteris, 2008, p. 493).*

Feteris (2008) assumes that reasoning from consequences can be distinguished from means end syllogism from the way consequences are presented. The argumentation can be analyzed as teleological (means end, desirability of behaviour) if the consequences are presented as the attainment of a particular goal, whereas it could be reconstructed as a policy argumentation, (policy based on consequences) if those consequences are presented as the implementation of a particular policy (p.491). Reasoning from consequences therefore, could be distinguished from the warrants in the argument scheme. Aristotle, for example, refers to two types of warrants for practical reasoning:

1. Predicable warrants (dynata)
2. Necessary warrants (anagkaia) (Kock, 2006, p.254)

Predicable warrants, we could say, refer to consequences; i.e. what would have happen if the action has to be taken. This type of syllogism would be classified as reasoning from consequences. Necessary warrants, on the other hand, refer to means end syllogism as has been elaborated in the previous paragraphs.

2.4.3.2.1 Reasoning from consequences as moral reasoning

Reasoning from consequences might be classified as a utilitarian type of moral reasoning. This type of syllogism might be reconstructed as a rule case syllogism, where the rule (warrant) that connects the premises to action is a principle of utility (Thorpe, 2008, p.163). In that sense, the moral worth of an action is determined by its contribution to overall utility.

However, since the principle of utility is not the only rule that guides moral thinking, reasoning from consequences might lead to moral argumentation regarding the moral status of consequences. Apart from deciding whether a consequence is possible or not, agents have to establish whether a consequence is desired or not (Feteris, 2008). As a result, they might be engaged in a kind of substantive reasoning aiming to relate the consequence to moral principles, laws and duties. This kind of reasoning might take the form of explanation of attitude, when what is elaborated is not the consequence's moral status, but the agents' preference for it.

2.4.3.2.2 Theoretical and moral reasoning for argument from consequences

Statements about the probability of a consequence (If you bring A then B will occur) may be supported by sub-argumentation in the form of argumentation from cause to effect, in which it is argued on the basis of one or more causal links that the predicted effect is likely to occur (Jan Schellens & De Jong, 2004). The hypothetical nature of reasoning from consequences, is evident: for our actions to be justified by their ends (consequential logic), it must be certain not only that the ends are right and good but that they would be right if they increased the good and furthermore that they occur with certainty (Pavlovic, et al., 2009). Certainty of the consequences however, is always under question and might lead to sub-argumentation with the purpose of establishing such a certainty.

When agents reason from consequences in a dialogue, they rarely base their decision on a single consequence. Usually, a number of consequences, presented as pros and cons are considered and evaluated in order to lead to a decision. Extensive forms of argumentation from consequences provide a detailed consideration of the various advantages and disadvantages of a number of alternatives, in which the feasibility, acceptability and cost of an action have to be taken into account. This kind of reasoning involves both a kind of moral, normative reasoning where consequences are evaluated and weighed, but also a kind of instrumental reasoning which actually calculates the "overall utility". As Sosa (1993) defines consequentialism:

> *"It is right for S to A (S ought to do A or S should do A) if no total state of affairs that would be a consequence of S's doing any alternative to A would be better than the total state of affairs that would be a consequence of S's doing A." (Sosa, 1993, p.101)*

This "total state of affairs" is not easily available to the agent. It is an entity that has to be calculated; and this is a kind of instrumental, theoretical reasoning, that actually calculates the overall situation, given the possible consequences of an action. This level of argumentation, according to Wooldridge et al (2005), could be classified as a meta-argumentation. It is a process of reasoning about arguments - in this case consequences - as propositions, trying to weigh, evaluate or even find ways to diminish them by proposing solutions.

This latter kind of thinking, proposing solutions for negative consequences is a type of productive thinking: a type of problem solving technique. The issue is perceived as a problem to be solved and agents propose, produce, possible solutions for it, either to further ground a positive position about the issue, or just solve the problem.

Summarizing, reasoning from consequences, a utilitarian type of moral reasoning, has to be established by theoretical reasoning that establishes the certainty of the consequence, weigh consequences and calculate the "overall utility", whereas moral reasoning might be employed to establish the desirability of the consequences and the definition of their moral status.

2.4.3.3 Rule case syllogism

A first conception of a rule case syllogism is one attached to virtue theories: the action stated in the conclusion does not promote any specific end, other than following the rule expressed in the syllogism. A man is acting virtuously if he chooses his acts for their own sake (Aristotle, as cited in Thornton, 1982, p.60). An example of this type of syllogism is the following:

> *I should be courageous*
> *Courage in this situation consists in not running away*
> *Therefore, I should not run away*

The action of not running away does not lead to any other end, but consists of a "means" to being courageous, thus it is a courageous act chosen "for its own sake" (Thornton, 1982). Accordingly, the type of inference employed in this type of rule, is one of figuring out how one could constrain his/her actions, in the particular case, in the way recommended by the rule, (Thorpe, 2008, p.164) a "rule guided" process, that should be reconstructed as different from a means end syllogism.

As Thorpe (2008) cites, this kind of reasoning is indirectly mediated by rules: the rule plays an indirect or regulative role in the person's reasoning about what she ought to do in particular cases, but the person does not appeal to the rule each time she acts: she rather appeals to it periodically, when she reflects on what sort of person she ought to be or what general sorts of conduct she ought to engage in (p.164).

In a rationalist approach however, rule case syllogism is directly mediated by the rules. According to the rationalist approach, actions are moral insofar as they are the direct result of principled reasoning: one's acceptance of a moral rule/principle must play a causal (inferential) role in the acceptance or rejection of resulting moral beliefs and/or actions or other mental states (Cole Wright, 2004). A rationalistic approach describes a "rule guided" than a "rule-followed" action.

Rule case syllogism respectively, according to a rationalistic approach, can be reconstructed as a deductive form of principle based syllogism. Principle based syllogism, or “from principle to an application of that principle” (we should not kill communists because we are Christians”, (Hastings, 1963, p.49) belongs, according to Hastings, to a kind of reasoning from definition to characteristics: an event or situation is defined in a certain way and, on the basis of this definition, either attributes or characteristics of the event or logical implications are drawn. In the warrant, the consequences or implications of the definition are mentioned.

Another view that confronts this conception of a rule case syllogism for its own sake is a teleological one. According to teleological views, there is no practical reasoning beyond teleological reasoning: a person’s action is goal-directed or teleological, meaning that a person performs that action in order to promote some goal, end or desire. A belief-desire theory of action assumes that we perform the act to implement the rule to arrive at Eudaimonia (Happiness) (Thorpe, 2008 p.157; Thornton, 1982 p.56).

Stocker (1981) counters the teleological view by arguing that it is inappropriate for understanding some forms of intentional action like acts of friendship and courage. Those acts are performed out of or from character, rather than in order to promote the goal of friendship and courage (as cited in Thorpe, 2008).

Conclusively, we might say that syllogisms using rules might be reconstructed as “appealing to rules”, “principle based syllogisms” or as a special kind of “means end” syllogism, according to different views. What is to be kept for an argument typology though, is not the kind of inference employed to such a kind of a syllogism, but actually its content: it is based, one way or another, on a moral rule, and represents a deontological or virtue based moral stance, rather than a consequentialist stance that is represented through a means end or from consequences practical syllogism.

2.4.3.3.1 <u>When principles, rules, aims and consequences are conflicting</u>

Each kind of practical syllogism might give contradicting claims. Agents have to weigh up consequences, rules and aims. When they reason from consequences, for example, agents might be engaged in a type of reasoning in order to choose the "lesser of two evils".

Weighing conflicting claims becomes more complicated when conflicting claims rest on warrants belonging to different dimensions, e.g. honour and utility in the guises of, respectively, bioethics and livelihood (Kock, 2006, p.253). An action, for example, may by "honourable" but not very "expedient" (convenient, useful); it may be "just" but not "lawful"; and so on (Kock, 2006). The difficulty in this case is that of weighing incommensurate warrants on the same scale, as we lack the common measure that will enable us to do this with certainty, necessity and rationality (Kock, 2006, p. 452).

Toulmin (1950) rejects the existence of the universal supremacy of any single principle (as cited in Kock, 2006, p.253). Thus, arriving to a decision goes beyond establishing a moral rule through practical judgment: humans face moral problems that require them to strike equitable balances (Kock, 2006).

According to Simonneaux (2001) there is an order of importance between different warrants. The theory behind this claim, the economics of consensus, or sociology of justification, considers that there are several "worlds" in which action takes place. Those words have different higher principles and orders of importance that are attached to objects of debate. Respectively, consensus in a debate becomes possible when there is a “consensus” on these orders of importance.

Beyond appealing to orders of importance, agents use other resources that can help them weigh alternatives whose weight cannot be measured. Those resources are according to Aristotle (as cited in Kock, 2006, p.452) analogies, opposites, and examples.

This line of reasoning is compatible with Hastings’ (1963) and Schellens’ (1985) typologies of arguments where arguments from example and analogy are defined as not bound to a special type of conclusion arguments: they can both be used to support theoretical and pragmatic argumentation.

Examples that support pragmatic argumentation are what Kock (2006) names as parallel arguments. Instead of universal principles, agents use parallel arguments: they draw on the outcomes of previous experience, appeal to the procedures they used to resolve earlier problems and reapply them in new problematic situations. In the same way they might use analogies, authorities and other ways that might help them arrive to a practical decision.

Summarizing the discussion about arguments that support a practical conclusion we get the following schemes (* indicates free floating arguments that are going to be further elaborated in next sections):

Reasoning scheme	Moral Practice
Means end	Defend an action as a means for another end (Utilitarianism)
From Consequences	Defend an action based on its consequences (Utilitarianism)
Rule Based	Defend an action based on a rule (Deontological)
From Analogy *	Defend an action based on an analogous example
From Example*	Defend an action based on an example
Authority* (Expert, source)	Defend an action based on an authority's prescription

Table 6: Argument schemes that conclude to practical statements

2.4.4 Theoretical reasoning

Theoretical reasoning is oriented to finding reasons for accepting a proposition as true or false (Walton, 1990, p.405). Schellens (1985) classifies theoretical reasoning as occurring in bound argumentation forms - those whose application is limited to a certain type of position or conclusion (as cited in Garssen, 2001, p.90).

The discussion that follows, aims to describe the reasoning behind accepting and modifying Schellens' (1985) typology of theoretical argument schemes, and to connect specific argument schemes with epistemic practices that might locate the interlocutor in the inquiry cycle, as this is described by Klahr (2000) as the SDDS: the Scientific Discovery as Dual Search, a model that describes the process of the establishment of a knowledge claim through hypothesis generation-the hypothesis space- and hypothesis testing –the experiment space. (For more details on SDDS model see Appendix B).

According to Schellens (as cited in Schellens & De Jong, 2004, p. 34) those schemes belong to the "restricted argumentation schemes" and we can distinguish between regularity-based argumentation that is used in support of a descriptive statement about the present, the past or the future and rule-based argumentation used in support of a normative statement about the value of a situation or process. The third type or scheme of restricted argumentation is pragmatic argumentation, described as practical reasoning that has already been elaborated in the previous section of this chapter. The typology is diagrammatically presented in Figure 6 below.

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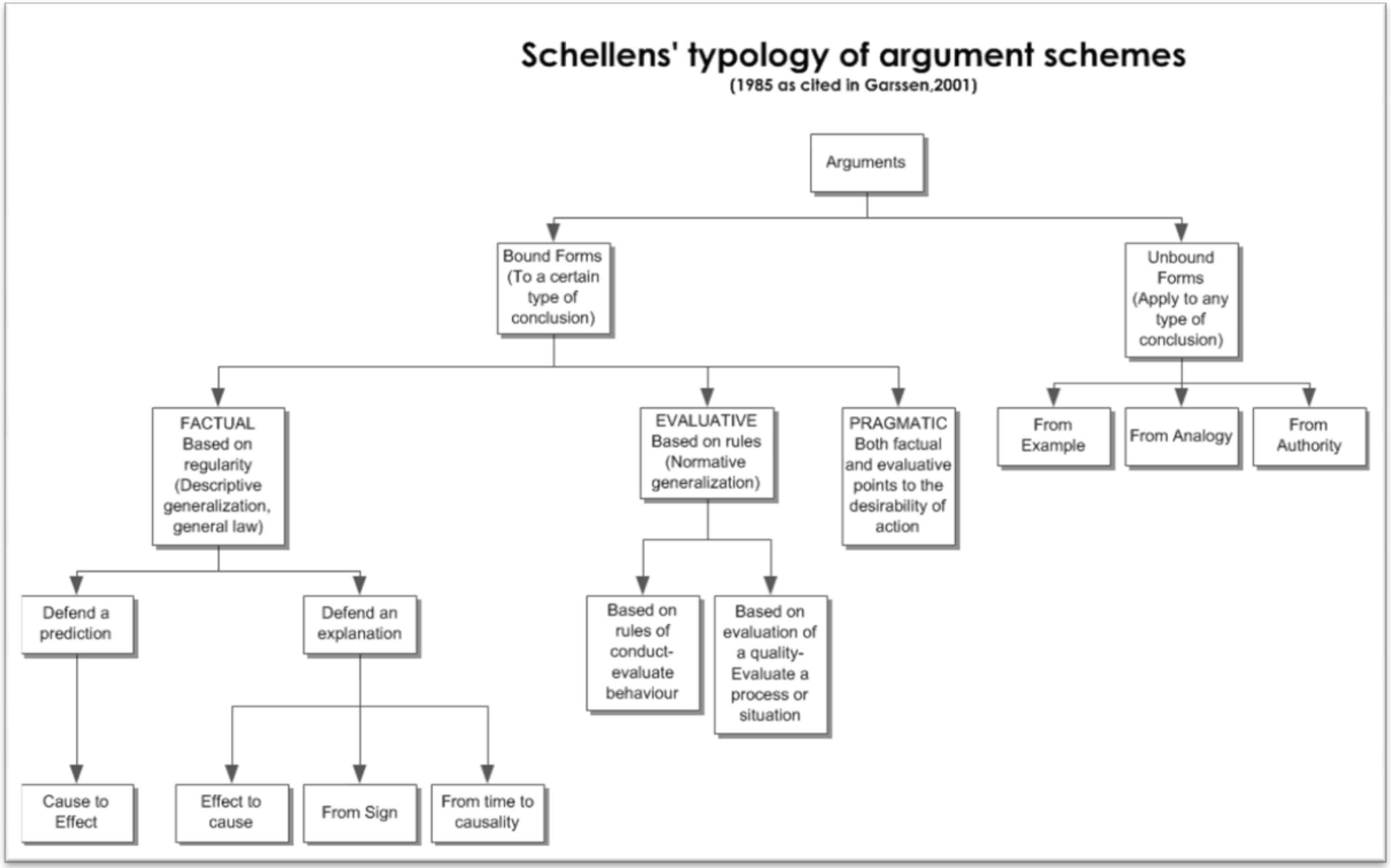


Figure 6: Schellens' (1985) typology of arguments

2.4.4.1 Normative and descriptive statements

A first problem to be addressed, regarding Schellens' typology, is the distinction between normative and descriptive statements, a philosophically questioned distinction. For example, it would be difficult for emotivism (see Appendix A for further elaboration) to draw such a distinction, as it takes the view that value judgments do not actually express judgments or normative statements but they express emotional attitudes or preferences. This view however, is compatible with viewing a normative statement as a factual one, and being subject to truth or falsify as one's sentimental situation.

On the other hand, prescriptivists would not accept a value judgment as a theoretical conclusion capable of being true or false. For prescriptivists, a judgment of the nature "Killing is wrong" expresses nothing but the command "Do not kill!"

Finally, moral realists even if they accept value judgments as being true or false, would not classify them as moral values but as moral facts: for something being good or bad is not a human construction, but a property of facts and entities (Jacobs, 2000, p.141).

The need, however, to draw a distinction between normative and non-normative statements is related to methodological purposes of this study. Either expressing emotional attitudes, prescribe action, or describing a property of an entity, normative statements that are related to morality have to be isolated. This process would enable the description of the moral reasoning that takes place during the lesson- even if this "reasoning" could refer to different things (reflections, prescriptions, descriptions) according to different scholars, as mentioned before. We need therefore to keep a category for moral judgments, that judge a behaviour/action as, expedient, lawful, just, pleasant, honourable, easy of accomplishment etc (Aristotle, as cited in Kock, 2006, p.254). This category could refer to those normative statements that could function as moral practical judgments and be used in a practical syllogism to point to an action.

This line of thinking is compatible with Schellens' (1985) classification of normative generalizations. Schellens (1985) classifies as normative arguments "arguments based on evaluative rules" where something is evaluated by referring to a certain quality, and "arguments based on rules of conduct". In the latter category, which is identical to moral practical judgments, the step from premise to conclusion is legitimated by a rule that states when the measure or step mentioned in the conclusion should be taken; in other words, the action is evaluated according to a rule of conduct (p.96).

Aristotle's category of warrants might provide a further classification of moral evaluation. For example, lawful or fair and just evaluation of action might point to deontological theories of moral reasoning: the evaluation of behaviour in accord with our moral obligation as morally right; behaviour not in accord with our moral obligation as morally wrong (Devettere, 2000, p.17). Accordingly, evaluations of behaviour as pleasant might be classified as indicating hedonism (Bentham, 1948 as cited in Smart & Bernand, 1973) and expedient evaluations as indicating Ethical Egoism or Utilitarianism, that represent Consequalist moral theories (Moore, 1912 as cited in Sinnot-Armstrong, 2006).(see Appendix A for further discussion about moral stances).

2.4.4.2 Descriptive factual statements

Having clarified the normative statements category, by subdividing them into normative arguments based on rules of conduct (moral practical judgments) and normative arguments based on evaluative rules, we proceed with the descriptive factual statements, the third branch of Schellens' (1985) typology of argument schemes.

Summarizing the typology for arguments that have as a conclusion a descriptive statement we might distinguish the following types of reasoning, as shown in Figure 6:

- Defending a prediction
    - *Cause to effect* (defending predictions via causal generalizations, accepted causal laws)
- Defending an explanation
    - *Effect to cause* (from the existence of something that is presented as an effect, something else is inferred as the cause)
    - *Sign* (an observed or known event is taken as an indication of the existence of an unobserved event)
    - *Time to causality* (an argument that defends a causal connection by pointing on the simultaneous appearance of two events)

We might add, according to Schellens (1985), in any place of the list (either defending a prediction or an explanation) unbound argument forms that can support any type of conclusion:

- argument from authority
- argument from example

- argument from analogy

2.4.4.2.1 Arguments defending predictions

Schellens' typology about descriptive-factual arguments, compared to other typologies has a main difference. The classification criterion does not rest primarily on the relationship between the premises and the conclusion (the warrant) but the nature of the conclusion. This is of special interest for this study; forming predictions might point to different epistemic practices than defending explanations, even if they both share a kind of causal reasoning, for example. Causal reasoning that actually is captured by the nature of warrant, does not precisely describe epistemic practice.

Other typologies, like Hastings' (1963) typology for example, are interested mainly in the type of the warrant from the premise to the conclusion, and since the warrant refers to a causal generalization, then the form of the argument is described as "causal" and then classified as reasoning from "cause to effect" or "effect to cause".

Arguments defending predictions, as described by Schellens, are akin to Toulmin's (1958) "warrant using arguments". Toulmin (2003) refers to a category of arguments that are "warrant using arguments" and defines the process of reasoning behind them as deduction. As he cites:

> *"Outside the study the family of words "deduce", "deductive", "deduction" is applied to arguments from many fields; all that is required is that these arguments shall be warrant -using ones, applying established warrants to fresh data to derive new conclusions. It makes no difference to the property of these terms that in step from data to claim will in some cases involve a transition of logical type - that it is - for instance, a step from information about the past to a prediction about the future." (p.112)*

However, not all scholars use the term "deduction" in the same way. For others, like Freely and Steinberg (2008), the word "deductive" refers to the logical form of argument, its probative force: This kind of argument can ensure the truth of the conclusion, given the truth of the premises, compared to inductive ones that cannot do that.

Freeley's and Steinberg's (2008) typology therefore uses the deduction - induction distinction as a primary classification criterion (Figure 7), regarding reasoning from cause to effect as an "inductive form of argument".

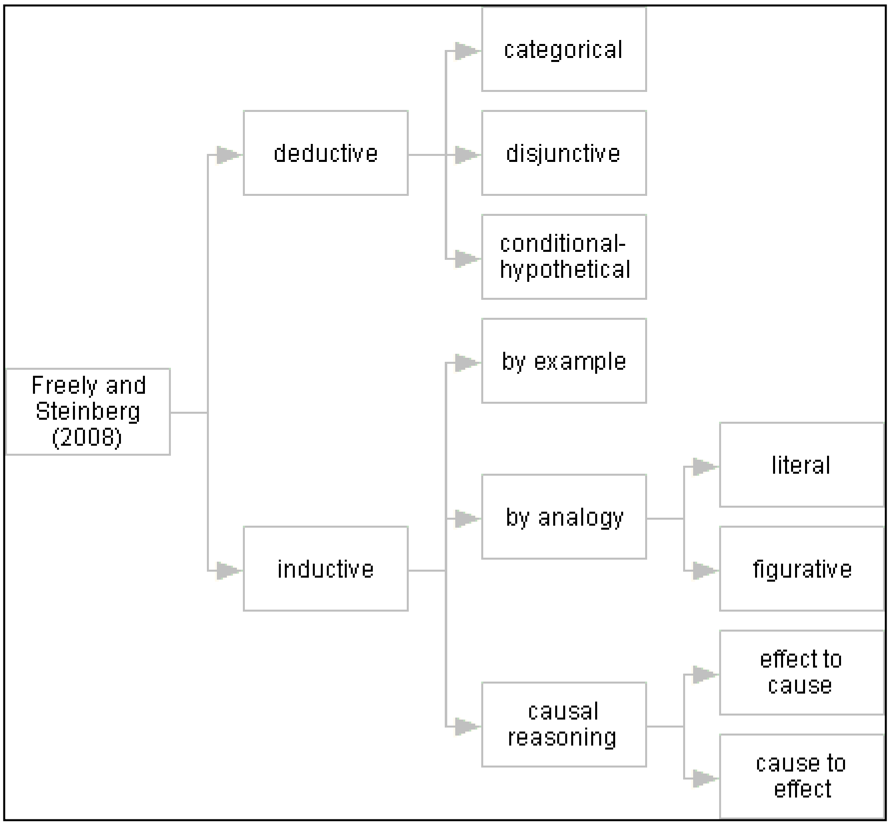


Figure 7: Freeley and Steinberg (2008) typology of argument schemes

How do Freeley and Steingberg (2008) view reasoning from cause to effect as inductive whereas Toulmin defines it as "deduction"? The first refers to the strength of the syllogism towards validity tests; the latter to the acceptability of the premises and the use of them in deriving new conclusions. According to Freeley and Steinberg

(2008) the relationship between cause and effect is not an “airtight” one, since there are probabilities that other undesirable effects might result from the particular cause, or a new cause might affect the system and the effect would not be the expected one (p.116). Therefore advancing a particular cause as a premise in the syllogism does not ensure the effect in the conclusion in the way that a deductive categorical syllogism would do.

On the other hand, Toulmin (2003) uses the term “deduction” referring to the capability of the syllogism to provide a new claim. As Schellens (1985) also cites, in causal generalizations, it is claimed that what is mentioned in the argument in general, leads to what is mentioned in the conclusion, in other words the relationship between cause and effect is already established and used by the argument; it is not established through the argument.

Therefore this category of Schellens (1985), defending predictions via causal generalizations, is akin to Toulmin’s warrant using arguments, and refers to the use of accepted causal laws in predicting facts about the future. The above lines explain why this study uses a typology that is not based on probative logical forms of the argument (inductive-deductive) for describing the theoretical reasoning that was expressed through arguments in the lessons: logical forms of arguments deal with validity; they cannot describe the epistemic practice performed.

This view of cause-to-effect arguments though has a problematic point: if the relationship between the cause and effect is known and accepted, then the syllogism performed is not an argument, but an explanation.

Aristotle refers to those types of syllogisms and defines them as “demonstrations”, as processes that reveal the cause or explanation of something, explain why the predicate belongs necessarily to the subject. Demonstration starts only from premises that can be established as "verified" or "known to be true" within a field of scientific knowledge (Walton, 1990 p.414).

How can demonstrations (explanations) be used as arguments? They both have the same structure; a premise for a prediction is an explanan for an explanation. However, the difference between those two refers to the event about which they deal: explanation refers to an event that has already occurred and thereby provides the cause for it, whereas an argument defending a prediction refers to an event that has not taken place yet; its occurrence is still in question, and that is what the argument points to: its probability to happen.

In other words, the dialectical nature of a cause-to-effect argument rests on the acceptability of its conclusion from the interlocutors: whereas explanations use the causal link to explain the occurrence of the effect - the conclusion- which is accepted by the interlocutors, arguments of the same kind use the causal link to support that the effect is likely to happen, a fact that might be under question.

Consider the following two cases:

Case 1

> *-Child: Mom, why do the ice cubes melt when they are left outside the fridge?*
> *Mother: Because outside the fridge the temperature is high, and high temperature causes ice to melt.*

Case 2

> *Child: I'm going to leave here my drink; I'll come again after playing with my friends to finish it.*
> *Mother: But the ice cubes are going to melt!*
> *Child: No, I believe it would be OK after one hour.*
> *Mother: But the temperature is high outside the fridge, the ice cubes are going to melt!*

The fact that the temperature out of the fridge is high is a *reason* that can explain *why* the ice cubes have melted outside the fridge in case 1. However the same reason can dialectically be used to *support the fact* that the ice cubes are going to melt if left outside the fridge, in case that this fact is doubted.

Even if it is difficult to distinguish between an argument and an explanation when both share a causal structure, the dialectical nature of the argument that might be grasped from the context of the conversation might help in this direction. As Mayes (2010) cites:

An argument is a piece of reasoning in which the reason is intended to provide evidence for accepting a doubted conclusion. An explanation is a piece of reasoning in which the reason is intended to provide a cause for an already accepted conclusion….Whether reasoning is understood to providing evidential or causal support depends crucially on the context of utterance. (Mayes, 2010 p.95).

2.4.4.2.2 Arguments defending an explanation

According to Schellens (1985) there are three forms of argumentation that defend an explanation: argument from effect to cause, argumentation from sign and argumentation from time to causality (Schellens, 1985, pp.77-102 as cited in Schellens & De Jong, 2004, p.299). The question is, which is the relationship of those forms of argumentation with scientific reasoning, in other words what epistemic practice does each one indicate?

According to Schellens (1985) in argumentation defending an explanation, from the existence of something that is presented as an effect, something else is inferred as the cause; therefore those arguments explain why the particular event has taken place and in that sense they support explanations.

2.4.4.2.2.1 Argument from time to causality

An argument from time to causality is an argument that defends a causal connection by pointing out the simultaneous appearance of two events (Schellens, 1985). This kind of argument would be dropped from a mechanistic account of causality, which accepts that two events are causally related if and only if there is a mechanism that connects those (Psillos, 2004). (For an extended discussion about accounts of causality see Appendix C). However, it would be finely adopted by a counterfactual approach of causation, that accepts that causes make a difference to their effects, and this difference-making is cashed out in terms of counterfactual dependence (Psillos, 2004, p.291).

2.4.4.2.2.2 Argument from sign and cause to effect arguments

Argument from sign is one of the most puzzling categories of argument schemes. A first question that rises is why keep two separate categories, effect to cause and argument from sign if, according to the definition of the category of arguments defending explanations are both described as effect to cause ones? How can those two categories be distinguished?

The answers between different scholars differ and in some cases are even contradictory. For example, Jan Schellens and De Jong (2004) interpreting Schellens (1985) typology cite that the recurring empirical link that supports a proposition of a factual or descriptive nature could be causal, but also correlative or sign, thereby distinguishing sign from correlation and causality. In the same article they cite that “in argumentation from effect (or sign) to cause a diagnosis is made; the regularity of a causal link makes it possible to make an assertion with some degree of probability about its cause, on the basis of observed consequences (or symptoms)” (p.299). By this definition they accept that a sign relationship is one of effect to cause, and thereby assign to a sign relationship a causal nature.

Hastings (1963) also comprises the category of “reasoning from sign to unobserved event” as a subcategory of causal reasoning main category. For Hastings, when reasoning from sign to an unobserved event, an observed or known event is taken as an indication of the existence of an unobserved event. The unobserved event is the cause of the observed event, and the warrant is a causal generalization between cause and effect.

In the same line of reasoning, Aristotle (Prior Analytics) describes as illustrations of *semeia*, or signs, enthymemes (arguments) that are based on a sign relation: “He is ill, because he has a fever"; "he has a fever, because he breathes rapidly"(as cited in Braet, 1999, p.115). Aristotle argues that in those kinds of enthymemes well known generalizations such as “someone who has a fever is sick” are usually omitted. According to this definition of sign relation, argument from sign is causal in nature, but it is actually a kind of converse causal argumentation (effect to cause) (Walton, 1996c, p.47). Therefore there is no clear indication as to how a sign reasoning/argument form can be distinguished from an effect to cause one.

What’s the difference therefore between reasoning from sign and reasoning from effect to cause? The answer rests on the directness of the causality between the cause and the effect, the cause and the sign of the cause. As Huber and Snider (2006) explain, the signs or symptoms could be effects arising from some cause, but the cause behind these signs are complex and numerous; in many cases they are distinctly indirect: “event one is an effect that is called a “sign” for event two which is a cause that is rather indirect or circuitous in its relationship to that effect” (p.139).

Actually, this form of argument is what is best described from Hempel (1965) as inductive statistical explanation: the arguments of this kind show that given the particular circumstances and the laws in question, the occurrence of the phenomenon was to be expected; and it is in this sense that the explanation enables us to understand why the phenomenon occurred (Hempel 1965, p. 337, as cited in Woodward, 2009) (See Appendix C for a discussion about scientific explanations). The fact to be explained was to be expected on the basis of the explanatory facts (Hitchcock & Salmon, 2001). This type of reasoning is non-monotonic, it might collapse in the light of further information (Bell & Staines, 1983, p.47), and this explains why two explanations of this kind of model might come to a contradictory conclusion.

There are views that this kind of reasoning, apart from monotonic, is restricted in supporting explanations only for particular facts and not generalizations, laws. Those kinds of explanations and arguments cannot support a law, but only a particular fact: they only intend to explain certain events or phenomena (Bell & Staines, 1983, p.47).

2.4.4.2.2.2.1 Reasoning from sign as non-causal /explanatory

Not all typologies of arguments, however, regard reasoning from sign as causal in the way described above. For example, Freeman (1994, as cited in Moulin, et al., 1992, p.186) argues that a sign relationship represents a correlational link between data and assertion. Van Eemeren and Grootendorst (1992) also distinguish between a symptomatic relation (e.g. argument from sign) and a causal relation.

In Freeley's (1993) view which is compatible with Freeman's (1994, as cited in Moulin, et al., 1992), reasoning by sign is based on a correlation between two variables and the claim of such a reasoning is that the two variables mentioned are so closely related that the presence or absence of one may be taken as an indication of the presence or absence of the other (p.87). Accordingly, this kind of reasoning does not explain *why* the proposition is valid, contrary to causal reasoning, but is to show that the proposition *is* valid. Therefore, a syllogism using a sign link cannot be regarded as an explanation of why the effect had happened, but an argument supporting that the cause has happened.

This view however would be contradicted by counterfactual approach for causation who takes it that causes make a difference to their effects (Psillos, 2004, p.291). (Appendix C). We could assume therefore, that Schellens' (1985) category of reasoning from sign is compatible with a counterfactual approach for causation, which accepts that when two variables are invariant, until we discover the third cause we think of the two of them as cause to effect (Sober, 2006, p.46).

How can we describe then reasoning from sign as an epistemic practice? In Freeley's (1993) and Freeman's (1994, as cited in Moulin, et al., 1992) view is non explanatory, but has the form of evidential support for a particular fact. In this sense the practice is akin to one of predictions: instead of using a cause-to-effect relationship to predict facts, they use an accepted sign-effect relationship to support that facts had happened. Reasoning from sign therefore describes a "warrant using" argument and is situated in the practices of using ready-made knowledge to predict or support facts.

If reasoning from sign is accepted as causal though, the form of inference cannot be described as a linear process of moving from effect to cause. As other causes might have the same effects, reasoning from effect to cause, or from sign to cause is a special kind of inference that is described by Peirce (1992) as "abduction" or inference to the best explanation (as cited by Flach & Kakas, 2000a, p.11). This kind of inference not only generates an explanation of why the particular fact (effect) has taken place, but also evaluates this explanation (hypothesis) against other plausible hypotheses. An example of such an inference is the best diagnosis of a disease given the symptoms in medicine (Magnani, 2001, p.25). This kind of explanation has the following syllogistic form, according to Harman (1965):

H is a hypothesis.
D is a collection of data.
H explains D.
No other hypothesis can explain D as well as H does.
Therefore H is probably true (as cited in Walton, 2001, p.147).

According to Magnani (2001) this kind of practice is described as hypothesis evaluation and according to Toulmin therefore, it would be a “warrant establishing” process, and to Klahr (2000) would be a practice of hypothesis testing situated in the experiment space. (See Appendix A for a further discussion about Klahr’s SDDS (Scientific Discovery as Dual Search) model for scientific discovery, which distinguishes between hypothesis generation and hypothesis testing phases as including different epistemic practices)

However, scholars admit that this kind of inference could also be used in an initial process of coming up with explanatorily useful hypothesis alternatives. Abductive inference, moving from effect or sign to cause, has been perceived as the creative generation of explanatory hypotheses, as Peirce discusses: “Hypothesis is where we find some very curious circumstances which would be explained by the supposition that it was the case of a certain general rule, and thereupon adopt that supposition” (as cited in Magnani, 2001, p.27).

Coming up with an explanatory hypothesis is distinguished from the process of critical evaluation where a decision has to be made as to which explanation is best. The need to distinguish between those two connected but, still, different in epistemological level practices - generate and evaluate hypothesis - is important when it comes to the evaluation of such reasoning. As Magnani (2001) cites, having a hypothesis that explains a certain number of facts is far from being a guarantee of being true. Therefore, reasoning from sign to generate a hypothesis, is far from reasoning from sign to identify a cause based on its symptoms, and would require a different type of argumentation to defend or counter it.

Concluding the above paragraphs I suggest the following:

1. Reasoning from sign can be perceived as one defending an explanation of why the effect had happened only if a counterfactual approach of causation is accepted; otherwise it has to be perceived as a reasoning that proves that the cause had happened.
2. Reasoning from sign, or from effect to cause is a complex process that could both be described as an inference to the best explanation, and situated in a latter inquiry phase which includes hypothesis evaluation, but also as a hypothesis generation process, which could be the start for a new inquiry cycle.

Therefore, to accept Schellens' typology for arguments defending an explanation, as far as sign reasoning is concerned, is problematic. Reasoning from sign as a syllogistic form cannot guarantee that the epistemic practice performed is one of defending an explanation (either in a primary or latter stage of inquiry). It might be a kind of proof. This issue cannot be solved at a theoretical level; we cannot defend, in any grounds of argumentation that reasoning from sign IS causal, if the interlocutor uses signs not to explain, but to prove that an event has happened. Schellens does not have any place in his typology for this kind of argument, perhaps because, as Garssen (2001) cites, since his main interest was in rhetorical and not scientific argumentation he does not deal with evidential supports. A solution for this problem is to use "reasoning from sign" as an argument form that supports an explanation of why the effect had happened, but also find ways to fill in gaps in Schellens' typology about proof-type arguments, a discussion that will take place in latter stages of this subchapter.

2.4.5 Free floating forms of arguments

According to Schellens' but also to Hastings' view, there is a category of arguments whose schemes are unrestricted, meaning that they are not used specifically in support of pragmatic, descriptive of normative statements, but maybe used for either category or position (Schellens, 1985). In other words the form of reasoning is not linked to a specific type of conclusion. Those are arguments from example, from analogy and from authority.

2.4.5.1 Argument from analogy

Argument from analogy is a kind of argument used by many typologies and its definition seems to be uncontroversial. It involves a kind of comparison between two cases: one that is accepted and one that is controversial. According to Van Eemeren and Grootendorst (1992, pp.98-99) the conclusion (standpoint) is defended by presenting the controversial as something that has similarities with something that is not controversial (as cited in Garssen, 2001, p.92). Walton (1996b, p.143) defines the syllogistic form of reasoning from analogy as follows:

> *Generally, case C1 is similar to case C2*
> *A is true in case C1*
> *Therefore, A is true in case C2*

Salmon (1984) describes these similarities in terms of properties and describes reasoning from analogy as an inductive type of inference which has the syllogistic form of:

Objects of type X have properties F, G, H ….;
Objects of type Y have properties F, G, H …… and also property Z;
Therefore objects of type X have property Z as well.

In this sense reasoning from analogy is a kind of categorical syllogism. Freeley and Steinberg (2008) on the other hand, perceive reasoning by analogy as a form of inductive reasoning, in which the advocate seeks to show that the factors of his or her analogy, which are accepted for case 1 are either a cause or a sign of the conclusion presented which refers to case 2. In this sense reasoning from analogy can support predictions, but also causal relations or even generalizations (p.165). That's why it is included as a category of arguments that is "free floating".

2.4.5.2 Argument from example

Argument from example takes the form of an inductive generalization where a case is made for the fact that something is always, often or sometimes the case (Jan Schellens & De Jong, 2004, p.309). The example takes the form of a kind of evidence for the generalization provided in the conclusion and according to Hastings (1963) the most important is not the number of examples used but their typicality. Sometimes a single case may be used to establish the generalization but more often a number of cases will be offered as a basis for the conclusion. Freeley and Steinberg (2008) define this form of reasoning as inductive and suggest that it involves either a cause or sign reasoning: the advocate is trying to show that the examples or cases are a cause or a sign of the conclusion presented (p.175).

2.4.5.3 Argument from authority

Argument from authority is also an unrestricted scheme of argumentation and can be used to support any sort of position. For example, it might support a statement that something is factually true, or argue for the desirability of behaviour on the basis of the judgment of an authority (Jan Schellens & De Jong, 2004, p.309). Argument from authority cannot be described as a deductive form of argument; however it has a form of epistemic practice that uses appeals to ground a knowledge claim, when talking about a theoretical claim.

A first conception of this type of argument is one of formal logic which regards it as a logical fallacy, the fallacy of ad-hominem: an argument which criticizes another argument by questioning the personal circumstances or personal trustworthiness of the arguer who advanced it (Walton, 1987, p.313) and not the argument per se.

Aristotle (Rhetoric) also perceives an appeal to the character of the rhetorician as one kind of persuasion that is differentiated from one of appealing to reason (to which we could add all the previous argument schemes referring to theoretical reasoning). However, he does not regard it as fallacious. When our evidence is poor we have to trust somebody; the case is not that we cannot process the data by ourselves (Nichols (1987). Aristotle therefore, does not locate the source of the authority solely in the audience's inability to understand a complex argument, but he rather argues that we trust worthy people where precision is not possible. (Aristotle, as cited in Nichols, 1987, p.669)

Argument from authority in this sense implies that the fact that a specific person (or institution) has made a statement is a sign of the truth of that statement (Hastings, 1963). As an argument though, does not guarantee the truth of the conclusion. And it is in this sense that this argument is perceived as a formal logical fallacy.

Apart from argument from authority, there are also other similar schemes - regarded also as fallacies - that share the same structure. For example, there are arguments that base the truth of their statement on the majority of people who believe it as true (appeal to people, or argument from common knowledge). Their syllogistic form is as follows:

Most people believe that a claim, X, is true.
Therefore X is true

The common core of those arguments is that they do not base the truth of their statements on evidence, but to an external "authority", a source which claims that this statement is true. This "authority" might vary from an expert in the field, a source of knowledge (books, journals and articles), the majority of people and finally, even common sense.

2.4.6 Beyond Schellens

2.4.6.1 Evidence based generalizations

Summarizing the typology of Schellens so far, we can say that he cites arguments that support predictions and explanations/hypotheses. A question to ask at this point is: are there any other reasoning schemes that would have a theoretical conclusion, beyond those referred to by Schellens? A first issue to note is that Schellens' typology does not deal with evidential support for a theoretical claim.

Apart from argument from example there is no place for arguments that their conclusion is a descriptive generalization in Schellens' typology. Schellens does not deal with arguments that stem from data. For example, Freeman (1994) recognizes two types of warrants: wtype1 warrants classify the relationship between assertion and data as explanatory or sign, whereas the wtype2 warrant, which includes evidential warrants, represents the strength with which the assertions can be drawn from data (as cited in Moulin, et al., 1992, p.186). We could say that Schellens does not deal with the second type of warrants.

Argument forms that are related to evidence and point to descriptive generalizations are described as inductive arguments and are encountered as arguments based on samples (Salmon, 1984 as cited in Flach & Kakas, 2001a; Grennan, 1997, p. 163-165, as cited in Walton, 2006b). According to Salmon (1984) in arguments based on samples, a generalization is defended based on a sample. Those arguments have the following syllogistic form:

X percent of observed Fs are Gs;
Therefore (approximately) X percent of all Fs are Gs

Toulmin (1958) describes those arguments as “warrant establishing arguments” which demonstrate that “a warrant is successful for a number of instances of Datum and Conclusion” (p.120). This is a kind of induction that refers to the process of establishing rather than using warrants, which is differentiated from formal logic’s definition of induction as a propositional relationship. The use of the term by Toulmin resembles the older meaning of term “inductive” coming from Aristotle and refers to the process of generalizing from a set of particular cases, moving from a part to the whole (Walton, 2001 p.116). This process is differentiated from deduction where a general law applies to a particular case, moving from the whole to its parts.

Peirce also defines this kind of reasoning as "induction" and describes it as the process of confronting a hypothesis, through selected predictions, with reality:

> *"(…) an experiment (…) is a question put to nature (…). The question is, "Will this be the result?" If Nature replies "No!" the experimenter has gained an important piece of knowledge. If Nature says "Yes," the experimenter's ideas remain just as they were; only somewhat more deeply engrained." (Peirce, as cited in Flach, 1996, p.3)*

This kind of a process, according to the SDDS model (Klahr, 2000) would be described as evidence evaluation, a process that is described as the decision made on the basis of the cumulative evidence to accept, reject, or modify the current hypothesis (as cited in Zimmerman, 2007).

Those kinds of arguments however, do not always support explanations. They support hypotheses, but not all hypotheses are explanatory (Flach and Kakas, 2000a). In this sense we have two types of inductive generalizations: those that are explanatory and those that are descriptive or confirmatory (p.30).

2.4.6.2 Statistical syllogisms

A second type of argument that is not included in Schellens typology is that of statistical syllogisms. Those kinds of syllogisms are described by Peirce (as cited in Fetzer, 2000) as "probable deduction", which is equated to "the use of a priori probabilities for the prediction of statistical frequency" (Keynes, 1921 as cited in Fetzer, 2000). The syllogistic form of those arguments is presented by Salmon (1984, p.32 as cited in Flach & Kakas, 2000b, p.6) as follows:

X percent of all Fs are Gs
a is an F;
therefore a is G.

In this sense a statistical generalization is used for making inferences about individual matters of fact. This kind of reasoning has a predictive power, but for others has an explanatory power as well. For example, Hempel's (1965) model of deductive statistical explanation is akin to a statistical syllogism presented above. In DS (deductive statistical explanations) the laws are not universal generalizations but have the form of statistical generalizations (Mayes, 2005). (See Appendix C for further exploration of Hempel's model of explanations.) Those that perceive statistical syllogism as explanatory accept that as we can explain scientific phenomena deducing them from more fundamental general laws, we can also have deductive explanations of statistical laws on the basis of more basic statistical laws (Hitchcock & Salmon, 2001, p.472).

This kind of practice, according to Toulmin (1958) would also be a warrant using one. Since a statistical generalization is accepted, then it can be used as a basis of warrant using arguments that could use it to predict future facts, or explain current facts. Those syllogisms therefore, are akin to cause-effect syllogisms used to defend predictions or explanations with a main difference: there is not a causal relationship between variables, however there is one of statistical generalization.

Even if Schellens (1985) admits that there are also "non-causal" ways of defending a prediction, and might refer to statistical syllogisms as having a predictive force, he surely does not assume that those kinds of arguments could support an explanation, in other words indicate causality. However, since there are views that accept those as explanatory, we have to include them also in a typology of argument schemes for a reason that has been elaborated before in this study: philosophical considerations as to what counts as causality is one aspect; one might argue on behalf of each school of thought and endorse a view. However, how those considerations are expressed in the classroom or in any scientific debate is another matter. If a student for example, uses a statistical syllogism to defend an explanation then, we should keep a category of such an argument scheme, even if several scholars would classify such reasoning as non-explanatory, inconsistent, or fallacious.

2.4.6.3 Analytic arguments

Analytic arguments (Toulmin, 2003) are another scheme of arguments missing from Schellens' (1985) typology. Toulmin (2003) describes those arguments as those in which in their conclusion do not tell us anything that it is not included in the data and warrant - backing (p.139). The conclusion necessarily comes out from data and there is no need to further explain or ground the warrant between the data and the conclusion. With analytic arguments there is no need to explain "how did we get there" from data, and the conclusion, once the data accepted, cannot be challenged. Toulmin (2003) provides an example of such an analytic argument:

> *Anne is Jack's sister;*
> *Every single one of Jack's sisters has red hair;*
> *So (necessarily) Anne has red hair (p.140).*

As he cites, we should not confuse this category with deductive arguments of the type "All A's are B's" or with the category of warrant using or warrant establishing arguments.

It is evident that this kind of argument is far from the definition of a dialectic, or rhetoric argument. A critical element of the definition of argument in dialectics is that is defensible (Mbasakos, 1999) and that's why dialectics is distinguished from analytics, since it is defined from the possibility to stand on the other side: argument is not a proof as the above analytic “argument” is. An argument in this sense is logically incomplete since it needs a “field” in which it can be situated and evaluated: political, ethical, law argument for example (Allen, 2007, p.13). Toulmin (2003) calls arguments that are situated in a field as substantial and differentiates them from analytic ones. Analytic arguments are rather proof syllogisms.

There are two options for the issue set above: either accepting analytical arguments as mere “inferences” and omit them from an argument scheme typology, or accept them as potential arguments and include them in a typology. The answer for such a dilemma rests on two aspects: a pragmatic and a methodological one.

The pragmatic aspect refers to the use of such analytic syllogisms from students in the classroom as arguments that counter a premise of another argument as false, or support it as true. Consider the following episode:

> *“446. Student 1: We should not clone people, because, for example, if I meet in the street someone I know and he does not talk to me, (and he is the clone) I would feel that he has a problem with me…It would create misunderstandings…*
>
> *447. Teacher: Yes, but remember that when we clone a person of 33 years old, for example, he will not come as a 33 year old grown up. He will come as a baby...”*

The teacher here performs an analytical syllogism:

> *The clone comes as a baby.*
>
> *Therefore, it’s not possible that the clone will come as a grown up person.*

This kind of syllogism drops the premise of the previous argument as false. It might not stand as an “argument” as defined by Mbasakos(1999) as it has not a gap in its syllogism, no one who accepts that a clone comes as a baby would by any way deny that she does not come as an adult. However, the dialectical strength of this syllogism is one of a counterargument: it drops the data of the previous argument as false. Since, analytical syllogisms are used as such they should have a place of an argument scheme typology.

The methodological aspect refers to the unit of analysis about arguments when chains of argumentation are created in the classroom. Regarding analytical arguments as such, enables us to define the unit of analysis for arguments as the argument scheme: two premises, serving as data and warrant, leading to a conclusion. How about other elements that Toulmin (2003) suggests such as rebuttals or backings? If we accept analytic arguments as an argument scheme, then a rebuttal would have the form of an analytic argument that drops the warrant as false in special circumstances. The backing would also be an analytic argument (though not always) that supports the warrant as true.

As Toulmin (2003) cites, warrants are defended according to the fields that they belong to; one warrant is defended if related to a system of taxonomical classification, another by appealing to the statutes governing the nationality of people, others by referring to statistics (p.96). This kind of analysis allows us to grasp every movement in an argumentative dialogue that aims to support or counter any component part of the argument, as a standalone argument, that can be described by the schemes included in the typology.

A backing is a reason - that can be reconstructed as a standalone argument - supporting the warrant. A rebuttal is an exception to the claim, and therefore it might have the form of an analytic argument of the type since not all A's are B's and since A leads to C then not *all* B's lead to C. (B leads to C refers to the Data-Claim whereas not all B's lead to C is the rebuttal in this case). A qualifier, finally, is a statement that evaluates how strong the claim is. It is therefore an argument (analytic or not) that deals with the Data-Warrant-Claim argument as a proposition and evaluates it. A qualifier therefore is a kind of a normative argument that rests in meta-level.

This kind of perception is in line with other scholars that have modified Toulmin's argument pattern so as to be feasible to apply it in real classroom discussions. For example, Erduran et al. (2008) note that all the statements (data, warrants) can be considered as claims in themselves; what makes them rebuttals is that they are positioned to be data or warrant relative to the main claim that creates a force for the generation of the subsequent elements, thus being considered as "nested": data of one argument counts as a claim for another argument (p.58).

By adding the analytical argument scheme though, we do not imply that all analytic syllogisms are arguments in the way presented above. Many of them might be steps for a syllogism that could add a premise for an argument for example. Others might be just implications of the conclusions of other arguments with no dialectical strength of supporting or countering anything else. The reasoning pattern of an analytical argument might be the same as an analytical syllogism, an implication, in the same way which a prediction from cause to effect has the same reasoning pattern with a D-N explanation. The difference rests on the dialectical strength of the conclusions: implications and explanations deal with conclusions that are already accepted; analytical arguments and other types of arguments question, or defend such a conclusion.

2.4.6.4 Appeals to passion (emotional appeals)

Aristotle talks about three kinds of appeals that a rhetorician has in order to convince his audience: appeal to logos (reason), Ethos (the virtue of the rhetorician's character), and Pathos (the emotions of the audience) (Kock, 2006). The differences between these forms of argumentation are akin to Toulmin's categories of arguments: in a substantive argument the warrant tells us something about the way in which "the things in the world about us" relate to one another, in a motivational argument it tells us something about the emotions, values, desires or motives which can make the claim acceptable to the person to whom the argument is addressed, and in an authoritative argument it says something about the reliability of the source from which the data are drawn (Brockriede & Ehninger, 1960 as cited in Van Eemeren, et al., 2000 p.56).

Argument from authority is captured in Schellens' typology as a free floating form of argument and has been presented before. However, authoritative arguments do not refer to an initial argument scheme in which a proposition is asserted as true, desired, good etc because an authority has stated so. Those kinds of arguments ground the quality of data on the reliability from its source, the authority that has stated it. An argument that uses as data the fact that a doctor is an expert in his field might conclude that the doctor's view about a dilemma should be seriously taken, for example. In this sense authoritative arguments are arguments supporting the quality of the data based on the authority's character, reliability etc. However, these types of arguments are captured by Schellens' typology as normative arguments.

The category not captured by Schellens refers to argument schemes that are in a sense motivational, they are trying to convince about the truth of a statement, or a desirability of a behaviour arising emotions from the audience. Those arguments are known as "appeals to emotion" and therefore regarded as logical fallacies; their use by a rhetorician is accepted as a rhetorical type approach of proof, from an Aristotelian perspective.

The connection between reason and passion implies that a rhetorician should use passionate (emotional) appeals to arouse his audience's passions to the argument of the speech itself; in other words, make his audience get interested in the reasons provided to convince for a particular view. Additionally, the same arguments that arouse the passions of the audience also reveal the rhetorician's character and in this sense the three proofs of rhetoric - reason, pathos and logos- are in the best case inseparable from one another (Nichols, 1987, p.662). The case is not always the best though; there are rhetoricians that appeal to emotions not to make their audience get interested in particular reasons, but rather use the emotional situation as a way to convince about a case, to use emotions instead of reasons. And it is in this case that those arguments should be described as specific type of arguments. We need therefore a particular individual scheme to capture them.

Examples of such arguments are appeals to fear (If you continue to drink, you will die early as your father did!), appeals to emotion (I've worked too much to prepare this thesis, please do not reject it!) and wishful thinking (It will rain tomorrow, I want it so much!). Appeals would have been a "free floating" form of arguments according to Schellens as they can support a belief about a fact to be true, but also might be used to convince a person towards a specific action.

A category of Schellens that could capture emotional appeals is one of pragmatic argumentation based on rules (rule case syllogism). If we translate an appeal as a rule case syllogism, we get the following syllogistic form:

> *Rule: You should feel sympathy for persons that do not have a job and have big families*
> *Case: I'm such a person and you are such a man (that sympathizes)*
> *Conclusion: You should offer me a job.*

Notice that the reason offered to support the candidate is not related to his abilities to perform the job, but is a way to raise awareness of the employer to sympathize with him and offer him the job. In a strictly logical analysis this is not a reason. On a different, more naive perspective however, it could be a reason: helping people with big families to raise their children, could be a reason for offering a job to a man who has many children.

Due to this slight differentiation of emotional appeals to rule case syllogisms, and due to the fact that emotional appeals might not only tell us what to do, but also what to believe, it would be better to keep them as a distinct argument scheme under the category of "free floating" arguments.

Summarizing the discussion about arguments that support a theoretical, factual conclusion we get the following schemes:

Reasoning scheme	**Epistemic Practice**	**SDDS stage**
Cause to effect	Defend a prediction Explain a fact (present or past) (D-N explanation)	Use ready- made knowledge
Effect to cause From sign	Defend an explanation (I-S) of a particular fact, or a law , defend a postdiction	Hypothesis generation Inference to the best explanation-diagnosis or hypothesis evaluation
From time to causality	Defend an explanation - a causal relation (Counterfactual account of causality)	Hypothesis generation
Evidence to hypothesis (From samples) From example*	Defend a descriptive generalization (either explanatory or not explanatory)	Hypothesis testing-Evidence evaluation
Statistical syllogism	Predict a fact Explain a fact (D-S explanation)	Use readymade knowledge to deduce a fact, or a categorical syllogism
From Analogy *	Defend a generalization	Hypothesis testing, Evidence evaluation
Authority* (Expert, source)	Defend any type of conclusion	Any stage
Popularity*		
Emotion *		

Table 7: Argument schemes that conclude to descriptive factual statements

The typology that has been proposed above, as mentioned elsewhere is a result of theoretical thought concerning theories about reasoning and argument schemes and how those could be used to describe epistemic practices; this theoretical thought though has been affected by classroom instances which actually fed the discussion in two ways: firstly they pointed to the demand to seek for such tools and conceptualizations and in a second place they have been food for thought for refinement and modification of existing theories and schemas (like the argument scheme's typologies). Actually, the modification of Schellens' (1985) typology is an example of this process: specific schemes of syllogisms encountered in the lesson could not be captured by the typology, or specific epistemic practices described as processes of the SDDS model (Klahr, 2000 as cited in Zimmerman, 2007), like hypothesis testing through evidential support, could not be described and therefore the typology has been modified/expanded so as to include categories that could fulfil those needs.

The application of argument schemes alongside other tools that have been used in this study were a result of the need to reconstruct argumentative talk in the classroom on the one hand, and describe controversial issues as the dialectical context in which epistemic practice was situated, on the other. Both processes will be further explored in the method and methodologies chapter that follows, within the data analysis section.

3. Methodology and Methods

3.1 Introduction - Restatement of Research Questions

The aim of this study is to investigate and describe the implementation of controversial issues within science curriculum, as performed by primary school teachers that had acted both as designers and pedagogues of such a proposed curriculum. The implementation of controversial issues in the science curriculum is perceived as an open ended, complex, and problematic task. This study recognizes the need to consider the problem of controversial issues teaching in its practical alongside its philosophical aspect. In other words, it aims to describe and analyze how theoretical assumptions about science teaching and controversial issues apply or not, in real science classrooms.

In other words this study aims to describe how controversial issues are “situated” in science education (Tiberghien, 2008, p. V) or vice versa, what kind of science education is performed, and how this is done, under the context of controversial issues. As noted in the introduction chapter, a methodological problem that had to be addressed was the description of the lessons both in science lesson terms, but also in socioscientific issues lesson terms. One question that arises is: if we describe the lesson alongside those two dimensions, do we automatically regard learning science and learning about socio-scientific issues as epistemologically distinct activities (Levinson, 2006, p. 24)? And if so, by which method would we address their boundaries? This issue actually assigns a new aim for this study: to define what a “socioscientific issue lesson” is and what a “science lesson” is, in order to describe them as distinct.

A theoretical construct that was used to refine this relationship was the definition of socioscientific elements of functional scientific literacy, as defined by Zeidler and Keefer (2003) (see Figure 1, in section 2.2.).

According to the construct they propose, functional scientific literacy related to socioscientific issues includes cognitive/reasoning development, moral reasoning, moral character education and the reflection of emotive belief systems. In this sense, socioscientific elements of functional scientific literacy are used as a priori theory that enables the definition of the areas which this study should describe: cognitive reasoning, moral reasoning and emotional reflection.

The selection of such a construct does not imply that the relationship between controversial issues teaching and science education should entail all those elements, or that a single lesson should include all those elements. In other words, the construct is not selected as an evaluation weight, but as a descriptive means. An additional reason for the selection for such a construct is that it has the capacity to endorse all other frameworks about controversial issues teaching: Zeidler's and Keefer's (2003) framework entails all those elements that could be used to describe any curriculum, that either includes elements that use controversial issues teaching as a means for humanizing science curriculum and an opportunity to deal with moral, social and epistemological issues, or uses it as an environment through which students should develop their scientific literacy in order to be able to engage in thoughtful decisions about controversial issues.

The question therefore of describing how socioscientific issues are situated in science education has been restated in the following form:

How can the lesson be described in its moral, emotional-reflective and cognitive dimension, and how can this be related to the context of controversial issues?

This new view had restated the research questions in a form that could capture the elements of functional scientific literacy and situate them within controversial issues discussion. As soon as this clarification has been made, two methodological problems have been raised:

1. How could moral, emotional-reflective and cognitive elements be described as content and process within the lesson?
2. How can we define “controversial issues” as the context for those areas?

The initial questions have been restated as follows:

Research Question	Restated Research Question
1. Which entities are found in a controversial issues lesson? (Scientific concepts, claims, values, ethical, metaphysical considerations, emotions, etc) **1.1.** What other areas of knowledge and expertise are infused in the lesson?	**1.** How can moral, emotional-reflective and cognitive processes be described in socio-scientific lessons? **2.** What is the moral, reflective and cognitive part of the lesson?
2. By which conceptual activities do students and teachers negotiate the thematic pattern of the lesson? **2.1** What type of science do those activities describe?	
3. Under which context do thematic entities come up in the lesson?	**3.** How can “controversial issues” be described as a context for functional scientific literacy? **4.** What is the context for the moral, reflective and cognitive part of the lesson?

Table 8: Restatement of research questions

The restatement of the research questions as presented above does not change the initial aims of the study: deciding to describe the moral, emotional-reflective and the cognitive does not actually differs from identifying scientific concepts, claims, values, ethical and metaphysical considerations or emotions.

However, finding a way to describe those entities both as content and as process and situating them in dialectical context has been more than a methodological issue for this study. The way that dialectical has been described as the context and the tools used to describe both the dialectical and epistemic within this study are actually *results* of this study. They are products of mutual interaction between theoretical consideration and instances from classroom data that pointed to the seek and modification of existing tools, or the proposal of new tools. The description of those tools could not be done within the strict limits of the methodological chapter. And since are described as results, they had to be stated as problems, as research questions that have been answered within this study beyond their role as methodological tools used to provide the answers for the theoretical part of the study.

3.2 <u>Methodological approach</u>

3.2.1 Qualitative approach

Since this study is situated in the hypothesis space, in other words it would serve better to "generate a hypothesis" (Merriam, 1988, p.3) rather than to prove or disprove a hypothesis about controversial issues teaching and science education, it has followed a qualitative research tradition.

Another reason suggesting qualitative research is its naturalistic character (Bogdan & Bilken, 1998). Being naturalistic, qualitative research seeks to develop detailed holistic descriptions of the field and the phenomenon/situation studied, and this is actually the purpose of the study: to develop a description about controversial issues teaching. The data needed to answer the questions of this study should derive from actual learning processes; therefore, the adoption of a qualitative approach was appropriate as it is focused on the natural settings where the phenomenon or the situation under study takes place (Bogdan & Bilken, 1998).

3.2.1.1 Case study approach

Case study design was selected as more appropriate for this study, because of its qualitative character and its capacity to answer the research questions appropriately. As a descriptive means “the case study is preferred in examining contemporary events when the relevant behaviours cannot be manipulated” and as a method of analysis it has the ability to examine a “full variety of evidence - documents, artifacts, interview and observations” (Yin, 2003, p.7-8).

Science curriculum related to controversial issues, implemented in primary school classrooms, is perceived in this study as the case, as a “bounded system” (Stake, 2000). Each of the lessons would constitute a sub-case of this case. Perceiving implemented curriculum as a system is grounded on several criteria that this system fulfils: this system is bounded by time and place. Delivered curriculum (a lesson, an instruction) is conducted by agents (students and teachers) in a specific place (classroom) and time (80-minute science lesson) and includes the processes by which this curriculum is delivered and shaped. Theories about what constitutes science education or dialectic practice are used to bind the system in its theoretical dimensions. Additionally, in the system under study the researcher has limited control over the case of the study whereas she can be the primary observer (Merriam, 1988; Yin, 1994).

Yin (2003) argues that the system can be studied with one of three types of case studies: exploratory case studies, explanatory case studies, and descriptive case studies. Merriam (1988) on the other hand proposes an analogous classification of case studies based on the analysis and reporting of the results: he proposes the categories of descriptive, interpretive and evaluative studies. Descriptive case studies use the data for the purpose of achieving a better understanding of the current status and serve as an initial step for theory building; interpretive case studies use description to develop conceptual categories or to illustrate, support or challenge theoretical assumptions prior to the data gathering; and finally, evaluative case studies involve description and interpretation to evaluate the merit of the case (lesson, program, event) whereas the efficacy of this study relies on the competence of the researcher to use the available information to make judgments (Guba & Lincoln, 1994).

Even if this study has a highly descriptive character, the major focus is to interpret the data in an effort to classify and conceptualize the information in terms of functional scientific literacy and controversial issues. Therefore, even if situated in the hypothesis space, this study goes beyond mere description, to interpretation of descriptions, and therefore is defined as an interpretive case study aiming to support or challenge theoretical assumptions related to functional scientific literacy and controversial issues teaching.

A note to be taken is that the lesson, as defined in this study, has been finally equated to the "discussion" about controversial issues. The majority of the time of the lessons has been devoted to classroom discussion, whereas little time was given to students either to study relevant information or to write down arguments that would be discussed in later sessions in the classrooms. Unfortunately there was not a way to capture small groups' discussions when trying to form decisions (in mobile phones lesson, an activity that had lasted 7 minutes) and announce them to the teacher. Though this is a shortcoming of the study, I believe that it could add some missing categories from classroom discussion, but surely does not affect the analysis of the rest of the discussion in the classroom. In a way therefore, this study analyzes classroom discussions rather than lessons about controversial issues, to provide information about related curriculum. The case therefore, the bounded system to be studied, is the *discussion about a controversial issue* within a science classroom.

3.2.2 Study setting

For the purposes of this study, the main focus has been three 80-minute lessons, by three Cypriot science teachers. The instructions took place in the academic year 2006-2007, two in 6th grade classrooms (10-11 year-old students) and one in 5th grade (9-10 year-old students). The teachers were participants in a larger professional development seminar that was proposed by the Pedagogical Institute of Cyprus and had as its main aim to help teachers connect theory and practice, by reflecting on their own teaching, with the help of videos of lessons conducted under the thematic units of the seminar. The seminar was set on a volunteer basis. One of the units of the seminar was related to controversial issues teaching. I was the instructor of this part of the seminar.

The teachers were informed from the very beginning of the seminar that their video-taped lessons would be used for research purposes, and their permission was taken for such a use. Additionally, parents of the students participating in the research were informed by letters, and those that did not approve of their child's participation in the video were omitted from the lessons (only two occasions within 82 students).

The seminar has the goal of informing teachers about controversial issues and science teaching, an aspect that has the status of an innovation for the Cyprus curriculum, but on the other hand, has presented the issue in its problematic sense, thereby leaving space for the teachers to act as experts, perhaps not about teaching controversial issues, but surely as experts in teaching other issues, to design their own instructions in the way that would reflect their own beliefs and understandings.

This kind of study is not an interventionist one; I did not want to "inform" teachers how to teach such a lesson, thereby using a top-down model of professional development, based on an informed by the literature, but still, limited conception of how teaching about controversial issues could be situated in science lessons. In this sense therefore, teachers have been used both as designers of a new proposed curriculum but also as subjects for professional development for such a curriculum.

The role of the instructor, me, as a researcher is not problematic in this sense, since the setting is naturalistic and not interventionist. My role was clarified during the first meetings as an informed- in a theoretical basis - member of a group of teachers that was trying to find solutions for a complicated problem that was set as "controversial issues teaching in science classroom". I did not have the solutions from the beginning; I was searching for such solutions and this was clearly set out to the teachers.

Actually, I gave little, to almost no guidance to the teachers while they were preparing their teaching; my role was limited in helping them clarify their thoughts, being there as a peer to which they could talk about their concerns, and I was there only when asked to do so. There were teachers who did not ask for such help. For others, I helped as far as logistics of the lesson were concerned: I had been looking with them to find relevant information that could be used in the lessons as information or evidence about the issue they have selected, translate resources from English to Greek when not available, and in some cases suggest available possible activities that could be used in the lesson.

By this, I do not assume that the selection of information or type of evidence is not of importance, or it does not affect the whole setting of the lesson. Additionally, the suggestion of activities also was an input from the researcher to the teachers;

however, the way that this was done had the form of free selection among possible different activities, rather than dictating the use of one versus another activity. Actually, there were lessons that took the form that I would never suggest for myself being situated more in the “science” and “more positive” side of science teaching, I would never suggest a lesson being more closed to social rather than natural sciences. However, those lessons, in the end, have been very valuable in indicating issues that I would never think of before, and this is actually fulfilling the purposes of this study: using teachers as experts.

The meetings lasted two and a half periods and were conducted in afternoon hours. The following structure of the seminar reveals its peer reflecting nature:

- One face to face meeting about the nature of science using Nott’s and Wellington’s (1995) critical incidents (This was actually a way to bring up considerations about epistemological issues that are not typically addressed by Cyprus National Curriculum for Science).
- One online meeting for the discussion of genetically modified food as an issue for their own reflection. Teachers were talking about the issue, not about its instruction.
- One face to face meeting which was a reflection between the participants about controversial issues and their place in science teaching.
- One online meeting in which the teachers should provide a lesson plan for controversial issues instruction and the others make a comment to at least two members of the group.
- A face to face meeting where participants created groups in order to discuss further their lesson plans.

- An online meeting where they submitted their final lesson plan and asked for help.
- A final face to face meeting where a discussion of parts of each lesson was conducted, with the use of videos and transcripts.

3.3 Data sources

Teaching observation (recorded on video) was the main data collection method for this study. Transcripts from classroom discussion were the primary data for analysis. For students' data there was no secondary data collected, though, as will be mentioned in the next sessions of data analysis, this was one of the shortcomings of this study.

The language of the lessons was the Greek language. This was not a problem for me as I am a Greek speaker also; therefore I regard the language as not an obstacle in analysis. Classroom talk reconstruction is not affected by the language, since the researcher and the participants share both the same language and culture. However, the presentation of episodes had to be done with care so no messages would be lost in translation, but also the modifications for an accurate translation would not affect the original meaning as expressed in mother tongue.

Another language-cultural aspect refers to the gendered pronouns used in the study. In Greek language the masculine pronoun (he, his etc) is dominant and expresses both masculine and feminine. Using the term "she" is not natural in Greek language. Respecting though issues that require equal treatment of men and women, this study uses the conjectures he/she, his/her etc to express a neutral gender and uses the actual genders of the interlocutors when analyzing their talk in the classroom.

For enhancing the description and interpretation of teachers' strategies, but also for triangulation reasons, secondary data was collected: teachers' notes and lesson plans, materials and teaching aids, alongside with teachers' descriptions of the lessons as those presented in a symposium that took place during the works of the 5th National Conference of History, Philosophy and Teaching of (University of Cyprus, Nicosia, 11-14 June 2009) have been used to describe teachers' practices.

Another data collection method that was applied in this study was the interview by the use of video stimulated recall. The following steps, proposed as a guideline for conducting a recall session have been followed (as those cited in Cashwell, 2001)

1. The researcher has reviewed the videos prior to the recall session.

2. The teacher has been informed that the purpose of the session was to reflect on thoughts and feelings of him/her during the session(s) that will be reviewed. Actually, we reviewed the whole lesson, a process that took a lot of time to be completed (several sessions within weeks).

3. The tape begun to play; at appropriate points, either person (researcher-teacher) stopped the tape and asked a relevant lead to influence the discovery process. If the teacher stopped the tape, he/she would speak first about thoughts or feelings that occurred at that time in the counselling session. The researcher facilitated the discovery process by asking relevant open-ended questions.

4. During the recall session, no evaluative weights were put at all; the purpose was for the teacher to explore thoughts and feelings to some resolution (Bernard & Goodyear, 1992).

Actually, the use video stimulated recall sessions in this study served two different purposes: on one hand, they have increased my awareness of teachers' thoughts and feelings and therefore enabled me to describe teachers' strategies in a more valid way. On the other hand, and this is the greatest input for this study, they have broadened my view of what could constitute teaching about controversial issues in a science lesson; this process really enabled me to "understand and act upon perceptions to which they- I - may otherwise not attend "(Cashwell, 2001), and have a view of the lessons that I would never have without the inputs from the teachers. This input also determined the way that the literature review is organized and presented in this thesis, and has reformed my perception of what "teaching science through controversial issues" or "implementing controversial issues in science curriculum" consists of.

3.4 Data Analysis

The purpose of this part of the chapter is to describe in detail the process that has been followed so as classroom data could be reformed in a way that could inform the study about the epistemic practice as this is situated in the dialectical practice, and therefore fulfil the aims of this study. In the first place, the study had to face the methodological problem of situating controversial issues in science education and define clearly this relationship, so appropriate tools would be used to describe it. The process by which this problem has been solved is described within the first part of this subchapter, 3.4.1 *Defining dialectical context alongside socioscientific content as dialectical context for this study.*

As soon as it was clarified that what was to be described was the epistemic as situated in the dialectical, there was a need to define the "epistemic" part, a process described in the second part of the subchapter, *3.4.2 Describe Moral, Emotional-Reflective and Cognitive part of the lesson.* Any effort though to describe the epistemic part had, among others, to extract arguments as products from the talk, a process that has been enhanced by conceptualizations from speech act theory which had enabled the identification of propositional and non-propositional, simple and complex speech acts; this process is described within the sections *3.4.3 Thematic content of the lesson -Epistemic content* and *3.4.4 Propositional content of argumentation.* Finally, the process of reconstructing argumentative talk as to extract arguments as products is described in the last section of the data analysis subchapter, *3.4.5 Reconstructing classroom talk: extracting the products of argumentation.*

3.4.1 Defining dialectical context alongside socioscientific content as dialectical context for this study

The restatement of the research questions had provided a methodological question of: how can "controversial issues" be described as context for functional scientific literacy? This question has been used as a data analysis scheme for the second, that is "What is the moral, reflective and cognitive part of the lesson?"

Since controversial issues include by definition argumentation, there was an initial effort for data analysis methods related to argumentation. Studies related to argumentation revised from the science education area (Erduran, et al., 2004; Zohar & Nemet, 2002; Aufschnaiter, et al., 2008; Osborne, et al., 2004) would be sufficient for providing different schemes that could be used for argument evaluation in terms of their epistemic quality. However, they are not sufficient in providing valuable information about how the "socioscientific context" of the study would by described.

A distinction between argumentative process and epistemic actions can be found in the Pontecorvo and Girardett (1993) study. Their study, situated in history education, distinguishes between historical epistemic actions and argumentative operations. Argumentative operations "are used by the children as a means of constructing and supporting their claims, and consequently, their reasoning and thinking" (p.368). Those operations are:

- Claim: Any clause that states a position (that can be claimed).
- Justification: Any clause that furnishes adequate grounds or warrants for a claim.
- Concession: Any clause that concedes something to an addressee, admitting a point claimed in the dispute.
- Opposition: Any claim that denies what has been claimed by another, with or without giving reasons.
- Counter opposition: Any claim that opposes another's opposition, which can be more or less justified.

Pontecorvo and Girardett (1993) have assumed that those operations had to be identified within a lower level of analysis and should be applied to the idea unit that was under discussion, and rests on an upper level of analysis. Duschl (2008) however, who has used those operations for analyzing argumentative talk, criticizes them as being too broadly defined, a fact that led to a difficulty of distinguishing the structure and patterns of arguments, but also for identifying epistemic operations. He also cites that the idea units did not work well with the argumentative operations (p.169).

A similar approach was adopted by Jimenez-Alexandre et al. (2000) who had separated argumentative operations from epistemic operations for the determination of the capacity of students to develop and assess arguments during a high school genetics instructional sequence. Jimenez-Alexandre et al. (2000) use Toulmin's (1958) argument components as argumentative operations: claims as hypotheses, warrants as reasons, qualifiers as conditions for the claim and rebuttals as conditions for rebutting the claim (p.768).

Even if this heuristic approach might be used to describe argumentative operations as the socioscientific context with epistemic operations as a way to describe epistemic practice, there were two major problems in such an analysis:

1. The talk in the classroom is not always argumentative; there was a need to define moral, reflective and cognitive aspects of the lesson within and without argumentation.
2. There is very little information as to how this single pattern of an argument would be applied in complex argumentation structures. For example it gives us very little information as to what could count as a unit of analysis for a single argument, or where an argument ends and a new one emerges.

Actually, the process used from Jimenez-Alexandre et al. (1998) was intuitively used in this study as the first attempt to give classroom talk its context. Information, Argument, Conflict Point, Dilemma, Acceptance of argument, Link for Argument, Evaluation of Argument, alongside other "elements" were all identified in the same way as Jimenez- Alexandre et al (1998) have described "argumentative operations", and have used as categories that could describe the "socioscientific context" of the study. However, when trying to group categories of such elements the task was really difficult and eventually it was abandoned.

The need for further elaboration of argumentation studies was evident. After the inputs of argumentation studies, the reason for such a failure was clarified: products of talk, like argument, explanation, and information were infused in a single category with processes like countering, supporting, dropping arguments, setting a dilemma etc. However, they could both be used to grasp a part of the socioscientific context.

Since argumentation studies located in science education were not sufficient for providing processes and schemes for analysis, this study has used conceptualizations that could describe argumentation as a process like Rhetoric (Aristotle, (*Rhetoric*); Mbasakos, 1989), Pragma Dialectical Argumentation Theory (Van Eemeren & Grootendorst, 1989; Van Eemeren & Houtlosser, 2000; Van Eemeren, et al., 2002) and has adopted schemes for analysis such as the Typology of Argumentative Dialogues (Walton 1990; 1992; Walton & Crabbe, 1995). For readability purposes those conceptualizations have been included in the literature review session and have already been presented in the subchapter *2.3 Argumentation as a process.*

My literature review has enlightened the definition of the "socioscientific context" with the following implication: the process of discussing a socioscientific issue, the dialogue, has primarily a dialectical aspect. This aspect could inform analysis about the "socioscientific context". In other words the epistemic, moral, or reflective practices to be described and analyzed are viewed as epistemic processes and products situated in a context that was created by the *discussion of a controversial issue*. Therefore, a part of what could be described as "socioscientific context" could be grasped from the dialectical context.

What is defined as resting in a "different epistemological level" therefore - returning to Levinson's (2006) question about different epistemological activities- is not learning about science or learning about controversial issues, but learning about anything while *discussing* about a controversial issue with the purpose of resolving it, or defending a view, a pre-held position. A primary distinction therefore, is situated between epistemological and dialectical activity. A construct that was used for the description of the dialectical context was Walton's and Crabbe's (1995) typology of dialogues as cited in Table 9 below.

Type of dialogue	Initial situation	Participant's goal	Goal of dialogue
Persuasion	Conflict of opinion	Persuade other part	Resolve or clarify issue
Inquiry	Needs to have proof	Find and verify evidence	Prove (disprove)
Negotiation	Conflict of interest	Get what you most want	Reasonable settlement that both can live with
Information-seeking	Need information	Acquire or give information	Exchange information
Deliberation	Dilemma or practical choice	Co-ordinate goals and actions	Decide best available course of action
Eristic	Personal conflict	Verbally hit out at opponent	Reveal deeper basis of conflict

Table 9: Walton and Krabbe's 1995 typology of dialogues

A first attempt to use the above categories and apply them to classroom talk was disappointing; the discussions were chaotic, and actually students and teachers have been arguing about anything! The first codes that have emerged from this analysis had revealed that the agents of the classroom discussion might argue, but not necessarily to convince about a judgment regarding the issue set in the beginning of the lesson.

A heuristic approach that enabled data analysis in aspects of socioscientific context was the description of the "socioscientific content". The socioscientific content as used in this study refers to the substance of the discussion related to the issue for each lesson. Since the whole discussion in the classroom was related to a socioscientific issue, referred to *the issue* from so far, and since any issue creates a disagreement space (Van Eemeren & Houtlosser, 2000; Mbasakos, 1999) this disagreement space could be a reference as to what else might have been discussed in the classroom. This decision has been made after lots of rounds of analysis and had actually enabled the description of the dialectical context in this study: relating the content of any conclusion to the issue under discussion and relating any other issue that has been elaborated in the classroom to the disagreement space created by that issue.

Since the results of the socioscientific content analysis have affected the further steps of analysis, they are presented here, in the data analysis, and not the results chapter. The questions that have driven such an analysis were the following:

- What is the agent (student or teacher) talking about?
- How is this related to the issue?

An open coding process was selected as appropriate for describing socioscientific content as it involves "breaking down, examining, comparing, conceptualizing, and categorizing data" (Corbin & Strauss, 1990, p. 61). The data in this case has to be categorized related to an issue that was concerned about an action that has to be taken. Open coding process revealed the following categories which the agents of the discussion had referred to.

Socioscientific Content	Description	Example
Issue and Sub-Issues	About the issue under discussion or to sub-Issues that emerged as chains of argumentation	Issue: We should not clone humans because there is a danger of cloning really bad people like Hitler that could destroy society (Cloning) Sub-Issue: Since our religion allows us eating meat there is no moral issue regarding meat eating (Hunting)
Issue Case	About the issue, the dilemma, as a standalone entity, per se.	Cloning or not humans is a really big dilemma (Cloning) Talking about buying a mobile phone to a 10 year old is a different issue than talking about buying a mobile phone to a teenager (Mobile Phones)
Self	About them, in order to describe their position towards the issue, inform about their decisions on personal dilemmas or reflect on their own views and actions.	I am against cloning animals (Cloning) I would not clone my dead cat (Cloning) I would like to buy a mobile phone, that's why I say that the information that mobile phones harm health is nonsense (Mobile phones) I go for hunting because I like it as a sport (Hunting)
Societal Agents	About the society members including the scientific community members, their motives, preferences, desires and actions.	Members of the parliament support hunting because they need votes from the hunters. (Hunting) My mother and father do not buy me a mobile phone because it harms health. (Mobile phones) There are people who clone their beloved animals, when they die from an accident, to have them back (Cloning)
Classroom Agents	About each other within the classroom discussion, either describing their views and positions, or attacking them.	Most of you have been in favour of animal cloning, but very few about human cloning (Cloning) Since you say that mobile phones create health problems you are against them (Mobile phones) Petros is an idiot for believing that argument 5 is the best argument of all (Cloning) I think that you became a hunter because you like it (Hunting)
Products	About their arguments, claims and explanations in a meta-level discussion.	This argument is very important because it deals with health (Mobile phones) What you have said about the animal is the same as the human being (Cloning) What you have told me is not a reason for buying or not a mobile phone. I need reasons (Mobile phones)
Argumentation and Decision Making Process	About argumentation process, or decision making process and their elements.	An argument is a reason in favour or against a view (Cloning) I cannot just count pros and cons and decide about an issue. I have to weigh arguments (Mobile phones) We should take sub-issues one by one in order to have a good discussion (Hunting)
Pedagogy	About pedagogy, or the lesson.	I do not want to go through this issue because this is another issue (Cloning)

Table 10: Socioscientific content categories

When the analysis had provided the socioscientific content entities, then the typology of dialogues (Walton & Crabbe, 1995) was applied to classroom talk.

A criterion to describe dialectical context as a type of dialogue described by Walton and Crabbe (1995) was that the conversation had to be identified in the issue or sub-issue level. In other words, argumentation for persuasion, deliberation, information seeking and eristic (from the ancient Greek word Eris meaning fight or conflict dialogues) were all classified as such, if and only if agents have been talking about the issue, or any other sub-issue that had come out due to argumentation chains.

Put as an example, if an agent was supporting the view that we should hunt because this is a sport and it is healthy, his context had been defined as "argumentation for persuasion (about the issue)" whereas, if he was arguing that hunters like hunting because they discover how ancient people had lived, an argument supporting an explanation of why people hunt (with no other link indicating that this explanation supports or not hunting) his context has been described as "argumentation for action explanation".

Argumentation for action explanation, alongside other contexts that were identified is going to be presented in the results chapter, in the socioscientific context section. A clarification though that has to be done at this stage is that the description of context refers to each interlocutor whose utterance was to be analyzed. The fact that agents of the discussion have been identified as holding different goals - some supporting a view, others admitting that they do not hold a position and others deliberating by bringing up information but do not link it in any argumentative way to the issue under discussion, all in the same episode, implied that context has to be assigned in a personal, topical level, even though the task that the teacher had assigned might have an argumentative, or deliberative nature, for example.

3.4.2 Describe Moral, Emotional-Reflective and Cognitive Processes

The first research question of this study, that has a methodological character, refers to the identification and description of moral, reflective and cognitive processes in the lesson as distinct areas.

Again, there was no input from science education about what could be used as a methodological tool that could capture those areas. The inputs from the literature review related to moral reasoning (see Appendix A) had enlightened the study towards the following direction:

Moral reasoning cannot be regarded as independent from cognition. Feeling, willing and thinking, are regarded as inseparable elements of moral reasoning (Poole, 1995), whereas moral judgment, according to cognitivists is a product of inquiry, a reasoned guided process. According to a cognitivist's view of moral reasoning, moral sentences are subject to truth or falsity, and the state of mind of accepting a moral judgment is typically one of belief (Van Roojen, 2009).

Even if we do not endorse a cognitivist view of moral reasoning and endorse an emotivist view, which interprets the process of moral judgment as one of depending on feeling and desire, we still have to admit that reason has a place in this process, since, according to Hume (as cited in Jacobs, 2000, p.131) moral judgments are based on moral emotions: emotions that recognize the situation as morally relevant by identifying morally relevant features in one's environment, in order to be reasoned about. Reason is in service by giving us the relevant data, even if, in Hume's words, "reason is, and ought to be, the slave of the passions." (Hume, 1739-1740 as cited in Fieser, 2006).

On the other hand, if we endorse an emotivist view of moral reasoning then we have no need to draw a border line between moral judgment and emotional reflection since, emotivists think of moral terms in grammatically assertive utterances that function primarily to express emotion and perhaps also to elicit similar emotions in others; they thus assume that moral evaluation such as “right”, “good” or “virtuous” signals a non-cognitive pro-attitude such as approval or preference (Barnes, 1933; Ayer, 1952; Stevenson, 1946 as cited in Van Roojen, 2009).

The conclusion from the above paragraphs is that the three areas mentioned in Zeidler’s and Keefer’s construct (moral reasoning, cognitive reasoning and emotional reflection) were overlapping either accepting cognitivist, or emotivist views of moral reasoning. Therefore, Zeidler’s and Keefer’s (2003) construct could not be used as a methodological tool for analysis. The problem was identified in the “cognitive” part of the construct and was resolved at a content level. Morality and emotional reflection could be regarded as distinct, perhaps not as process, but as they refer to different objects: morality deals with states of affairs and regulates human conduct, whereas emotional reflection refers to desires, attitudes and preferences. The problem was the definition of the “cognitive” part. How could cognitive elements be defined in terms of content? What does cognition deal with? It is evident that cognition deals with everything, and states of affairs are a part of it, even observing and analyzing our own emotions might be a part of it. And if the cognitive part might exist in moral reasoning and emotional reflections, to what else might it refer?

Primary data analysis had enlightened this process, since categories such as “Natural Sciences”, “Sociology” and “Psychology” had emerged as areas describing the content of the lesson. The direction moved from describing the “cognitive part” to describing the “epistemic part” of the lesson. There was a need therefore, to have a tool that could help towards the direction of describing the different epistemic - or other areas - of the lesson and accordingly assign epistemic practices of classroom agents to those areas.

A theoretical construct that was used for determining the border lines between those areas was Peirce's (1839-1914 as cited in Pietarinen, 2006, p.130-132) taxonomy of the Sciences (Table 11).

- **A. Science of Discovery (Heuretic science, Explanatory science)**
    - a. Mathematics
        - 1. Formal logic
        - 2. Discrete mathematic
        - 3. Continuous mathematics
    - b. Philosophy (cenoscopy, *philosophia prima*)
        - 1. Phenomenology (phaneroscopy)
        - 2. Normative sciences
            - i. Aesthetics
            - ii. Ethics
            - iii. Logic
                - a. Speculative grammar
                - b. Critic (Logic proper)
                - c. Methodeutic (Speculative rhetoric)
        - 3. Metaphysics
            - i. Ontology
            - ii. Physical metaphysics
                - a. Cosmology
                - b. Time and space
                - c. Matter
            - iii. Religious metaphysics
                - a. Theology
                - b. Theory of freedom
                - c. Doctrine of another life
    - c. Special sciences (Idioscopy)
        - 1. Physical science
            - i. Nomological (general) physics
                - 1. Molar physics (dynamics, gravitation)
                - 2. Molecular physics (thermodynamics)
                - 3. Etherial physics (optics, electrics)
            - ii. Classificatory physics
                - 1. Crystallography
                - 2. Chemistry
                    - a. Physical
                    - b. Organic
                    - c. Inorganic
                - 3. Biology
                    - a. Physiology
                    - b. Anatomy
            - iii. Descriptive (explanatory) physics
                - 1. Geognosy (geology, geography)
                - 2. Astronomy
        - 2. Psychic sciences (psychognosy, human sciences)
            - i. Nomological physics (general physics, psychology)
                - 1. Introspective psychology
                - 2. Experimental psychology

            3. Physiological psychology
            4. Developmental psychology
        ii. Classificatory physics
            1. Special psychology
                a. Human psychology
                b. Social psychology (economics)
                c. Animal psychology
            2. Linguistics
                a. Phonetics
                b. Word linguistics
                c. Grammar
            3. Ethnology
                a. Social
                b. Development
                    1. Customs
                    2. Laws
                    3. Religion
                c. Technology
        iii. Descriptive physics (History, Individual subjects)
            1. History proper
                a. Monumental history
                b. Ancient history
                c. Modern history
            2. Biography
            3. Criticism
                Literacy criticism
                Art criticism
B. Science of review
C. Practical Science

Table 11: Peirce's (1990) classification of the Sciences (source: Pietarinen, 2006, p.130-132)

Peirce's (1990 as cited in Pietarinen, 2006) classification was selected as it provides a means to analyze an interdisciplinary area that is controversial issues teaching in its basic building blocks, in other words describe the "disciplines" that form the "interdisciplinary". Peirce classifies Aesthetics, Ethics, and Logic as belonging to a branch of Philosophy which he calls Normative Science. He also classifies Metaphysics as another branch of Philosophy. The Sciences belonging to Philosophy are not based on experiences or experiments in order to set theoretical questions, and therefore are distinguished from Special Sciences (Idioscopy) that resort to special experience or experiments in order to settle knowledge claims.

Physical (Natural) Sciences are a class belonging to Idioscopy which includes Physics, Chemistry, Biology, Geognosy and Astronomy.

The second branch of Idioscopy refers to "Psychical", the Sciences that study the human and not the nature (psychi: soul, physi: nature).The group of Psychical includes Psychology, Ethnology, Linguistics, and finally descriptive Psychics (History, Biography).

He also follows the Aristotelian tradition as he proposes a distinction between theoretical sciences of discovery and the practical sciences of human conduct and art, whereas he adds a third main class, the retrospective sciences of review, a class that includes issues concerning the history of science, the classification of sciences itself, and synthetic forms of philosophy, the philosophy of science (Pietarinen, 2006, p.134).

Even if Peirce's taxonomy has been published a century ago, it is selected as an appropriate classification tool because, as Pietarinen (2006) cites, "the boundaries of the overall classification of the sciences that Peirce provided have not been probed to any great extent in terms of their breadth, even though the content has, of course, accumulated in depth" (p.129).

Actually, Peirce's taxonomy could describe both moral reasoning (Ethics as a Normative Science belonging to Philosophy) and emotional reflection, as this could be assigned to the class of Introspective Psychology, which is defined as the science of self-observation and reporting of conscious inner thoughts, desires and sensations.

Data analysis had applied this tool as a methodological scheme to classify propositional statements to the disciplines described above and therefore describe the epistemic content of the lesson. A primary step though to this kind of analysis was to extract the thematic content of the lesson.

3.4.3 Thematic Content of the lesson - Epistemic Content

The thematic content of the lesson had to be captured under an analysis of the content of the discussion in the classroom. We therefore had to adopt an approach to analyze classroom talk in terms of propositional statements and accordingly categorize those statements.

This study shares the view that both reasoning practices and concepts are in part cultural constructions; consequently, this study does not focus on individual students' constructions of identities but rather uses classroom talk as records of communication events rather than reports of private sense making (Hogan, et al., 2000, p.382). As cited in the introduction chapter, when talking about the thematic pattern of the lesson, "the scientific story" (Mortimer, 1993) we cannot assume that this story has been "conceptualized" as "common knowledge" by all students (Scott, 2007). The thematic content of the lesson stands as an entity that is differentiated from private sense making; it rather refers to "collaboratively shared knowledge objects" (Hogan, et al., 2000).

The thematic content of the lesson, therefore, as perceived in this study, is the substance of the conversation, the substantive matters being discussed. It is captured from the meaning of the statements, the topics about which students and teachers speak.

As Bridges (1988) cites, one cannot simply "discuss", nor have a "discussion"; discussion always involves a subject, question matter or issue which is "under discussion" (p.16). Lemke (1990) provides some insight as to what could be captured as "content" in a science lesson. He recognizes two patterns in a science dialogue in the classroom: an organizational pattern, represented by its activity structure and a thematic pattern (p. 13). As he argues:

> *”In all dialogues there are at least two different things going on. First, people are interacting with one another, move by move, strategically playing within some particular set of expectations about what can happen next (the activity structure). But they are also constructing complex meanings about a particular topic by combining words and other symbols (the thematic pattern)” (p. 14)*

He also assumes that every move of a dialogue has meaning both as a part of a thematic pattern and as a part of an activity structure, and thus, it is not always easy to carry out both a thematic development strategy alongside a social interaction strategy and sometimes the teacher has to choose between them. The implications for analysis of classroom talk are evident: it must always take into account both of these two dimensions and how they relate to one another, moment by moment (Lemke, 1990).

3.4.3.1 Conceptualizations from speech act theory

In order to be able to differentiate between thematic and activity structure, this study has used conceptualizations from pragmatics and especially speech act theory (Austin, 1962; Searle, 1985).

According to the speech act theory, any speech act has two distinct dimensions: the proposition, which is communicatively inert, and the “move in a language game” that the utterance consists of, the illocutionary force of the utterance (Green, 2007). The illocutionary force can be used to characterize and group illocutionary acts, and is categorized according to Searle (1985) in the following categories:

1. Assertives: we tell people how things are

2. Directives: we try to get people to do things (ask, order, request, beg, plead, pray, entreat, and also invite, permit and advice)

3. Commissives: We commit ourselves to doing things

4. Expressives: We express our feelings and attitudes

5. Declarations: We bring about changes in the world through our utterances

(p.vii, pp.1-9)

This categorization provides a useful unit of analysis in terms of describing the thematic content of the lesson. However some issues have to be discussed and refined.

3.4.3.2 Propositions and thematic content

A first issue of discussion is whether all speech acts could be used to describe the thematic content of the lesson. According to the speech act theory, illocution acts presented above, differ in the forms of propositional content but also in their direction to fit the world. According to Searle (1985), some illocutions have as part of their illocutionary point to get the words (more strictly, their propositional content) to match the world, others to get the world to match the words (p. 12). Accordingly, those acts have differences in expressed psychological states. How illocutionary acts vary alongside those dimensions (Searle, 1985, p.253-270), is presented in Table 12.

Type of proposition	Propositional content	Direction of fit	Point of purpose
Assertive: *I think the film is moving.* States, explains, asserts or claims	p: the proposition uttered	The words fit the world	Commit the speaker (in varying degrees) to something's being the ease, to the truth of the expressed proposition
Directive: *Close the door!* Asks, orders, commands, requests, begs, pleads, entreats, invite, permit, advise	The hearer H does some future action A.	The world fits the words	The speaker is attempting (in varying degrees) to get the hearer to do something.
Commissive: *I will bring you that book.* promises, vows, threatens	The speaker S does some future action A.	The world fits the words	Commit the speaker (in varying degrees) to some future course of action
Expressives: *I'm sorry for the mess I have made.* "thank", "congratulate "."apologize", "condole", "deplore", "welcome"	Different possible psychological states expressed	There is no direction of fit *(In performing an expressive, the speaker is neither trying to get the world to match the words nor the words to match the world; rather the truth of the expressed proposition is presupposed*).	Express the psychological state specified in the sincerity condition about a state of affairs specified in the propositional content
Declarative: *I declare the meeting open.*	p: the proposition uttered	Both words-to-world and world-to-words	The successful performance of one of its members brings about the correspondence between the propositional content and reality, successful performance guarantees that the propositional content corresponds to the world.
Assertive declarations a special class of declaratives: *You are guilty*			

Table 12: Illocutionary speech acts (source: Searle, 1985, p.253-270)

3.4.3.3 Speech acts out of thematic content

Speech acts as defined above were used as a unit of analysis for this study. Each utterance was analyzed to one or more speech acts, according to their force and propositional content. Not all speech acts however could be used to describe the thematic pattern of the lesson. Table 13 shows how speech acts informed the thematic pattern analysis, a process elaborated in the next paragraphs.

Simple speech acts Unit of analysis: speech act			
Speech acts	**Elements**	**Thematic pattern of the lesson**	**Example**
Assertives	Knowledge claims, information, descriptions, hypotheses, points of view, positions	Propositional content	Scientists clone animals to save the food chain. Cloning is bad. I am against cloning. Mobile phones might harm brain. My brother is 10 years old. Even nuns in monasteries eat meat.
Commissives	Intentions related to personal dilemmas	Propositional content about the speaker	I would clone my dead cat.
Declarative assertions	Decisions	Propositional content	We have decided that buying your brother a mobile phone is not a right action.
Directives	Instructions	Out of content	Write down three arguments against cloning.
Indirect directives	Descriptions-Instructions	Out of content	I am sure you can write more than two arguments.
Declaratives	Declaratives	Out of content	The presentation about cloning has just finished. Our lesson has ended now.

Table 13: Simple speech acts propositional content

Directives were taken out of content since they are speech acts that do not describe the world, but they rather make the world fits the words. An utterance of the type *Please open your notebooks and write three arguments against cloning* is a move that hasn't got any meaning as a part of the thematic pattern of the lesson. It can only be analyzed as a part of an activity structure, it cannot describe what students and teachers have *talked about*.

Additionally, questions were taken out of the thematic content. According to Searle, questions are a special class of directives as they ask from the hearer to perform the speech act of asserting what is asked in the question. Therefore, according to Searle the question “Do scientists’ discoveries affect our lives?” is a directive with propositional content “students answer this question”.

According to Walton (1989, p.27) questions do not have propositions, but they do have presuppositions: propositions need to be acceptable to the respondent when the question is asked so the respondent becomes committed to the proposition when he/she gives any direct answer. In this way, asking a question may be a form of asserting propositions in a dialogue. However, since the content of a question is probably going to be a *set* of propositions (the possible answers to the question) and not a proposition (MacFarlane, 2009) questions cannot be used for analysis of the thematic content of the lesson.

Another category of speech acts that does not describe the world but fits the world into words is one of commissives. Utterances of the type “*I will write down everything you tell me*” commit the speaker to do the action uttered and consequently do not need to be included in the thematic content of the lesson. The action uttered in this commissive is not related to the thematic content of the lesson since it refers to the activity structure.

The problem arises when we have to deal with speech acts of the type "I would (not) clone my dead cat" that actually consists of decisions related to personal dilemmas. Are those commissives or not?

One problem about commissives is that even if they commit the speaker, student or teacher, to perform an act in the future, a hypothetical one when talking about a hypothetical dilemma, utterances of this type could be translated into assertives. Consider the example given above:

I would clone my dead cat.

When a student commits himself to cloning or not his cat, at the same time he/she informs his teacher and classmates about his/her intentions, or points of view.

The use of commissives related to personal dilemmas as assertives is important for this study since self reflection processes are to be described and evaluated. When issues are not put in a macromorality but in a micromorality mode (Zeidler, et al., 2004) students do not express points of view but their personal intentions or decisions towards hypothetical dilemmas (clone a dead cat, go for hunting). They both take a position but in the same time they inform the others about themselves. An analysis that would allow the description of self reflection processes in terms of lesson content, needs to consider those types of commissives - when a student or teacher commits him/her self in doing action A (related to the issue under discussion) - as a special type of assertives: student or teacher is informing the rest of the class about his/her intention to do action A.

Another issue that concerns propositional content are utterances that are expressions of points of view. A range of such utterances can be found in any argumentative discussion and in the lessons under study:

Hunting is unfair for birds (Lesson C)
Birds have soul (Lesson C)
Mother of Dolly is the one that gave DNA and not the one that gave birth (Lesson B)
Mobile phones affect our health (Lesson A)

In a first place, those utterances, according to Van Eemeren and Grootendorst (1984, p.96) are difficult to be classified as assertives since the criterion that Searle assigns to this category, is that the propositional content must always be capable of being characterized as true or false. Points of view cannot always meet this criterion, especially when they are of the form of ethical, aesthetic or normative statements. However, as Van Eemeren and Grootendorst (1984) cite, attitudes or points of view need not refer exclusively to propositions that are either true of false but may also relate to other propositions whose acceptability (in the broader sense) may be a point of discussion.

Another issue concerning the expression of points of view is non-propositional points of view. Utterances of the type:

I agree with cloning.
I'm against cloning.
I'm fanatical about cloning.

have to be differentiated from utterances of the type

Cloning is unethical
Cloning is bad
We should not clone.

The first group of utterances refers to the psychological state of the speaker towards the issue. Should they be classified as expressives?

According to Searle (1985) an expressive is a speech act that expresses the psychological state specified in the sincerity condition about a state of affairs specified in the propositional content. The key point here is that, what is expressed refers to a state of affairs between the speaker and the hearer. As Searle comments, “I cannot congratulate you on Newton’s first law of motion”. Expressives then, should be differentiated from speech acts that express feelings or describe the position of the speaker towards an issue. Those speech acts are assertives; they are not about a state of affairs between the interlocutors, but they rather describe the speaker’s psychological state; even if they cannot be tested as true or false, their propositional content fits the world - the internal, psychological state of the speaker - into words.

This consideration is even more evident in expressions of non-points of view like:

I am both yes and no.
I have not decided yet.

Those utterances have the same force as “I would not clone my dead cat”. They have though different propositional content: some refer to citing, describing the speaker’s position or point of view towards an issue, and others to intentions/decisions towards hypothetical personal dilemmas.

Another issue that had to be taken into account is the existence of indirect speech acts. For instance, to use Searle’s example, the remark that you are standing on my foot is normally taken as not an assertion that only describes reality, but it is in addition, a demand that you move; accordingly my question whether you can pass the salt is normally taken as a request that you do so. An assertive sentence might be an indirect directive (Searle, 1985). This creates an issue for data analysis as some utterances could be categorized in more than one category.

Such examples were evident in the lessons, where one speech act was an indirect other type of speech act. One class of indirect speech acts refers to assertions that served the purpose of indirect directions. For example, a teacher in an effort to make students cite more arguments says:

- *I'm sure that you can find more arguments than those you have already told me.*

A speech act of this kind is rather categorized as a directive, rather than an assertive statement. Recognizing indirect directive speech acts however, could not be based on a single, stable criterion. It depends on the context of the conversation. As Green (2007) cites, the identification of an indirect speech act would seem to depend on the discussant's intentions. Consequently, indirect speech acts, can be explained within the framework of conversational context.

Assertives as indirect directives however, are not the only examples of indirect speech acts. Searle (1985) refers to another kind of indirect speech act. Those refer to speech acts whose meaning is different than their propositional content. Searle cites the following example of dialogue:

-*Are you going to the cinema tonight?*

-*I have to study for an exam.*

Studying for an exam is not directly related to going to the cinema. However, it is a reason for not doing the action proposed in the first utterance. Providing reasons for doing or not doing, willing or not willing to do something is argumentation. Van Eemeren and Grootendorst (1984) regard argumentation not as an indirect speech act, but as a complex speech act (p. 32). This act differs from the others in the following aspects:

a. Unlike other speech acts (asserting, requesting, promising etc) in argumentation more than one proposition is always involved.

b. The utterance of an argumentation, as a speech act, always has a dual illocutionary /communicative force: besides functioning as argumentation, it is also an assertion, a question, a form of advice, a proposal, or whatever.

c. Argumentation cannot stand by itself, but is always in a particular way linked to another speech act that expresses a standpoint. If this specific relation is absent, referring to the speech act as argumentation is not justified (Van Eemeren & Grootendorst, 1989, p. 368).

The issue is of special interest for the purposes of this study. The discussions about controversial issues in the lessons under analysis were in a great part argumentative. Extracting the thematic content of argumentation was one of the most difficult parts of this study. The process is described in the next paragraphs.

3.4.4 Propositional content of argumentation and epistemic practice

A question that had to be answered is: what is an argument? How is this defined and therefore extracted from an argumentative discussion? The answer rests on a process-product analysis of argumentation. Blair and Johnson (1987) identified four central features as characteristic of a dialectical conception of argumentation:

- A product/process link: an argument understood as product - a set of propositions with certain characteristics - cannot be properly understood except against the background of the process which produced it- the process of argumentation

- The roles of arguers: “The process of argumentation presupposes a minimum of two roles” (here identified as that of questioner and answerer)
- The beginning of argumentation: The process of argumentation is initiated by a question or doubt - some challenge - to a proposition.
- The purposive nature of the activity of argumentation: “Argumentation is a purposive activity. Each participant has the goal to change or reinforce the attitude of the interlocutor or of himself (Blair and Johnson, 1987, as cited in Walton & Godden, 2007, p. 3).

The last point reveals the interrelationship of process and product: the participants’ goals to support or counter on one hand, but the existence of a propositional content in which they refer, on the other. This description is in line with other scholars who define argument as a social operation, which is oriented to context and to purpose (Mork, 2000), or a goal-directed form of interactional activities in which both the content of argumentation and the discourse structure within which it evolves are sensitive to the goals the arguers pursue in specific contexts (Van Eemeren, et al., 1987 as cited in Leitao, 2001; Walton, 1990, p.411).

The above conceptualizations imply that extracting argument as a product cannot be isolated from adopting a process analysis for describing argumentation moves. In other words, an analysis that aims to extract the propositional content of argumentation needs to take into account the goals of the participants on one hand, and the propositional content to which those participants were referring.

A unit of analysis used by many studies for extracting arguments from argumentative talk is Toulmin's' (1958) argument pattern. Studies that have used Toulmin's argument pattern (1958) admit that the application of such a pattern has yielded difficulties when applied in classroom-based verbal data, with the main difficulty the clarification of what counts as claim, data, warrant, and backing (Erduran, et al., 2004, p.919). The same authors imply that only careful attention to the contextualized use of language could provide information as to how different elements of speech could be classified as Toulmin's pattern elements. This is compatible with Toulmin's view that the entities in his model do not represent static, abstract entities but they rather describe processes alongside products.

According to Toulmin (1958) the utterances that make up an argument have different functions: claims can be questioned in the context of a discussion when two or more participants disagree between them, grounds are the "the facts we appeal to as a foundation for the claim" but as soon as they are challenged then become claims (as cited in Russell, 1983, p.33), warrants are situated in the steps, in the movement from data to claim (Toulmin, 2003, p.93). A careful reading of those lines implies that the components of this model have to be situated in the process of "disagreeing", "backing" and "rebutting".

3.4.5 Reconstructing classroom talk: Extracting the products of argumentation

Reed and Walton (2007) describe the process of extracting arguments from an argumentative talk as follows:

> *"First, to identify the argument, and to classify it as an argument, as opposed to some other speech act like an explanation, one has to identify the conclusion as a specific proposition that doubt is being expressed about, or at least that is open to doubt"(p.2).*

The identification of the doubted conclusion leads to what Walton and Godden (2007, p.8) describe as the product view of argumentation (Figure 8):

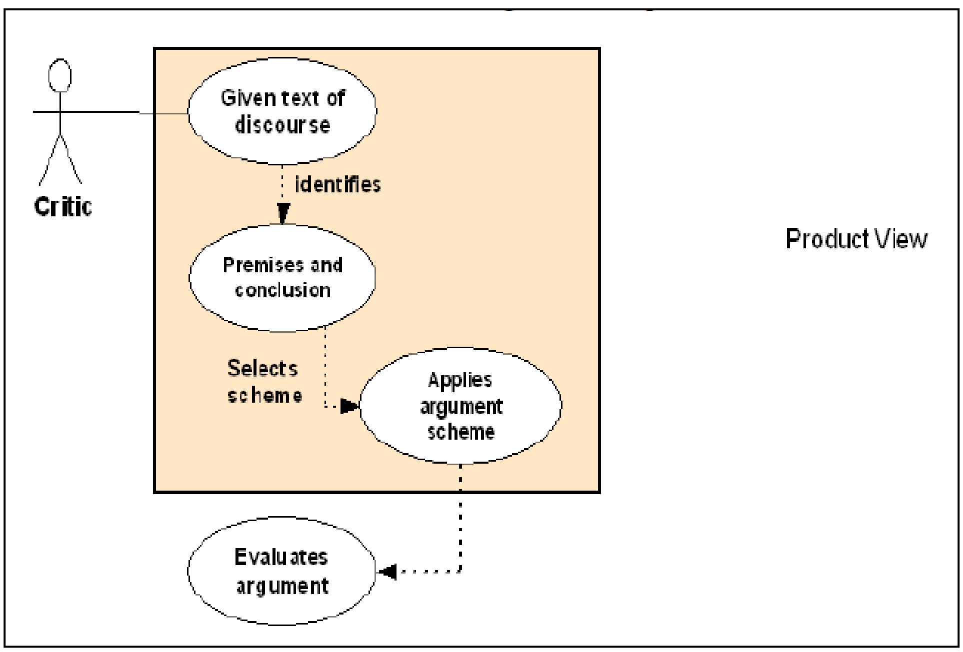


Figure 8: Product view of argumentation (source: Walton and Godden, 2007, p.8)

Although Walton and Godden refer to a process of evaluating argument, this study has used this approach in terms of reconstructing argument. It follows the steps of identifying premises and conclusions and applies the argument scheme in order to extract arguments as outputs of the process of argumentation.

A step that has enabled the analysis of this study was one of answering the question: if not argumentative - support or doubt - then what goals would a discussant have in a discussion? The need to identify the goal of a participant as argumentative was important as it served as a criterion to classify the speech act as complex and therefore complete any missing statements, and not as an unlinked premise. The identification of the context was enabled from the process analysis described above that was used to describe the dialectical context of the study.

The following step that had to be taken was the application of argument schemes in order to extract the arguments as products. The ground for the typology of argument schemes that has been used in this study is presented in the subchapter *2.4 Reasoning and argumentation: a justification of a typology of argument schemes*. As supported in this subchapter, the unit of analysis for each argument was the argument scheme, and the use of analytic arguments as an argument scheme had enabled the analysis of complex chains of argumentation. A special case of arguments that had to be further clarified was that of convergent arguments (Conway, 1991 p.145)

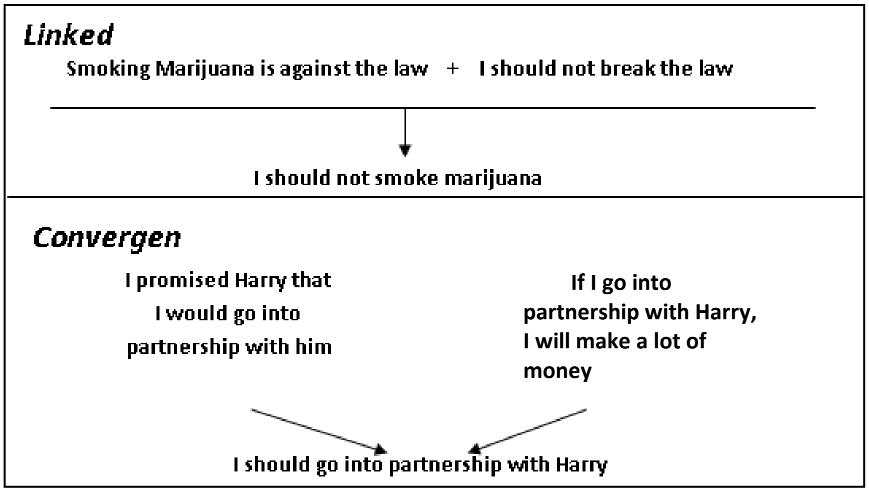


Figure 9: Linked and convergent argument examples (source: Conway, 1991, p.145)

As Conway (1991) argues, “premises that are individually relevant to a conclusion are to be diagrammed as providing convergent support for that conclusion whereas premises that are relevant to a conclusion only when conjoined are to be diagrammed as linked”. The problem for analysis though is that convergent arguments need to be reconstructed as such for reasoning purposes: considering the premises together gives more support for the conclusion rather than considering them as two separate arguments, and therefore the conjecture between the two cannot be omitted from an analysis that aims to capture the reasoning process. On the other hand, if we look carefully at the diagram of the convergent argument above, we soon realize that convergent arguments actually contain two linked arguments, in that the premises need different warrants to reach the conclusion. If the agent had promised Harry to go into partnership with him, he needs a warrant of the type “I should keep my promise”, in order to get the conclusion for actually getting into the partnership, whereas, making a lot of money is a means end syllogism that implies the action as necessary/efficient for achieving the means of being wealthy. In that sense a product analysis of a divergent argument of this type should consider not only both syllogisms, but also the fact that the agent had used them together in order to further support his/her conclusion.

The use of divergent arguments also resembles what Wooldridge et al (2005) label propositional use of argumentation. The creation of a divergent argument rests on a meta-level of argumentation, the two premises used in a divergent argument are actually two different arguments - though they might need each other in order to be strong- and actually indicates a higher level of thinking. The agent goes beyond forming individual arguments to the calculation of them by combining them, using the convergence criterion.

The above considerations imply that the linked-convergent criterion has to rest in a prior level of analysis, before the application of the argument scheme. As a result the application of argument schemes had been done after identifying the relationship between the premises and the conclusion, linked or divergent.

The application of argument schemes to classroom discussion was a process that was enabled by talk reconstruction. This process has applied what Van Eemeren and Grootendorst, (1989, pp. 375-380) describe as four dialectical transformations that an analyst needs to carry out in order to reconstruct argumentative discourse:

a. Deletion
b. Addition
c. Permutation
d. Substitution

The following paragraphs show how those transformations have been applied in classroom discourse in order to reconstruct classroom talk and apply argument schemes.

3.4.5.1 Deletion

Deletion is defined as the selection of elements from the original discourse that are immediately relevant to the processes of resolving the dispute: elements that are irrelevant such as elaborations, clarifications, anecdotes, and side-lines, are omitted (Van Eemeren and Grootendorst, 1989). Consider the following episode as an example of deletion from Cloning lesson:

> ~~“186Teacher: Nicholas, are you in favour or against? (cloning animals)~~
>
> 187.Student: I’m against, because all animals will be the same and they will lose their value.
>
> ~~188Teacher: Ok then, Nicholas says… who is against.~~
>
> 190. Teacher: He says that all animals will be the same and will lose their value, they will lose their attribute of being unique, it will not have…
>
> ~~191Student: They will not be unique~~
>
> ~~192Teacher: They will not be unique, very nice!~~
>
> ~~193. Teacher: I will write down: Uniqueness, what about this?~~
>
> ~~194. Teacher: This is Nicholas’s argument. Let’s hear another student”~~

What we need to keep from this argumentative session is the argument that all animals will be the same and this is something bad for the student as it supports his negative position. Line 190 is regarded as different from line 187 since the teacher makes a deductive syllogism of the type: since all will be the same they will not be unique, that's why they will lose their value. The teacher in this case acts as an analyst and provides the unstated premise to fill the student's chain of reasoning. All the other sentences repeat/clarify the same propositional content of the statements composing the argument in line 187, or are irrelevant in the issue resolution; an argument scheme cannot be applied here.

Line 194 though is propositional, and rests in a metadiscussion level: the teacher extracts the argument and "sends" it back to the classroom.

The argument scheme to be applied here is a practical scheme, reasoning from consequences, and the product we get from this episode is the following:

Syllogism	**Scheme**
All animals will be the same. Deduction Animals will not be unique.	Theoretical Analytical argument
Animals will not be unique. Being unique assigns value. Animals will lose their value.	Theoretical Normative (value of being unique)
Animals will lose their value. This is an undesired consequence. We should not clone animals.	Practical From consequences

Table 14: Applying argument schemes by deletion

3.4.5.2 Addition

Addition is described as the process of completion which is the supplementation of those elements left unexpressed in the original discourse: unexpressed premises, conclusions and other elements in the various stages of discussion (Van Eemeren & Grootendorst, 1989). Consider the following episode as an example of addition from the cloning lesson:

"245. Student A: If I had a pet, cat or anything, and it had an accident and died, I would like to clone it and have it back again.
246. Student B: And have it back??
(………)
252. Student C: I disagree with this.
253. You have lived good and bad times with the authentic cat and not with the cloned one."

The statement "you have lived good and bad times with the authentic cat and not with the cloned one" has to be connected somehow with the reason "I would like to clone my dead cat to have it back again". There is something unstated here, a premise that might bridge the two in terms of reasoning.

Additions however, have to be done with care: the reconstruction needs to be as close as possible to what has been said. Missing statements can be added with the application of argument schemes.

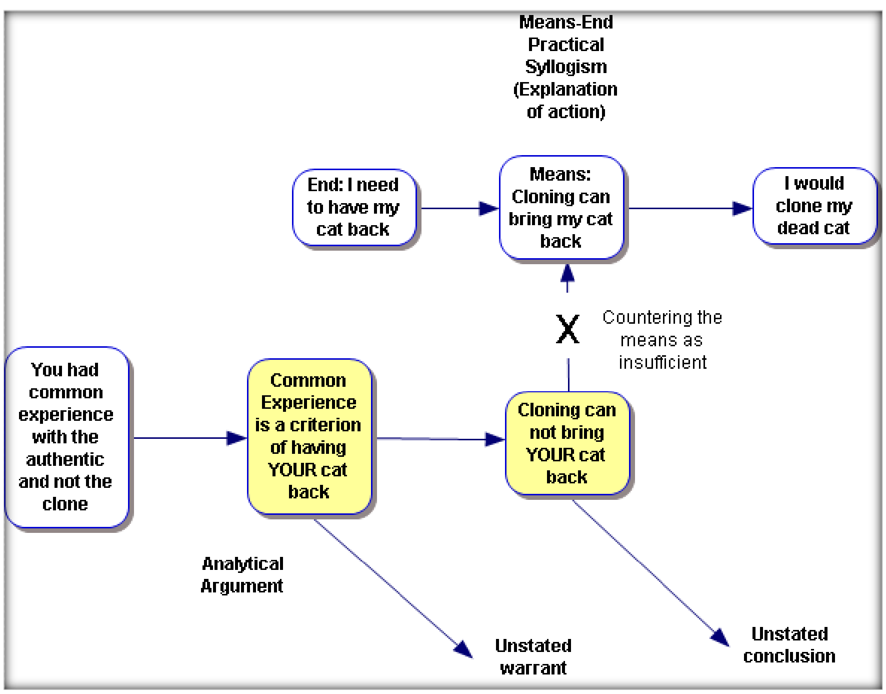


Figure 10: Additions for argumentative discourse reconstruction

If we reconstruct the first argument as a means end practical argument (actually it is an explanation of intention which takes the form of a means end practical syllogism) then the student supports his action of cloning the cat as a means to his goal to have his cat back. The second student explicitly cites that she disagrees with the previous argument. So we need to find out what does she counters when she provides the reason "you have common experience with the authentic and not the clone". If we add a new premise "Common experience is part of being your cat" we easily reconstruct the syllogism as rebutting the efficiency of cloning as a method of "bringing your cat back". This of course is under question, since another analyst might have reconstructed differently the discussion. One of the rules that this study has applied, is that additions were as little as possible and did not add more than one warrant in the argument map. For example, in the above example, once you add the unstated warrant, "common experience is part of being your cat" the other syllogism is deductively reconstructed with no need to add any further warrant.

Another factor that was taken into account when adding missing statements was that of dialectical context. Where the student did not explicitly add a disagreement or agreement and just cited a premise that could confront a previous argument the analysis did not reconstruct the talk as argumentative but as deliberative or inquiry and therefore, missing statements were not added; the utterance was regarded as an unlinked premise. Unlike Van Eemeren and Grootendorst (1989) for considering the discussion as maximally argumentative, this study has applied a "minimally" argumentative reconstruction for the following reasons:

a) Van Eemeren and Grootendorst (1989) reconstruct an ideal model of discussion, a critical discussion in which the two interlocutors have agreed to engage , since they both have difference in opinion. Any statement therefore that the interlocutors exchange may be a part of “winning the game”. Students in the classroom are not committed to such a role; they are just there and might be in a deliberation mode and not a persuasion one; therefore, by citing a premise that could construct an argument they could express a doubt but not a rebut, they might contribute to the pool of reasons that could be used to construct arguments but still, not argue. There might be more reasoning beyond the uttered premise, but also may not. Therefore, reconstructing the discussion as maximally argumentative might be inappropriate in describing classroom argumentative discussions.

b) A critical discussion is a normative model of argumentative discussion. This implies that the reconstruction aims at last to define where the reasons stated are relevant to the conclusion, strongly support the conclusion etc. That’s why an interlocutor or an analyst of such a discussion should analyze it as maximally argumentative in order to perform such examination of soundness, validity or relevance of arguments and thus accept them or not. However, this is not the purpose of this study. There is no need to evaluate arguments, but describe them. Therefore, if there is even a small possibility that they are not arguments, but just unlinked premises, this study analyzes them as single claims and not as complex argument structures.

An example from lesson B further explains the above paragraphs:

> *23. Student: I think you should not buy your brother a mobile phone because it has radiation and will affect his hearing.*
> *24. Teacher: Ok, you cite health problems.*
> *…………………………………*
> *34. Student 2: I think that …..I have heard from TV that radio-energy goes through all children's brain but in the case of adults it does not go through all the brain.*
> *35. Teacher: So you say no because my brother is a child. No, because he is a child.*
> *36. Is that what you say?*
> *37. Student: Yes.*

In the case above, in line 34 the second student has stated a piece of information that is not directly connected to a conclusion at stake (buying or not a mobile phone). The student had just cited that radiation might be dangerous for the child's health. However he does not assume that the teacher should not buy her brother a mobile phone, he does not assume that this is good or bad; he does not even assume that he is convinced by TV or not, about the truth of the statement.

The teacher above uses a maximally argumentative approach for analyzing students' talk. Since the other students were citing arguments against or in favour of buying a mobile phone for a 10-year old child and the previous argument was related to radiation, she regards the statement of the student as supporting the conclusion "Do not buy your brother a mobile phone", something that is not evident from the student's sayings. We will not further analyze the teacher's strategy at this point, but we would say that at least in such a reconstruction the student had been probed to agree to such an analysis and therefore had the opportunity to refuse and provide another conclusion in case he did not mean so (if there was a way to assume that he is not driven by the teacher's authority in the classroom). If the teacher had not elaborated student's reasoning, how could we say from that single statement that the student was in favour or against buying a phone? How can we know that the conclusion is “Do not buy a phone” or is it “Mobile phones harm?” or “There is a possibility that your brother will harm himself” or even assume that there is a conclusion at all? We could even assume that the student hears about mobile phones in a classroom and cites a coherence of the type: “Now you are talking about mobile phones….Oh! I’ve heard somewhere that they harm health”. That’s why we believe that a “minimally” argumentative reconstruction allows us to be on the safe side, having the possibility of leaving some implicit, unstated reasoning beyond analysis, but at least being as valid as possible to analyze what has been said in the classroom.

Returning to our example, if the teacher didn’t clarify the scene, though in a questionable way, the student’s utterance “I’ve heard that mobile phones harm health” should be reconstructed as an unlinked premise and not an argument. In the cases where the teacher had cited the premises, analysis was enhanced with triangulations with teachers’ IPR transcripts. However, this was not possible to be done with students’ arguments also, and this is actually one of the limitations of this study: there was not an opportunity for students to reflect on their own views, as teachers have done by watching the video in the classroom and reflecting on what was going on. A question like, “Ok mobile phones might affect a child’s brain. What does this mean to you? Why have you cited this in the discussion?” would help us deal with those kinds of statements. A study of this kind though would not be feasible for the limits of this study, as 115 students have participated in the lessons taught. Nevertheless, I point out the need for extra data that could help towards a more valid description of students’ contributions to the discussion.

To increase the validity of the analysis, part of the discussion of each lesson (approximately 25%) was reconstructed by a second analyst. The second analyst was a PhD student with a background in classroom talk analysis and argumentation from her Master Thesis. The occurring disagreements between me and the second analyst referred to the level of analysis. The second analyst sometimes has adopted a maximally argumentative analysis, therefore connecting the utterance to the global level and therefore, more additions had to be done to the original text. Discussions were made in order to define the "shortest path" of the syllogism, with the fewest additions possible. In this way the analysis has been kept as close to the local level as possible.

3.4.5.3 Permutation

Permutation is the process of ordering or rearranging elements in the original text in such a way that the dialectical process of resolving the dispute is made as clear as possible (Van Eemeren and Grootendorst (1989). Consider the above episode as an example of the need for permutation from phones lesson:

> *"53. Teacher: Tell me reasons why should I buy my brother a mobile phone*
>
> *54. Student A: If he goes to private lessons.*
>
> *55. Teacher: OK*
>
> *56. Student A: If you go and get him he will hold it when he finishes.*
>
> *57. Teacher: Ok, therefore we need a mobile phone to find my brother. To locate him.*
>
> *58 Student B: You have to tell him that when he buys a mobile phone he has to use it only for a few hours a day.*
>
> *59. Teacher: But the problem that I have told you and I need you to answer me about this, is if I should buy him a mobile phone or not.*
>
> *60. Teacher: Wait until I buy him one or not and then you will tell me what to do.*

61. Student B: You should buy him because he might need it, but also no …

62. Teacher: Therefore you tell me both yes and no.

63. Student C: I am also both yes and no.

64. Teacher:: Therefore, I will put a question mark here.

65. Student D: I am also both yes and no.

66. If he uses it for useless things, then no.

67. If he uses it for useful things, then yes.

68. Teacher:: So, it depends on how he uses it, you say. Aggelos;

69. Student E: No, because when he wants to call when he is in private lessons, he might find other mobiles phones to use; there is no need to use his own mobile phone."

The extract above shows the need to reorder statements that are related, either supporting or rebutting the same conclusion, or a premise from an argument. In lines 54-57 there is a collaborative constructed argument supporting that we should buy the teacher's brother a mobile phone, since we need to locate him when he is in private lessons. A rebuttal to this argument comes in line 69, (12 lines after, some may come much later since we have a group discussion and interlocutors do not respond to each other but may need to have permission to cite their views) after a discussion irrelevant to the specific argument issues. Permutation, therefore, refers to the process of rearranging the discourse so that the utterance in line 69 is considered as a rebuttal to the argument, even if it occurs later in the discourse.

3.4.5.4 Substitution

Substitution, according to Van Eemeren and Grootendorst (1989) is an attempt to produce a clear and explicit presentation of elements which fulfil the same function (some elements may function as arguments although they are formulated as rhetorical questions)

However, as they cite, this process is also done under a maximally argumentative analysis (Van Eemeren, 1987, p.201). According to Van Eemeren (1987), since a standpoint has been stated in the dialogue for acceptance or rejection, with the principle that the relevance of a speech act is being dependent on the presence of the other, elements such as rhetorical questions should be actually reconstructed as statements in arguments. An example of such a rhetorical question is given by Van Eemeren: (1987, p.210):

> *Taking on Gadaffi (Times, April 28, 1986)*
> *If you hear about an accident or two on the highway, will you stop driving an automobile? Please do not allow the terrorists to think they have succeeded.*
> *Alexandros Panagopoulos, Athens*

Van Eemeren (1987) analyzes the question as rhetorical and assumes that it has to be analyzed as “A traffic accident or two in the highway would not stop you from driving an automobile or a similar formulation”, which is actually an argument that could serve the justification of the standpoint “Do not allow the terrorists to think they have succeeded”.

Van Eemeren (1987) supports the reconstruction of such a question as an argument statement, among others, to the essential condition of an argumentative discussion: “Advancing the constellation of one or more speech acts constituting the point of view counts as taking responsibility for a positive or negative position with regard to the propositional content of these speech acts, i.e. assuming an obligation to defend that position if challenged to do so” (Van Eemeren, 1987, p.207).

The application of a substitution therefore, assumes that the interlocutors had already advanced a point of view. The application of such a process though in classroom settings has to be done with special considerations.

Classroom argumentative discussion, as we have already mentioned, cannot be reconstructed according to a normative model of a critical discussion, since the pedagogical moves in the classroom might not always have the goal of the resolution of the dispute, nor are the participants divided into two groups where the one acts as the proposal - defender of a viewpoint and the other one is trying to reject it, or advance another one. Classroom settings are far more complicated with each student being in his/her own context - affected by the classroom context, but still his own - and the teacher as not an equal participator, but as one who also organizes and orchestrates discussion but also acts as a pedagogue.

An example of substitution of a rhetorical question to an argument premise is presented in the following episode:

> *"7 Teacher: The question is the following: Should people of our age hunt?*
> *8 Student: They should hunt because as soon as birds or animals give birth and give life to other animals, if we did not hunt animals they would be increased a lot.*
> *9: Teacher: Therefore, we hunt to control animal population, so it does not increase a lot.*
> *10: Student: Yes.*
> *(…..)*
> *39: Teacher: In countries where people do not hunt or in jungles that people cannot even walk does animal population increase a lot?"*

The teacher in the episode above assigns a rhetorical question in line 39. Actually, the teacher advances a possible rejection to the student's argument that humans need to control animal population, but he does not do it by directly citing his objection. If a student had advanced such a question we would be much more sceptical as to analyzing it as an objection and we would rather regard it as an inquiry about the issue, as a hypothesis stated that could form an objection but still as not an objection, thereby following a "minimally" argumentative analysis as supported in previous sections. Why then assign a teacher such an argumentative mode?

One possible solution to the problem is to follow the conversation and see what happens next:

> *39 Teacher: In countries where people do not hunt or in jungles that people cannot even walk does the animal population increase a lot?*
> *(…)*
> *41 Nature does not find alone the way to ……Konstantinos?*
> *42 Student: In jungles where no human beings hunt, other animals eat them.*
> *43 Teacher: If no human beings are in the jungle then other animals will eat them.*
> *44 Student: Animals that eat them are like hunters, like us.*
> *45 Teacher: Conclusively, the jungle finds its balance. It finds its balance because there are other hunters.*

It is evident here that the teacher orchestrates the construction of a rebuttal to the argument that hunting is a necessary means for animal population. Triangulation with transcripts from IPR also validates this substitution. This teacher himself says about his own intervention:

> *"I had noticed that nobody had advanced a reason like "in places that there are not human beings animal population is controlled", and I had to tell it. However, I thought of this reason this particular time. I had not planned something like this…It was a hard job. "(Teacher of Hunting lesson, IPR, p.7)*

Data analysis in this case therefore, has gone through the substitution process transferring the rhetorical questions to statements forming arguments - rebuttals as follows:

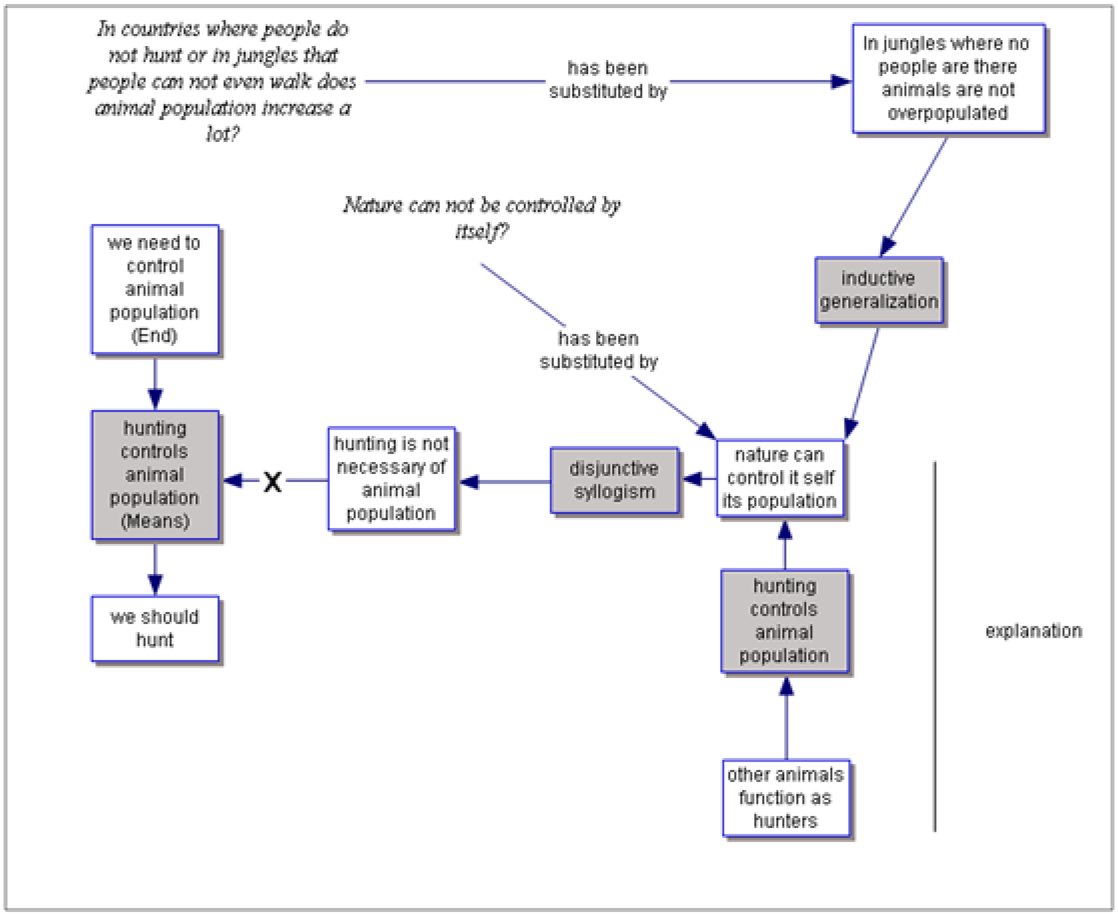


Figure 11: Substitution of rhetorical questions in argumentative talk reconstruction

Interventions were not so clear in all instances, though. There were cases where the teacher-challenger asked questions, but he/she did not advance a rebuttal; he/she rather needed a clarification of students as to what their actual thought was. An example of such an intervention is shown in the example from lesson B:

> *An argument has been stated in previous stages of the discussion that people with special gifts should be cloned so they could advance technology and society. A student raised an objection by citing that there is a possibility to clone really bad people, like Hitler, and then the consequences would be disastrous for humanity.*

448 Student: If the clone is not good, then you kill him.
449. Teacher: To do what?
450. Student: You kill him.
451. Teacher: You kill so easily a life? Why?
452. Student: But he is a clone!
453. Teacher: Therefore, you consider that clones are not humans?
454. Student: Well, if he is bad….
455. Student B: If the clone, teacher, is not good what are we going to do with him?

A maximally argumentative analysis in this case would substitute the question of "You kill so easily a life? Why?" with an objection of the type "You should not easily kill a life!" However the text below shows that the teacher really tries to find out why the student indeed supports the view that it is so easy to kill a life. This question is not rhetorical. As the teacher says:

> *"I just wanted him to tell me how he conceived the issue of clones as human beings. I have to admit that Demetris (the student) is one of the cleverest in the classroom; he is out of sentiments and stays in logic. He has understood the whole process of cloning as an industrial process… he is good you keep him, he is not good you kill him". (Teacher of cloning lesson, IPR p.15)*

Nevertheless, the question stated by student B at the end of this dialogue, is rhetorical and could be reconstructed as a different version of the previous argument: "If the clone is bad, then you have no option but kill him".

In summary, data analysis has used the following schemes-typologies for analysis:

1. Searle's (1985) speech act theory for the identification of propositional/non propositional, simple and complex speech acts.
2. Schellens' (1985) modified argument scheme typology for extracting arguments/syllogisms as products-complex speech acts from classroom talk. The

typology has been revised in the light of argument schemes which emerged from data with a combination from relevant literature input.

3. Van Eemeren's and Grootendorst's (1989) dialectical transformations for reconstructing argumentative talk, with the modification of using a minimally rather than a maximally argumentative analysis, which Van Eemeren (1987) advocates.
4. Walton's and Crabbe's (1995) typology of argumentative dialogues for describing the dialectical context which respectively had affected the decision of whether a speech act might be classified as simple - unlinked premise- or as a complex indicating argumentative, explanatory or exploratory force.
5. Peirce's (1839-1914, as cited in Pietarinen, 2006) taxonomy of the sciences for describing epistemic content and practice.

The unit of analysis was the speech act. (Searle, 1985) The speech acts were classified in simple and complex, propositional or not. Walton's and Crabbe's (1995) typology of dialogues was used to identify whether the talk was argumentative or deliberative, so argument or simple speech act could be distinguished and extracted from the text. The unit of analysis for the argument – as a complex speech act- was the argument scheme (modified Schellens' (1985) typology of arguments).

Once the argument was extracted then the reasoning scheme applied with the contextual context enabled the description of the epistemic practice performed according to the stage of the scientific discovery (Klahr, 2000). For example, an argument from cause to effect was indicating a forming of hypothesis in an initial stage of scientific inquiry or the evaluation of the hypothesis as the best explanation among others in a latter inquiry stage, whereas a cause – to – effect argument might point to an explanation or prediction with the use of accepted /established causal law (knowledge claim).

The following tables provide examples for argumentative talk reconstruction, the application of argument schemes and the assignment of propositional content into disciplines.

Reconstruction of argumentative talk					
Episode line	Reconstructed As	Argument scheme	Epistemic practice	SDDS stage	Situated in Discipline
145. Teacher: Could human beings survive only with vegetables; without meat?	Question (Non Propositional)				
146. Student: No. Because if we did not have meat we would not take energy for our body.	Argument (complex speech act) If we take meat we take energy. *We need energy to survive* (unstated premise) We cannot survive without meat.	From cause to effect	Explains a fact	Uses an accepted knowledge claim to explain another	Biology
147. Student 4: Proteins. Our bones would not be able to grow regularly.	Meat has proteins. Proteins are essential for bones to grow. Without meat our bones would not grow.	From cause to effect	Predicts a fact	Uses an accepted knowledge claim to predict another.	Biology
148. Student 4: I am vegetarian and I do not have problems with my bones, I am fine!	I am vegetarian and I do not have problems with my bones, I am fine! Vegetarians are healthy.(unstated conclusion)	From example	Defends a descriptive generalization	Hypothesis testing	Biology
149. Teacher: You do not eat meat?	Clarification question (non propositional)				
150. Student: I eat meat, but very little.	Clarification answer (propositional but its proposition has always been encountered in the argument scheme in line 150)				
151. Teacher: How about you Valentina?	Pedagogical Question (Non Propositional)				

152. I know many persons that eat only vegetables and are fine. Because vegetables provide vitamins. It is not necessary to eat meat.	Two arguments: *Argument 1:* I know many people that are vegetarian and do not have problem with their health. Vegetarian people do not have problem with their health.	Evidence to hypothesis	Defends a descriptive generalization	Hypothesis testing	Biology
	Argument 2: Vegetables provide vitamins. Vitamins can ensure health. (unstated premise) (That's why) Vegetarian people are healthy.	Cause to effect	Explains a fact	Uses an accepted knowledge claim to explain another	Biology
153. Teacher: It is not necessary to eat meat. Hm…	Repetition				
154. Student: Nuns do not eat meat and they are OK.	Nuns do not eat meat and they are OK (healthy) It's OK not to consume meat.	From example	Defends a descriptive generalization	Hypothesis testing	Biology
155. Teacher: So, our religion allows us eating meat. Did we spend the time for discussing whether we should eat meat or not with no purpose?	Our religion allows us to eat meat Since our religion implies so, it is ethical to act so. (unstated premise- Appeal to Divine Law, or Commitment to Religion) It is ethical to eat meat. (There is no need to discuss about the ethical status of the action)	Appeal to Divine Law	Evaluates action (Practical Judgment)	Practical Reasoning –not related to SDDS stage Moral Reasoning: Establishing moral rules	Ethics

156. Valentina: Our religion allows us to eat meat, but does not force us to eat only meat. We can eat anything. Because we are omnivorous animals.	Two arguments with a convergent link *Argument 1 :* Our religion allows us to eat meat. Allowing eating meat does not mean forcing eating only meat. Our religion does not force us to eat *only* meat.	Analytical argument	Deduces a knowledge claim from another accepted claim		Religion
	Argument 2: We are omnivorous animals (by nature) If you act according to nature you are OK (ethical, right, proper) It is OK (ethical, right, proper) to eat both meat and vegetables.	Appeal to natural law	Supports a practical claim	Practical Reasoning –not related to SDDS stage	Social/Private Policy
157. Teacher: Ok. We should eat all food, including meat. There is no problem eating meat.	Repetition				
158. Teacher: We have finished with this issue I think. Let's go to another issue					

Table 15: Reconstruction of argumentative talk from hunting lesson

The epistemic practices performed by students and the teacher in the episode above (predicting, explaining facts, providing evidential supports and examples to support a descriptive generalization) have been situated in the dialectical context of establishing the necessity of means (eating meat) for an end (be healthy) as true.

This kind of analysis allowed a quantitative representation of results: the description of the situation of epistemic within the dialectic practice uses numbers that actually present the frequency of speech acts assigned to each epistemic area, or epistemic practice. The above episode for example, would provide, two explanations about *wh*y meat is necessary, one prediction and three descriptive generalizations (two from examples and one from evidential support), that support that meat *is* not essential. Establishing meat as necessary for the organism is a practice assigned in Biology and performed within the dialectical context of establishing the necessity of means for the practical judgment about hunting or not.

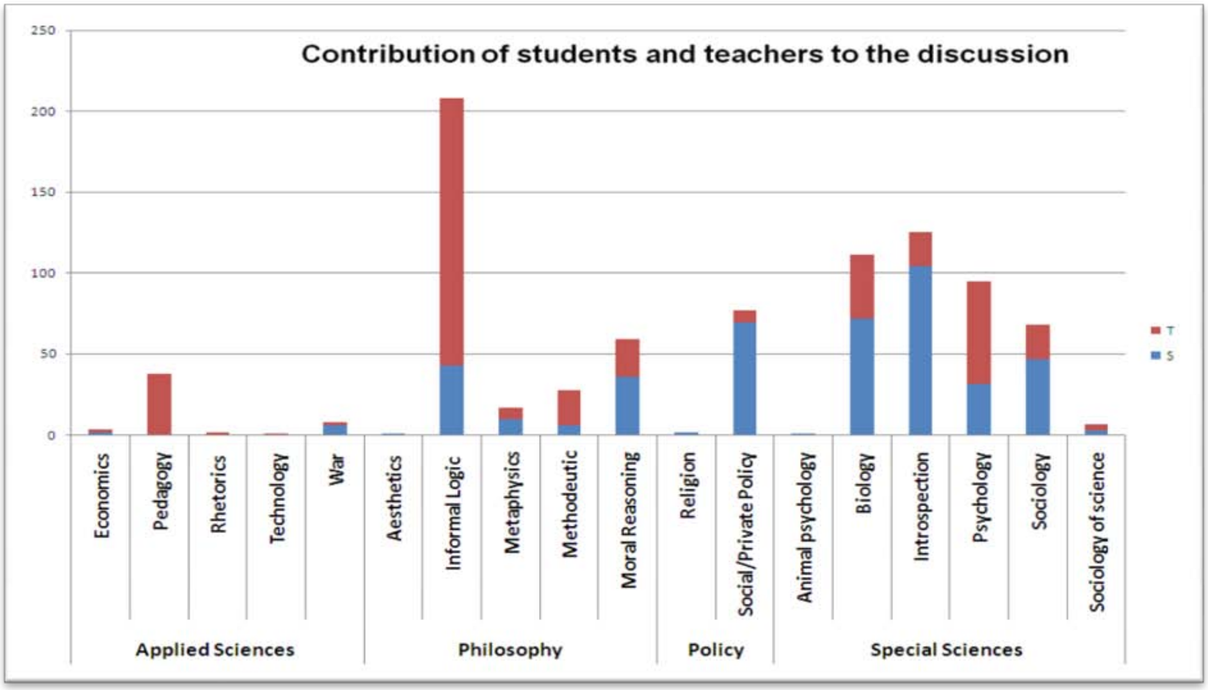
The numbers are used to describe the results of the study, but it is apparent that they do not hold any generalization force due to the nature of the study. On the other hand, even one instance in the lessons might be enough to indicate that this kind of reasoning/epistemic practice can be encountered while discussing a controversial issue.

The numbers though might be important if pedagogy is going to be explored. Why do some aspects of reasoning occur more than others? Why in some lessons have consequences been more dominant than means, for example? However, those considerations fell beyond the scope of this study. I do not imply that the nature of the issue does not affect the answers to such questions, but I do believe that pedagogy is an interfering factor, and given this situation it is very difficult to draw “conclusions” based on numbers. However, since numbers constitute a result of this study, they are presented; they might serve the role of data collected used to form initial hypotheses that could be tested through other studies.

Summarizing the consideration of using numbers to describe the results of this study, I would say that this study presents the results as instances, or rather as “opportunities”: while discussing about controversial issues children or teachers had the opportunity to engage in those epistemic practices, either a lot of times, a few times, or even once. The numbers indicate the frequency of each instance in the lesson, and will be food for thought. The above consideration is applicable for all results presented in this study.

Another issue that has to be clarified is the presentation of the results as the mutual contribution of students and teachers in the classroom, for all lessons. The term “agents of the discussion” dominates in the presentation of the results indicating both students’ and teachers’ inputs in the discussions.

By this, I do not assume that there is no importance if students or teachers perform specific strategies, as one might argue that those are opportunities for the teacher, and not for the student (For example one might argue that those are higher level strategies that students could not use). However, evidence presented in the following graph indicates that, apart from Informal Logic, students have entered all the other sciences in equal footing and even in greater extent than the teacher, who had the role of the chairman of the discussions.



Graph 1: Contribution of students and teachers to the discussion

It would have been a shortcoming of the study though, if it had not used teachers' inputs in the classroom, as they add to the content analysis types of syllogisms that enrich the data for this study, as the teacher might be regarded as an "informed" fellow of the students.

Pedagogical strategies such as assigning tasks, or enforcing discipline had been omitted from this analysis. The teacher is analyzed as cited above, as "an informed fellow", on equal ground with the students. The following chapter will present the results that came from the data analysis applied as described within the methods and methodologies chapter.

4. Results

4.1 Description of the implemented curriculum: The sub-cases

The lessons presented in this study refer to the following issues: Cloning, Hunting and Mobile phones. The lessons are described below, both from the lenses of the teacher, as those presented in a symposium in the 5th National Conference of History, Philosophy and Teaching of Science that took place in the University of Cyprus, (Nicosia, 11-14 June 2009), the extracts of the IPR, and my perspective.

4.1.1 Cloning lesson

The teacher has selected cloning as an issue because as she says "by definition cloning is an issue that emerges because science methods are criticized as ethically problematic, but also for its probable consequences to the wider social space". The lesson was structured in such a way so students have been given the opportunity to take a position about animal and human cloning, but also see the issue from a personal angle and take decisions in dilemmas about cloning a dead pet or a beloved person.

The instruction has been addressed to 24 students of the 6th grade (11-12 year old) and had a duration of two teaching periods (80 minutes) which is the usual teaching time for a science lesson per week. The lesson has been designed, having as its core the process of argumentation. The teacher, a 34 year old female, has been involved with argumentation in her master thesis (Master in Science Teaching) and she perceives that argumentation is a skill that can and has to be taught. She also believes that through the use of argumentation, she could enforce epistemological and conceptual understanding.

The teacher has selected the issue because it is a contemporary issue that creates social and scientific discussion, and therefore, could be an opportunity to discuss issues regarding the relationship between the scientific activity and the society, ethics and religion.

Her instructional goals referred to the conceptual understanding of cloning, the development of argumentation skills and the understanding of some issues related to the nature of science. Specifically, the teacher wanted her students to understand and get involved with the concept and process of “argument”, and be able to refer to ways that science affects the social and vice versa.

Her preparation had taken the form of personal involvement with the issue, as an effort to get more information about it. She needed to have inputs of many sides of the aspect, whereas as an individual could not take a position towards it. She was trying also to find information that would enhance students’ understanding about the issue, since genes and DNA are not concepts elaborated in those ages in Cyprus Science Curriculum. She had therefore put an extra effort to simplify information about cloning practice. Additionally, she had structured her lesson based on four different issues concerning cloning: Should we clone animals? Would you clone your own pet? Should we clone humans? Would you clone your dead son?

She had perceived animal cloning as less complicated than human cloning. She had also perceived personal involvement in taking decisions about personal dilemmas as more complicated than discussing neutral issues. That’s why she had designed her lesson in a way that, according to her view, would move from more simple to more complicated forms.

She had also prepared a PowerPoint presentation for the informative part of the lesson and a handout with structured questions about the four dilemmas stated above, with a small informative text about cloning.

The lesson began with a PowerPoint presentation with the title “Cloning: A blessing or a curse?” The specific title was intentionally selected by the teacher, because she wanted her students to take a position towards the issue of cloning and thereby, be ready for argumentative tasks that would follow.

The lesson proceeded with a series of argumentation activities with the goal of engaging students to the complication of the issue, step by step, as stated before. So the teacher had addressed a “neutral” issue at a first place, proceeding with issues that had the form of dilemmas, with the goal to involve students personally and emotionally.

The first issue that was stated was “Are you in favour or against cloning farm animals?” The task had the form of a debate, with those who had stated a positive position, trying to cite arguments in favour of cloning animals, and those with a negative position acting accordingly. Students’ arguments were about the value of being unique as a negative point, and the opportunity to save food chains in the case of endangered animals, as a positive point. A remarkable point is that students did not have a lot to say about this issue and after those two arguments the discussion came to an end soon. The teacher believes that this fact was due to the very little information they had about the issue, alongside the fact that they did not have a personal interest about it. However, in the end of the lesson, after lot of argumentation tasks about other dilemmas, students had started to process pieces of information and had asked questions about cloning animals such as “Would the milk and meat of cloned animals be of good quality?”

In a second phase the teacher stated the personal dilemma “Would you clone your dead cat?” The teacher gave worksheets to her students with a small text describing the opportunity to clone a dead pet and assigned some questions which they should answer. She had actually used it as a technique to let the students rest from an endless oral argumentation session that would make non-participants to create noise, and generally get students tired. After having some time reading and writing the students had stated their position - answer to the dilemma and had tried to defend it.

The main discussion point was about whether cloning could “bring” the dead pet back. The discussion had a sentimental character. The students were trying to describe their emotions when having a cloned cat that was created as a substitute for their beloved pet. Those emotions have been the bases for their arguments. However, not all students have been emotionally evolved with the situation; some of them had regarded other aspects of the issue like the possibility of “failure”, and the high cost of the practice.

In a third phase the students were asked to take a position about cloning or not human beings. Even if the dilemma was stated as a neutral issue, very soon it had turned to a personal one, and students were grounding intentions about the dilemma “Would you clone your beloved person that had died?” This dilemma was not explicitly stated by the teacher, but in a later stage the teacher had stated the dilemma of “Would you clone your dead kid?”

This discussion took the greatest part of the lesson. Students had been involved in different ways in the issue. The discussion about cloning human beings has been similar to cloning own pet, as far as the emotions of the presence of a clone but not the original were concerned. However, students when dealing with what emotions they would feel in such a case, they had to agree on what a clone is, and how a clone comes in life, the age in which he comes in life and the time he needs to grow up so he/she would really "be back with us".

Additionally, the fact that the students had situated the personal dilemmas to their own cases (for example, a student had lost her mother because of cancer the previous year) enabled further theoretical discussion about whether a clone would inherit the prototype's diseases, and what the emotional cost of having back a sick person again would be. Accordingly, some students had started to produce solutions for the issue of disease inheritance, like the selection of "healthy" genes for the clone, an issue that has taken the status of a sub-issue by the teacher, who had explicitly addressed it to the classroom: "What if we had the opportunity to go to a lab and order our son?"

The discussion took another route; students who discussed issues about selecting genes for a new baby, or the clone, were concerned about how they would remove bad characteristics like diseases, but not "removing all of them, as we do not need perfect people because other people would envy them and this could be worse".

Students were also concerned with issues related to the consequences of the presence of clones in the society and with issues concerning the social status of the clone. The issue of social confusion was the first issue to be elaborated. The previous issue, about cloning an own pet, had framed their understandings in such a way that they perceived that a clone would come up as a single copy and they did not consider the possibilities to have a great number of same clones. So, the issue of social confusion took the form of confusing two persons, the clone and the prototype, an issue that was dropped because of the different age of the two, since the clone comes in life as a baby.

Some of them perceived the clone as a person totally related to the presence and the needs of the person who had decided to clone him. Therefore, they had concerns about how the clone would continue his life in the case where the one that had decided for his/her cloning would die, for example.

Furthermore, students supported cloning human beings, especially people with special characteristics, for example very clever persons that could enforce technological development and therefore would offer a social progress. This issue was a start for further discussion concerning the possibilities of creating really "bad" clones with characteristics that would be disastrous for the society. The argument led to a discussion concerning the quality of a "scientist" as a person that is by definition concerned with the wellbeing of the society, the "scientist with good character" who could be apart from clever, motivated to move society to progress or distraction. Einstein was stated as an example of a clever person that should be cloned again, whereas Hitler was stated as a possible danger: a very clever man who had been disastrous for society. The complexity of the issue was revealed and students started to set social issues - conflict points such as:

> *«Who is going to choose who is to be cloned? And how can we know in advance whether the clone will be a good character? »*

The discussion proceeded with discussing - establishing solutions of the type "if the government decided then this would not be a problem" or that "cloning would be a controlled process, so those problems would not appear.

The above discussion about the possibility of cloning really bad people had driven some students, who were positively positioned in favour of cloning, to produce solutions of the type: “Ok if the clone is not good, then you can kill him”.

This solution was a start for negotiating the status and the value of the life of a clone. The arguments of this session regarded the existence of a soul in the clone, the respect to a human life that has or does not have a soul, and the status of the life of a clone, an entity that was assigned to the authority of the person that has decided to clone him.

There were students that had perceived clones as totally connected to personal or social needs of the persons or groups that had taken the decision for their cloning, and therefore supported that when the needs of the “cloners” were not fulfilled then the clone would not have any purpose in this life. This issue was further elaborated, with arguments related to the status of the life and the “purpose” of the life of the clone, as well as his rights as a “human” or “living” being.

It is remarkable that those metaphysical and ethical concerns were not a primary argument that has been used for grounding a decision about cloning or not human beings. In other words, if clones would have a soul was not an issue about which the students have been concerned in a first place. It came up in a “naïve” if we could evaluate it, solution of a student when discussing about the danger to clone really bad people, if people with special characteristics are to be cloned.

Another ethical issue that was raised was the right of bringing in life a clone without his permission, since the process would not be a regular one. Again, this issue was an opportunity to refine the concept of the “clone” since some students had perceived that the clone and the original would be the same entity, and therefore there would be no need to take the permission of the clone since you would have taken it from the prototype. This branch had led students to think of further possibilities like cloning dead persons, where the “permission” could not have been taken. The discussion had ended because of lack of information about such an issue (cloning dead persons).

In the final stage of the lesson the teacher wrote on the board all the arguments that had been cited in the discussion as reasons supporting or countering cloning. She had then assigned the students the task of selecting which argument would be the “strongest” of all, if they had only one to support their position. Students had voted for the “best supporting” or the “best countering” argument.

The teacher perceived that such an activity would enable students to use evaluation criteria for argument validity and soundness. She also supported that such a task would be a reflective one, since students would have to consider apart from their own arguments other arguments also, and that’s why she had forbidden them to vote for “their own argument”. She further supported her decision to her students also by citing that “I know that you have your own opinion and that will not change”.

Unfortunately, there was no time for students to further discuss their evaluation of arguments. The time was coming to an end and the teacher finished the lesson with an investigation of how many students had a positive, negative or a neutral position about the issue and which of them had changed their minds during the discussion. Finally, she ended her lesson by stating that:

> *“Those issues are so puzzling….we should always think and learn more and more before we take a decision about them”.*

4.1.2 Mobile phones

The teacher selected the issue of mobile phones because, as she believes, it is a questionable issue which creates controversy between several groups and does not have "one correct solution". The issue of young children using mobile phones has fulfilled those criteria. Additionally, it was a very interesting issue for the students. As the teacher said "I've been a science teacher for those kids for one year, and I knew that the issue of mobile phones was one of a high interest, especially outside classroom settings".

Teaching about mobile phones has been a challenge for this teacher. On one hand, the topic is not included in the formal Cyprus Curriculum in any lesson and this was of special interest for her, as a teacher. Additionally, it was an issue in which she knew that she was negatively positioned, even prejudiced about young children using mobile phones (her central issue). Therefore, the challenge for her was "to try to drop out any personal charge, and try to let students take decisions based on information and arguments that would not come from me, but from other sources that I would provide them with."

The teacher considered that she should clarify her thought about a complex issue and that's why she had thought about pros and cons about mobile phones and put them down in a form of a concept map. (Figure 12) The concept map presents the pros in green colour and the cons in red. The teacher has considered health issues, addiction, financial issues, distraction from the classroom in case it is used within it and issues related to personal data as possible cons for holding mobile phones. The pros were far fewer and included the need to hold mobile phones for communication and emergency cases and the development of human relations that communication enhances.

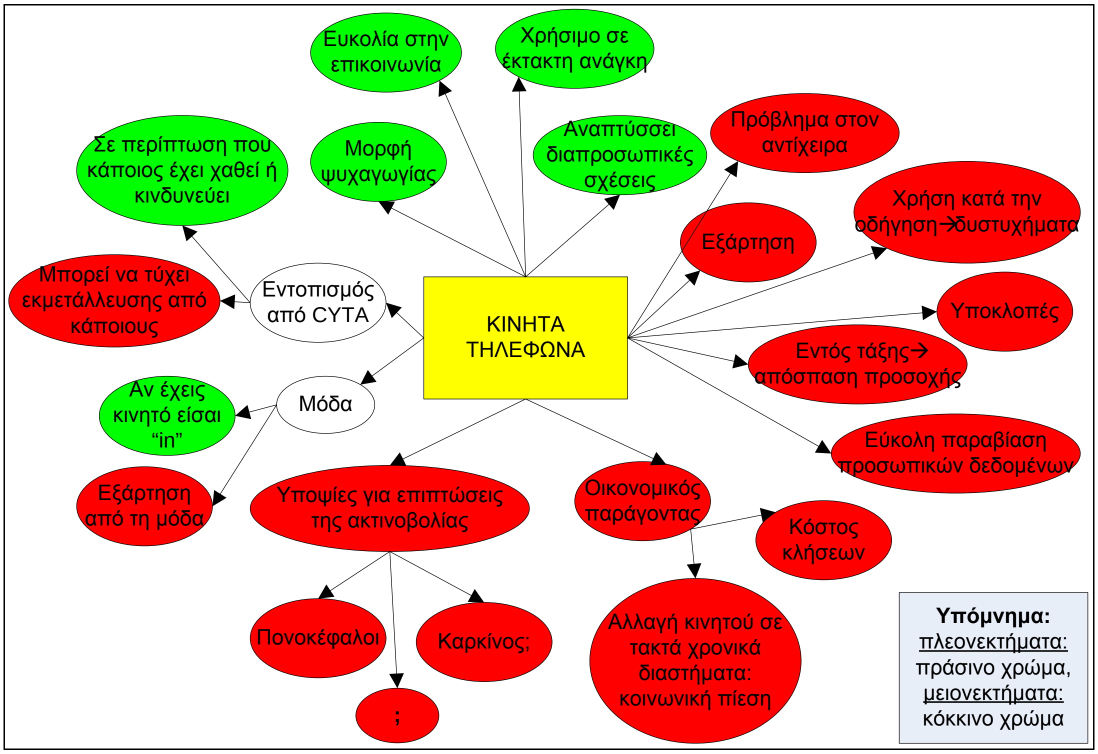


Figure 12: Concept map from the teacher about mobile phones' pros and cons

Her preparation proceeded with a search in local or foreign press and the Internet for relevant to the issue information. The task was time consuming since most of the sources available were in English and even sources in Greek were too complicated for the conceptual level of a 5th grader (10-11 years old). Therefore, the next step for the teacher was a preparation of sources in a way that they could be conceivable from the students (translate, use synonyms for difficult words, remove irrelevant information, slim texts, etc).

This teacher had stated explicitly the goals for her lesson. She wanted her students:

a) To develop an ability to study available sources and select relevant information

b) To be able to identify potential arguments in available sources and evaluate their pros and cons

c) Realize the complexity of the issue

d) Form an opinion, either positive or negative and defend it with the use of arguments

The teacher also structured her lesson and she actually followed the structure in the classroom.

Her instruction was addressed to a 5th grade class (10-11 years old), with 24 students and had a duration of two teaching periods (80 minutes). The teacher selected a specific case as an issue for her lesson, presented in the following form:

> *"My brother is 11 years old. His name is Constantinos and he recently had his birthday. When asked what he would like for a present, his answer was immediate: He would like a mobile phone; he even knew the brand and the model of the mobile phone he would like to get. I was puzzled….*
>
> *I do not have a formed opinion about mobile phones, but from time to time I come up to various information….that they cause or do not cause harm to young children or to adults in general. I do not know what to do. Buy or not buy my brother a mobile phone?"*

The teacher wanted to know her students' initial positions and arguments and additionally, she needed an activity where students could express themselves as a reflection process. That's why in a first place she had asked students to cite reasons for buying a mobile phone to her brother.

The activity had the form of "reason citing" rather than a debate, or an argumentative dialogue, even though there were students that did not cite their "reasons" but had dropped other reasons as false or irrelevant. The main arguments that have been used in favour of buying a mobile phone to the teachers' brother were arguments for convenience, referring to communication enhancement. Some of those arguments that had the form of means end (mobile phones are a means for communication, location etc) were dropped as mobile phones were proved as not necessary when alternatives had been presented.

Additionally, some arguments had the form of emotional appeals. Students cited that the teacher should feel pity for her brother being sad because he did not have a mobile phone. This argument was dropped by the teacher as "not a reason". Additionally, there were arguments supporting that the teacher's brother was a kid and therefore the teacher had to do favours for him. They additionally cited that if the teacher's brother was well behaved, or a good student, then the teacher should buy him the phone as a gift.

This made the teacher realize that the case in which the dilemma was set was really important for the discussion to follow. When she realized that the students were stuck on the age of her brother she changed the issue by asking "Well if my brother was not a kid, but a teenager would you advice me to buy him a phone? How would the situation change?" Students compared the cases in terms of social exclusion: they had perceived having a mobile phone as a social necessity for teenagers, but not for kids, so there was no question for them whether a teenager should have mobile phone or not.

The discussion proceeded with further reasons for the issue. Most negative points were related to health issues, with students claiming that mobile phones harm hearing, or health and others just citing that they have heard from their parents or the TV about such information. Finally, there were students that did not have a clear opinion about the issue, and others that provided conditional decisions such as “you should buy him a phone only if he uses it for “useful” purposes”, or “only if he uses it in extreme occasions”, and so on.

In a second phase, the teacher gave handouts to the students that included several pieces of information that could be evaluated as arguments supporting or countering buying a mobile phone to a young kid. She gave a different piece of information to each group of students (she had four groups of five and one group of six students) because as she believed, this would feed a fruitful discussion in the classroom.

The students worked in groups and highlighted with red colour the information that was evaluated as cons to mobile phones, and with blue the pros.

Then, the teacher asked the groups to take a group decision about the issue stated, after being informed about the issue. The discussion that followed had the form of defence to the specific decision of the group which was initially announced in the classroom. Four groups decided that the teacher should not buy her brother a mobile phone, whereas only one decided in favour of it. The first group grounded its decision for not buying a phone on the reason that “from all relevant information that we encountered, only one was evaluated as positive”. Afterwards the specific group started to cite all the arguments situated on the negative site. Since the information available in handouts contained technical terminology or issues that the teacher had perceived as “difficult” for her students to perceive, the teacher elaborated on each argument, so she could ensure that the students understood the concepts involved in each argument.

An argument that was confronted from other groups was one of mobile phones as a source of family members' isolation, as some students had perceived it as a means of communication between family members, whereas others had perceived it as a means of distracting parents from family, since mobile phones extend working time at home.

There were many arguments that cited available evidence regarding the relationship of mobile phones' effects on health, directly from the sources:

> *"We have found that the use of mobile phones for many hours per day might affect the hearing nerve. This is negative". Or, "The possibility for brain cancer to appear exists, and even gets bigger, with the use of hands free".*

Finally, the same group cited as "positive" the piece of evidence indicating that after ten years of use, mobile phones do not affect the hearing nerve".

The second group grounded its decision on the fact that "negatives, when counted were much more than positives" and continued by citing negatives and positives. This group's information included "a positive thing": the fact that there has been a research that did not find a positive relationship between mobile phone use and brain cancer. The teacher grasped the opportunity to bring them in front of a problem, according to her, which was the fact that they had two contradictory results from research: mobile phones being and not being responsible for brain cancer. Actually she selected the information presented to the students in such a way that this contradictory result would appear. She needed to explore issues related to research credibility, evidence validity and therefore she had addressed questions to the students like "Can those contradictory results (mobile phones affecting, or not affecting brain cancer) be both right? True?"

The students reacted in various ways. Some of them did not even go through the process of evaluating research credibility but cited alternative explanations in the form of “Perhaps it depends on the organism of each person”; others cited their trust on one side of the results grounding it on circumstantial evidence like “one woman had died from brain cancer and she had been using her mobile a lot”. Other students confronted the evidence as not reliable since it did not come from research, but when the teacher asked what to do because of contradictory evidence, students proceeded with questions like “Is your brother going to use it a lot?” They used the answer of the teacher to calculate the danger as they had available evidence indicating that the danger is related to the hours of use per day. Others supported that since there was conflicting evidence, it was not sure if her brother would have a problem with brain cancer when using a mobile phone and finally, there were students that insisted on one of two sides (mobile phones create/do not create brain cancer) by just appealing to one of the two pieces of evidence.

A student changed the subject of the discussion citing that the teacher should not buy her brother a mobile phone since there were really important negatives about mobile phones and what is of importance is not how many, but how important the negatives are. This brought a new session to the lesson in which the teacher asked her students to weigh arguments in terms of how important was the pro or con mentioned in them. The teacher, before entering this new task, in an effort to collect more arguments, had asked the students to explain to her why they have mobile phones, writing their explanations as arguments on the board, alongside all other arguments encountered from the sources. Some students explained the necessity of mobile phones for communication, others mentioned it as a means of entertainment, whereas others even “apologized” for having mobile phones, defending their action by saying that “I did not want to play, I had to communicate with my mother”. Finally, some others recognized that there was not a special reason for having a mobile phone, or had one because they just “wanted it”.

The lesson ended with the activity of weighing the arguments. However, there was not enough time for that and the teacher ended the lesson by saying:

> *“When go home I will evaluate each argument and try to weigh it. Afterwards I’ll take a decision based on this evaluation. My advice for you is to do the same”.*

4.1.3 Hunting

The instruction was addressed to 22 6th graders (11-12 year-olds) and lasted for 80 minutes. The teacher was the Science teacher for the school.

The initial wish of the teacher, a 35 year old male - was to teach about evolution and especially human evolution as the theory had been proposed by Darwin. He had actually come across information which indicated that among 25 countries Cyprus was 23th in accepting Darwin’s’ theory. He had a personal interest to see students’ reaction when confronted with the theory, given their prejudice created by their parents, teachers and the church.

However, he did not proceed with his idea, as he had realized that the principle of the school was not very supportive and he did not have the strength to challenge any religion or other beliefs of children, parents, teachers and school principals. Instead of natural selection he decided to teach about hunting, with the dilemma “Should contemporary human beings hunt?” He had thought that the discussion about hunting could have been in an environment where issues about natural selection might come up indirectly and naturally, and therefore they would not be a “risk” for him.

The teacher decided to go to the class with no special lesson plan. He wanted the children to lead the discussion, and perceived his role as one that could “tidy up” their thoughts, and do not let them go from one subject to the other. He also wanted to encourage all students to engage in the discussion and prevent ironical comments for any view presented in the classroom. Finally, he wanted his students to come up with arguments to support their position.

He had perceived the issue of hunting or not as an issue that does not have right or wrong solutions, therefore he could not predict if the discussion could lead anywhere. Therefore, his goals were oriented to the creation of a fruitful discussion, with his students having the opportunity to realize that there is always another view, apart from their own, a situation that is not regular in the classroom.

He included in his plan a “break” in which the students could rest from discussing and do some written work concerning issues related to hunting, like the use of swallows for hunting practice in Malta. He was concerned with having the students talking for 80 minutes, as he believed that this is a fact that would make them tired, anxious and not disciplined. He was concerned with whether the students would like to engage in such a discussion in a controlled classroom environment.

Another issue that concerned him was a logical coherence for the discussion topics. The fact that many questions during discussion would remain with no answer, in addition to the chaotic nature of such discussion made him anxious about how he could survive in such a situation. He could not define what would be the "end" of each subtopic and the "start" of a new one. Finally, he had a concern about students' experience with the topic. He did not expect his students to have a lot to say about this issue and he was worried that the discussion would unexpectedly come to an end.

Eventually, the lesson was beyond his expectations. Students had so many issues to discuss that the time of 80 minutes was not enough to explore them all. Students were highly engaged in the discussion and according to the teachers' view the discussion was of a high quality. Many children that were traditionally silent in the classroom had a voice in the discussion; this fact was mentioned from all the teachers participating in the seminar.

He had started the lesson directly with posing the dilemma "Should contemporary human beings hunt?"

The discussion had begun with children advancing arguments in favour of, or against hunting. A student advanced the reason of hunting to control animal population. Other students cited that there should be a limit, otherwise animals would be extinct, and others stated other arguments like "we have to live, to eat, we need to kill animals", or "it is unfair to kill birds". The teacher informed his students that he wanted the discussion to be sub-issue clustered, in other words, he would like them to discuss in depth about each argument, so the issue would be somehow "finalized" and they would not need to return to it in later sessions.

When students had no more arguments regarding animal population, the teacher advanced his own reason, through a rhetorical question: "In jungles, when no human beings are present, is animal overpopulation evident?" The question was answered by the students which started advancing further reasons like the one that natural death could control animal population. This last argument was confronted by the teacher, also by a rhetorical form, with an analogy of human beings’ population which is not controlled by physical death. As the issue was taking a distance from the initial question (hunt or not to hunt) students started talking about how to control human population, with a student supporting that there can be such a control, since in China population control methods are applied.

When the teacher realized that the students had stopped discussing about animal population control and started to deal with other issues, he ended the animal population sub-issue and started a new session about hunting as an unfair activity, an argument stated by a student in an earlier stage, but dropped as irrelevant to the animal population issue being discussed at this time. Anthropomorphism was evident in this session since students had expressed perceptions about birds and hunted animals, citing that they “have soul” or “have rights to be treated as we would like to be treated”, thereby attributing human characteristics to animals and respectively, establish moral rules related to hunting activity.

The teacher confronted the unfairness argument by advancing an analogy supporting that in nature animals are also “unfair” to each other: an eagle hunts and eats a rabbit, the human does the same. Anthropomorphism was also evident in this session, as students did not accept the teachers’ argument, by citing that the eagle is not in advantage like human beings, it catches only what it needs and does not “store” food as human beings do; they had further mentioned that an eagle does not have alternatives for eating.

Students also cited their own experience in hunting as evidence supporting that human beings do not hunt because of food need, but because of pleasure, bringing up examples of hunters that do not even eat the food.

In the end of the session a student supported that unfairness to birds is not a problem since birds are also unfair to human beings because of transmitting human beings the bird flu and kill a lot of them. The last argument was confronted by students and the teacher supported that this was not done “intentionally”.

A new session was initiated after this argument by the teacher, which was each time announcing the transfer to one sub-issue to the other (“Ok enough about this”, “let’s move to the next issue”, or “to this argument” etc). The new issue to be discussed was raised in the previous session by a student and referred to the explanation that human beings hunt because it is a pleasure for them. Talking about hunting as a pleasant activity brought chains of explanations and arguments. The students and the teacher tried to advance explanations as to why hunting is pleasant and further situate hunting as a sport or as an activity that would make us feel like primitive people (However the last explanation was confronted as primitive and contemporary hunting methods have been compared).

Additionally, they brought evidence to ground the truth or to falsify that hunting is really pleasant by referring to friends’, relatives’ or even their own experiences and feelings after hunting. Finally, there were students that did not perceive hunting as pleasant but as a very difficult and dangerous activity, a view confronted by others that had perceived those characteristics as criteria for an activity to be “pleasant”.

Other students changed the context of the discussion from one of situating hunting as a pleasant activity to one defending the action of hunting because of that. Those students cited that “There are so many other things to do than killing birds for pleasure”, or “There are other alternatives for sports in nature”.

During this discussion the teacher brought up the issue of hunters that kill only wild animals able to protect themselves, and not animals that have been raised in farm conditions and then left in nature for hunting, being unable to be protected. He actually asked students to explain and evaluate such an attitude, as it was difficult for him to understand the morality behind this action. This move however, removed students from the main issue under discussion and a discussion started to ground whether hunters really do this, bring evidence from themselves and their parents - as hunters - to prove that they act or not in such a way etc. The teacher had realized that the discussion was derailed and decided to end this session.

The teacher returned to an issue that needed further exploration, according to his view: whether human beings really have alternatives for food apart from animals, and if meat is necessary for the human body.

Some of the students did not enter the discussion of eating meat; they mentioned that this was an irrelevant for them issue as hunting was not a means for eating, as far as they were concerned, but a means for pleasure and exercise.

Other students tried to establish meat as necessary for the human body because of its proteins. On the other side, there were students that supported that such a necessity does not exist by bringing evidence from vegetarians and vegans who do not seem to have health problems. The teacher grasped the opportunity to relate the issue with evolution theory, by guiding his students to cite that human beings have the teeth of carnivore animals and therefore humans are created for such an activity.

A student brought nuns as such an example of healthy vegetarians and the teacher distracted the discussion from the necessity of meat to the human body and transferred it to an issue of morality, by appealing to a Divine law: “If our religion allows us to eat meat (some children cited that there are nuns that eat meat) then what’s the point discussing whether we should eat meat?

After that the teacher tried to bring up the main issue back, to hunt or not to hunt, by referring to a student’s argument about human beings as having alternatives for food (an argument advanced to ground that the eagle is not unfair to its prey whereas humans are). The teacher had used this argument as an argument against hunting. The student had denied that her argument had been advanced for supporting or not hunting, however the discussion proceeded with the teacher looking for further arguments supporting or not hunting. A student had cited that eating animals is irrelevant for him, as he hunts animals but does not eat them. This has been the start of a new session in which several sub-issues had been explored:

- Is killing animals ethical if you do not do it for their meat?
- What’s the difference between killing and eating an animal from slaughtering one?
- How did we come up to decide which animals are domestic animals for eating and others are pets for care and love?

Students were trying to establish moral rules by appealing to attributes of animals akin to human ones. For example they have cited that animals should feel grateful for the people that had fed them for their whole life and therefore they should give back what they have got (an argument establishing slaughtering as moral). Others had supported that since wild animals have such a difficult life to survive, it is so unfair to kill them, because this makes their life even more difficult.

A student had advanced an argument supporting that there is no reason dealing with animals' lives since they are going to die one day, one way or another. This argument was directly confronted by the teacher who has cited his perception that an animals' life should be respected as a human life and since we make so many efforts to extend human life (medicine) it is not fair to treat animal life as not important.

Other students had advanced reasons referring to animals having the perception to realize that they are going to be slaughtered and thereby establish the cruelty of the action, an argument that brought other chains of argumentation. Students had started to bring examples that could prove that animals really have such a perception, whereas others were advancing arguments that were questioning the existence of such a perception.

Finally, there was a group of students that had not perceived the issue of slaughtering or hunting animals as a moral issue related to the status of animals' life or the methods of death, but as an issue of convenience. They therefore discussed whether slaughtered or hunted animals' meat is healthier, or easier and cheaper to get and by this way they have answered the question "Is it better to slaughter or hunt animals?"

The discussion had gone so long that when the teacher had asked a student what her opinion was, her answer was: “About what? Hunting or not? Eating animals? Slaughtering or hunting animals?” After that the teacher asked his students to tell him whether they had formed an opinion about hunting or not. Most of them were in favour, whereas others cited solutions “hunting with limits”, and a few of them were negative.

The next activity was a silent one. Students had to read a text about policemen (hunters) in Malta who were killing swallows for practice, a second piece of information referring to the hunters’ habit to abandon their dogs in nature after the end of the hunting season, and finally a paragraph talking about members of the parliament as supporters of hunting in Greece. Students had to read the information and write down some comments. After that a discussion had started again.

The first issue that was discussed was about dog abandoning. Students had not perceived the hidden message of the teacher that was explicitly cited in the end of the session (hunters cannot claim that they love nature as a reason to support hunting, since they are so cruel to their own dogs). They were rather being concerned to the direction of establishing such a fact as true or false. They had started to talk about dog prices, bring evidence about finding abandoned dogs, or defending themselves as hunters that do not act like that.

When the discussion came to the issue of killing swallows for practice, students had defended the immorality of such an action for its cruelty and not necessity, since there are shooting centres for practice purposes, whereas others - especially students that were hunters (going with their parents for hunting) had defended the necessity for “real life” practice. The discussion was derailed when students had started talking about which birds would be better for practice, because of their number, availability etc. It was evident that the students did not perceive all issues cited by the teacher as moral. The teacher referred to extra arguments hidden in the text about the illegality of the action and called his students to explain why the policemen acted illegally.

The teacher asked from his students to explore members' of the parliament motives for supporting hunting, and then students had started citing reasons like "people in Greece are poor and they need food", etc. When the teacher had realized that he did not get what he wanted, he guided his students through cued elicitation to cite that parliament members need hunters voting and that's why they support hunting, and that hunting is a profitable activity, since hunters have to pay their hunting license to the government for a lot of money, whereas other society members get also their profit by selling guns and other hunting equipment.

The lesson was coming to an end and the teacher told his students that "As I realize from our discussion, human beings like hunting...". After that he started a reflective session and asked his students to cite their own experiences, if they were hunters, if they like it, why they like it or not and if they would like to become hunters etc. Students reflected their experiences about hunting and explained why they liked it or not, or how they started the hobby.

The last session of the lesson started with a teacher's question: "Do we finally become what our parents are? If our fathers are hunters, then we will probably become hunters, won't we?" He cited himself as evidence of not being a hunter, because his father has never been one and he asked his students to further discuss this issue. Some students agreed with him, but others brought evidence to support that there were hunters that started the activity at a later age or others that have been hunters but their parents did not like it. In some point of the discussion, students changed the issue of how we become hunters, with the issue of comparing shooting centres and hunting swallows for practice, whereas others started to explain why people like hunting by citing information that hunting gives an internal feeling of satisfaction of completing a difficult task. The teacher grasped again the opportunity to discuss about natural selection issues, and asked his students to discuss whether human beings are by nature hunters, as they have carnivorous teeth, nails, can run fast etc. The students started again comparing primitive hunting with nowadays hunting and cited differences and the fact that contemporary human beings are in advantage because of guns and therefore cannot be regarded as hunters by nature.

The time ran out and the teacher had to finish the lesson. No concluding session was included and the teacher said after the lesson:

> *"I had a feeling of standing to nowhere…I did not know what the students concluded from this lesson."*

4.2 <u>Socioscientific content and dialectical context</u>

As explored in the method chapter, the description of the dialectical context was enabled by the use of the socioscientific content: the term that relates the substantive matter of the discussion to the issue that relates to the decision for an action (cloning, buying a mobile phone for a young brother, hunt) to be taken. As also mentioned, the analysis had provided that the agents of classroom discussion talked about the issue and sub-issues that had emerged as chains of argumentation, about themselves, societal agents and their classmates, about solutions and finally, about issues related to the decision making process. Below I present the results that describe the dialectic context as related to the categories of socioscientific content.

4.2.1 Talking about the issue: Expressing beliefs about the action to be taken

When the agents of the discussion were talking about the issue, the dialectical context was defined according to Walton's and Crabbe's (1995) typology of dialogues. When the typology was applied in classroom data though, new categories emerged. The categories are shown in Table 15.

Talking about the issue: Expressing beliefs about the action to be taken		
Goal of the participant	**Dialectical Context**	**Example**
Present a view about the issue, or sub-issue, defend or counter such a view	**Argumentation for persuasion**	You should not buy him a mobile phone because it would harm his health.
Seek for a solution	**Deliberation**	Mobile phones harm youngsters' health. This is a negative argument.
Seek for a truth about a factual sub-issue	**Inquiry-Argumentation for inquiry**	Do mobile phones really harm health? The claim that mobile phones do not harm human brain comes from scientific research; they have investigated a lot of people for claiming that.
Provide information about concepts related to the issue	**Informative**	Radio-energy is a special kind of energy that is used in mobile phones and other electrical appliances.
Establish and defend a solution towards the problematic situation	**Practice establishing/Defence ***	You should tell your brother, when you buy him one, to use it only for a few hours, so he will not harm his health.
Provide a solution based on conditions	**Conditional decision making***	If your brother will use the mobile for useful thinks, yes you should buy him one, otherwise not.
Provide claims with the aim of answering a teachers' prompt while teacher uses it to advance argumentation through cued elicitation.	**Teachers' guided argumentation***	T: Are we born to be hunters? How are our teeth? S: They are sharp, some of them are. T: Which animals have sharp teeth? S: Carnivorous animals T: We have sharp teeth as carnivorous, nails; we are born to be hunters.
****Contexts not described by Walton and Crabbe (2005)***		

Table 16: Talking about the issue (expressing beliefs about the action to be taken)

The context named after “teachers’ guided argumentation” actually describes a type of an IRF (Initiation-Response-Feedback) exchange in the classroom. However, IRF is a scheme that describes the organizational pattern of the dialogue and the role of the student is described as a respondent to the teachers’ initial prompts; IRF therefore cannot describe the dialectical dimension, it cannot describe the teacher’s and students’ goals regarding the resolution or the defence of a controversial issue.

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Teacher’s guided argumentation therefore describes the speech acts under which students are actually manipulated by the teacher who is using his authority as one that can carry an IRF dialogue, to advance an argument in the classroom. If the setting was not educational then the type of dialogue could be described as a manoeuvre, a rhetorical strategy that uses rhetorical questions that eventually will lead to a proposition, or an argument in favour of the one who uses the strategy. However, since the setting is educational and the teacher does not stand as an equal interlocutor but he/she is an interlocutor *via* educator (or vice versa) the context is not named after the IRF (due to the limitation of describing the dialectical aspect), nor after the manoeuvre term (due to the limitation of describing the educational aspect). Teacher’s guided argumentation therefore describes the context in which an educator helps his students advance, or discover a proposition, or an argument that can be used in a controversial issue's discussion.

4.2.1.1 Argumentation for persuasion: Disagreement Space

Students and teachers, agents of the discussion, have been located in the disagreement space, holding positions and arguing about the issue, or sub-issues that had emerged. This context is defined as "argumentation for persuasion" according to Walton and Crabbe's (1995) definition: the initial situation is a conflict of opinion and the goal of the participant is to persuade the other party.

Space	SSI Content	SSI Context	Example
Disagreement space Criteria: Holding and defending a position about the issue or a Sub-Issue. The goal of the speech act is the defence or doubt of such a position	**issue**	Argumentation for persuasion	We should not clone because all animals will be the same and they will lose their value
	Sub - issue (issue)	Argumentation for persuasion (Local level)	Eating meat is morally ethical, since our religion allows us to eat meat.
	Products of the Discussion (arguments)	Argumentation for persuasion	If your brother is a good student then you would buy him a phone. *Yes, but this is not a reason. Tell me a reason for buying him or not* (Your argument does not consist a reason).

Table 17: Talking about the issue within the disagreement space

As shown in Table 16, the discussion has also moved to a meta-level. Agents had used meta-arguments (Wooldridge et al, 2005 p.46): they have been dropping arguments as not being "reasons", or as being irrelevant to the issue at stake, for example.

A very difficult problem that had to be addressed was the identification of the agents' context while talking about a sub-issue. As the sub-issue at stake might get distant from the initial issue, it was hard to say whether the agent supporting a view about the sub-issue, was also supporting the view that was resting levels above it. For example, a student supporting that meat is necessary for humans, did not necessarily support hunting, even if another student had provided the necessity of eating meat as an argument supporting hunting. Students have been found to act in a local and not necessarily in a global level. One episode in the hunting lesson provides evidence for this:

> *"39. Teacher: Ok let us discuss another issue. Panayiotis, please tell us again….you have said that hunting is unfair.*
>
> *40. Student: Yes, it is unfair because birds have life, they have soul. Imagine, as we kill them, they could kill us…*
>
> *41. Teacher: Yes, but in nature? Let me tell you an example from nature: a predator and a prey. Think, not humans, think of an eagle and a rabbit. It's the same situation, isn't it? The eagle….*
>
> *42. Student: No.*
>
> *43. Teacher: What, the eagle is not in an advantage position?*
>
> *44. Student: Ok the eagle is in an advantage position, but it does not kill as much as human beings…it might not even catch the rabbit....*
>
> *52. Student 2: The eagle kills because it is the only food it can eat, whereas we have many alternative solutions for food.*
>
> *53. Teacher: Like what?*
>
> *54. Student 2: we can eat vegetables, it is not necessary to eat meat.*
>
> *55. Teacher: Do you all agree that we are in advantage position?*
>
> *56. Students: Yes*
>
> *57. Teacher: However, I do not think that you all agree that it is unfair. Do you agree that it is unfair to kill birds? Is it unfair because we are cleverer than them? Vassilis?*
>
> *58. Student: We are subject to be unfair also. Sometimes our parents die, our relatives…We are treated unfairly….*
>
> *59. Teacher: So you say that nature is unfair one way or another….*
>
> *(After discussing whether we should eat meat or not)*

160: Teacher: Ok let us go back now, if we should hunt or not. Valentina (student 2) said that we should not hunt. Valentina you said that we should not hunt. Why did you say so?

161: Student 2: I did not say that we should not hunt!

162. Teacher: But you have said that we have other alternatives to eat than meat!

163. Student 2: I did not say that that we should not hunt!"

The diagrammatic representation of the argument structure is shown in Figure 13. As shown, the student supports that an eagle is not unfair to a rabbit as a man is, because he does not have alternatives for food. However, either this student does not have the capacity to realize how this argument connects to the upper levels of argumentation that had preceded her own argument, or she really acts in a local level, under a deliberation mode: she does not have a problem considering arguments that might contradict each other. However, she is conscious enough to cite that she did not argue about hunting or not, even if this was the initial flow of the argument. She locates herself in the local level and does not relate this to the global level.

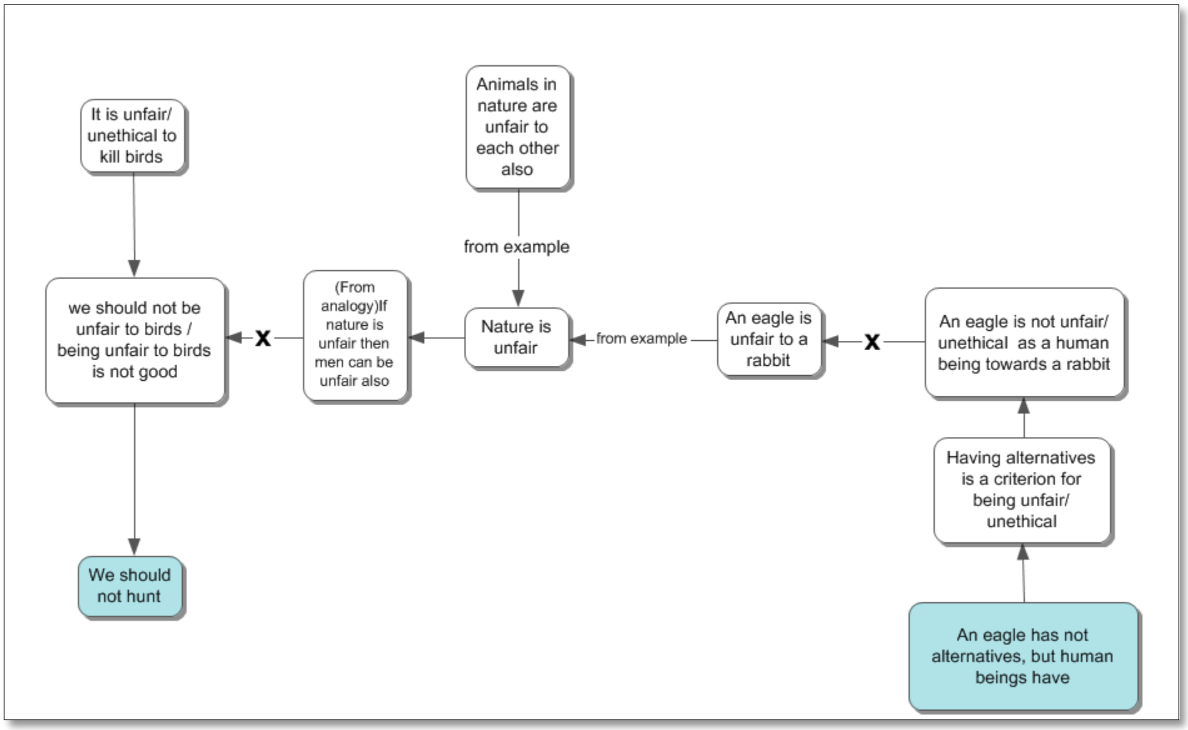


Figure 13: Acting in a local and not in a global level

What can we infer, therefore, for the context of this student? We still do not know if she holds a view about the issue, hunting or not, but she argues to persuade for a sub-issue that could drop a counterargument for an argument defending not hunting - therefore supporting not hunting, as the teacher has analyzed.

Actually, in many cases during discussion, there is no evidence indicating students' commitment to the global issue when being in a local level. Unfortunately, there was no secondary data collected from students, such as interviews or stimulated video discussions, as done with the teachers, which might help to further define their dialectical context. The solution for this problem was the following:

When contextualization cues, like positioning before uttering the local level argument, or the same student was furthering support an initial claim that he/she has cited in the discussion, then the context of the student has been described as argumentation for persuasion and hidden premises were completed respectively. However, when those cues were absent, then the context was described as “local argumentation for persuasion” indicating what has been elaborated in previous sessions: arguing in a local but not necessarily for the global level. Hidden premises were reconstructed accordingly.

4.2.1.2 Deliberation and Inquiry: Peripheral Space

Agents have also been located in the “periphery” of the disagreement space, seeking for a position and therefore acting under a “deliberation” context (Walton and Crabbe, 1995). Speech acts that did not reveal any goal of persuading the other parties, but they rather contributed in the direction of deciding which was the best action to take upon the issue, were indicating a participant acting in a deliberation context, not having a thesis, a viewpoint to defend.

Space	SSI Content	SSI Context	Example
Peripheral Space Criteria: Seek for a position towards the issue, reveal their context	**Issue**	Deliberation	Mobile phones harm health. This is a bad consequence.
	Products	Deliberation	Most of the arguments about mobile phones are negative.
	Sub-Issue	Inquiry	Do mobile phones really harm health?

Table 18: Peripheral Space: Inability to take a position, Deliberation, Inquiry

One of the most important contributions of locating the agent to the peripheral and not to the disagreement space was the reconstruction of speech acts as unlinked premises and not arguments, following a "minimal" rather than a "maximal" argumentative analysis of discourse (as proposed by Van Eemeren,1987), as already explored in the data analysis section of method chapter.

4.2.1.2.1 Inquiry

When a factual sub-issue has been put under question and agents of the discussion were trying to define whether this was true or not, then according to Walton and Crabbe's (1995) definition the context of the talk was described as Inquiry. This kind of definition grasps the philosophical account of inquiry, and only a part of what could be described as "Inquiry-based learning", that includes also pedagogical and curriculum approaches based on the need to find the truth about a factual statement. Inquiry is a puzzling context related to the disagreement space. Even if I argue that since an agent seeks for an answer and does not hold it, he/she is actually located in the peripheral space and deliberates about the issue, the episodes from the classroom indicate that there were cases that inquiry was not only a means of questioning a factual claim that has emerged as a sub-issue, but also as a way to advance a new argument to further support or counter a view about the issue. The following example explains the above statement:

> *"373. Student: Yes, but you might want to clone a man, but the clone might not want to be born like a clone!*
> *374. Teacher: Yes, this is another issue; did we ask the clone if he would like to be reproduced in such a way?*
> *375. Student: But we can ask them before cloning them.*
> *376. Teacher: Paul, I am not talking about the original, I am talking about the clone!*
> *377. Student: You can still ask him before you clone him if he wants to be reproduced in this way.*
> *378. Student 1: Is there a possibility that you can reproduce a clone only using the bones from a dead man?*

379. Teacher: I do not know, Demetris. We should not talk about issues that we are not sure about."

The last question is a start for an inquiry session that ends very quickly since the teacher does not seem to be interested in this issue. In the first reading of the episode I have encountered confusion, as the teacher does. In the second and third reading though, issues have been clarified: students regarded that the clone and the original are the same person and since the original is asked for permission then the clone rights are not violated. However, another student implied that if there is a possibility to clone a dead man, then his permission cannot be taken and then the argument is dropped.

Another similar example is when a student, during an argumentation session about animal cloning, asks whether the milk of cloned animals will be of as good quality as the regular's one. The teacher grasps the opportunity, brings data from American market, and an inquiry episode has started. I still do not have further data to support that this student advanced such a question for defending or countering animal cloning, but the direction of the talk points to such a direction. Milk quality is a potential argument; he actually seeks for arguments, however I do not know if he is located in the disagreement or the peripheral space. If his intention was to use the answer of such a question as a possible argument against or in favour of cloning he is located in the disagreement space, seeking for further arguments that could support his thesis. However, he could also be located in the peripheral space reasoning about possible consequences of the action of animal cloning and after a careful analysis of such consequences find a view for himself.

That's why the Inquiry context cannot be easily located in the disagreement or peripheral space and is a puzzling context. Only secondary data taken from methods like students' interviewing might enlighten this direction.

4.2.1.3 Informative dialogues

According to Walton (1992) there are types of dialogues where argument is peripheral - it is not the main engine that moves the dialogue along. Informative dialogue is a kind of such a dialogue: the agents do not advance reasons for supporting or not a view, nor do they seek for such a view. They however, have gaps of knowledge that need to be overcome and need further information to understand the issue. To put it in other words, it would be extremely difficult for a third participant to identify whether the agent that provides the information supports or not anything, whereas the information provided could be transformed into arguments from a fanatic towards an issue.

When the teacher says that "cloning is the creation of an exact copy of an organism…..scientists take DNA from an organism and actually copy it and create a new organism", she actually defines cloning. She provides the necessary conceptual means by which the students will be able to contribute to the discussion. She enhances understanding. Accordingly, when a student in the same episode asks: "And how do scientists do that?" she also acts under an informative context. There are not further moves to support that she needed this information to support or drop anything. She needs it to understand the issue, not to decide towards it, even if the first one might enhance the second.

4.2.1.4 Solution establishing/defence

When Walton's and Crabbe's (1995) typology had been applied to classroom talk, it was evident that students had some goals that could be not be described by the typology. Practice establishing indicated that the agent was talking about the action to be taken but he/she did not deal with the issue of whether should he/she should the action or not; he/she was actually dealing with the issue as a problem and not as a dilemma and therefore, had provided solutions that could actually diminish or eliminate undesirable consequences.

For example, a student citing that "We should hunt with limits, otherwise animal population might be extinct" does not deal with hunting or not; she actually perceives the issue of hunting as a problematic situation, as it might cause problems to animal population and therefore, she provides solutions for this problem.

A second thought about this dialectical context was to remove it from the issue socioscientific content level, as those utterances did not talk about whether agents should do the action or not, even though they are related to it. They were actually talking about solutions, which in this sense becomes a new socioscientific content category.

This context has to be distinguished from conditional decision making, even though they both share a similar kind of thought that relates to diminishing undesirable consequences. For example, advancing an advice of the type "You should buy him a phone, only if he uses it for useful things and not for entertainment" is differentiated from the solution of "You should tell your brother to use his phone only for useful things, and not for entertainment" in terms of dialectical force. Conditional decision actually uses a rule based practical reasoning, which accepts an action only if a rule is true; it is therefore a kind of argumentative dialogue that advances a rule of “Mobile phones should be used only for useful things and not for entertainment” and applies it as a condition for a decision to be made. It deals with the issue.

4.2.2 Talking about own selves (SELF)

The agents of the discussion were expressing beliefs about the resolution of the issue. However, there were cases in which the interlocutors explicitly talked about themselves for two different purposes: the first one relates to their need to inform their interlocutors about their positions or their intentions when a personal dilemma was set down. The second one is not related to their role as opponents in a critical discussion, but rather refers to a process of personal inquiry into their actions as members of the society. Students and teachers had tried to locate themselves as society members acting upon the issue, trying to explain or defend their actions. The contexts described when agents were talking about themselves are further explored below.

4.2.2.1 Beliefs about the issue, or reflections about our decisions, positions and views

A dichotomy that had to be done was to identify when classroom agents were expressing beliefs about the issue, or they were describing other psychological states towards the issue, and therefore were talking about themselves. Table 18 shows this dichotomy.

Beliefs about the issue		Reflections of psychological states about own self towards an issue	
We should not clone humans	View	I'm against cloning humans.	Position
You should not buy to your brother a mobile phone because it would harm its health.	Argument	I've decided that you should not buy to your brother a mobile phone because most of the arguments I've encountered were negative.	Explanation of decision
		I would not clone my cat.	Intention (Micromorality)
		I would not clone my beloved person because, if it would get sick again from the same sickness and died again, I would crash.	Explanation of intention (Micromorality)

Table 19: Socioscientific content: issue - self dichotomy

The ground for such an analysis rests on a cognitivist view of moral reasoning. For non-cognitivists moral theorists such a distinction would not exist, as they support that when people utter moral sentences they are not typically expressing cognitive states of mind (beliefs) but they are rather expressing non-cognitive attitudes more similar to desires, approval or disapproval (Van Roojen, 2009; see APPENDIX A for further discussion on the issue). Even if the limits of this study do not allow a philosophical analysis that would ground a cognitivist versus a non-cognitivist view of moral reasoning - there are two reasons for distinguishing between beliefs about an issue and attitudes, desires, approvals or disapprovals:

1. Firstly, the talk per se allows us to make such a distinction. "We should not clone humans" and "I'm against cloning humans" are encountered in the same lesson; the use of language permits us to distinguish between instances expressing a belief on one hand, and a standpoint, a position, a worldview perhaps of the agent, on the other.
2. Secondly, if there is a possibility to describe the reflective part of the lesson we

have to make such a distinction. A belief of the type “We should not clone humans” has to be grounded with reasons. On the other hand, a personal reflection of “I’m against cloning” is further explored as an explanation of attitude, and it is usually followed by explanations rather than argumentation chains.

Classroom talk had actually allowed distinguishing beliefs from reflections, defining when students were providing reasons for grounding a moral practical judgment and when they described their “passions” as explanations of adopting a specific view or action.

Distinguishing beliefs from reflections allows us a second distinction about the context: this of micromorality and macromorality context (Zeidler et al, 2005). The micromorality mode, emerges when the issue set does not refer to a decision about a theoretical issue for a decision to be made (Should we clone humans?), but refers to a personal dilemma about the issue (Would you clone your dead cat?).

The first question is an issue with possible viewpoints. The second though, is a personal dilemma. The answer to a personal dilemma, rests in a micromorality mode, and does not necessarily express a belief; it expresses an intention. Accordingly, grounding a decision upon a personal dilemma might rest on the level of explaining our psychological states that had driven us to such decisions, and has to be distinguished from advancing arguments as reasons for adopting or not a specific standpoint towards an issue that has been set in a macromorality mode. That’s why the utterance “We should not clone humans because it would create social confusion” is reconstructed as an argument, and the context is described as argumentation for persuasion (Reed and Walton, 2007) whereas, the utterance “I would not clone my beloved person because if it died again, I would feel a lot of pain” is described as “explanation of intention” that rests in a micromorality mode. Even if the same “reason” is used, i.e. the agent implies that “I would not clone my cat because it would create me confusion with my original cat”, the reason explains the agent’s preference about performing an action towards a personal dilemma, rather than advancing a reason that does not support cloning animals. In other words, arguments and argumentation for persuasion refer to beliefs, cognitive states of mind, whereas intentions and explanations of decisions refer to non-cognitive states of mind and they can be better described as personal reflections.

4.2.2.2 Beliefs or explanations of actions

Another kind of reflection was encountered when the agents were explaining/defending their own actions. I use both the terms explaining and defending, as the agents were advancing explanations for their actions, by providing reasons that would also be used to defend their actions This study reconstructs this kind of talk as explanatory. The utterance “I go for hunting because it is a sport, it is a very good exercise” explains an action, as it refers to the person and not to a theoretical construct, the issue. However, as soon as another agent might argue in the sense “There are many other things to do for exercise than hunt!” he/she evaluates this action, and the argumentation chains that follow refer to action defence, a context similar argumentation for persuasion about the issue emerges.

Argumentation for action explanation though, even if it includes evaluation of actions, is a bit different from argumentation for persuasion. Defending our actions involves an action done. Talking about the issue is about a decision for an action to be taken. This kind of analysis is supported by the view that reason alone cannot move us to action, since some other psychic state must be conjoined with a cognitive state to perform actions (Zagzebski, 2003 p.106). This actually can explain the fact that people might know what to do, but they do not all act in the same way. As Aristotle implies, even if the virtuous and the akratic (one that cannot hold himself) know the same thing in a sense, the latter does not appreciate the morally salient features of the situation because his judgment is clouded by desire (Zazebski, 2003).

Respectively, analyzing our or others' actions, falls into different kinds of talk than expressing our beliefs about an issue. Even if the talk takes the form of defence for the action taken, it still hits the person, his options and actions and not a reason for performing an action or not.

The contexts described that were referring to SELF socioscientific content are summarized in Table 19 below.

Socioscientific Content: SELF		
Goal of the participant	**Socioscientific Context**	**Example**
Inform the others about his/her position towards the issue	**Positioning**	I am against hunting.
Announce his decision upon a personal dilemma	**Intention/view announcement**	I would not clone my cat (micromorality)
Explain/defend his/her decision upon a personal dilemma	**Intention explanation/Defence**	I would not clone my beloved person because the clone might get sick again and I would be very sad because of this (micromorality)
Defend or counter an explanation of intention	**Argumentation for intention explanation/defence**	I would clone my dead cat to have it back. Yes, but you did not have any experiences with the cloned cat, cloning cannot bring YOUR cat back! Yes, but I would see it and since it would be the same I would feel the same as happy.
Describe himself in action related to the issue, explain or defend this action	**Action citing** **Action explanation/defence**	I am a hunter because I like hunting, for me hunting is a sport. You walk, you go to the nature.
Defend the explanation in case the others counter it.	**Argumentation for action explanation/defence**	I do not like hunting. I can go to shooting center instead. Yes, but shooting animals is not the same as shooting discs… For me practice is the same….shooting centers are situated in the nature, you still exercise…
Cite and explain his/her preferences towards an action	**Preference citing** **Preference explanation**	I like mobile phones because they are fashionable.
Explain his/her view (evaluation or reasoning)	**View explanation/defence**	I did not vote for this argument as being the best because I do not like it.

Table 20: Socioscientific context related to self reflections

4.2.3 Talking about the societal agents

A similar context has been identified when agents of the classroom discussion were explaining or defending societal agents' actions. In those cases they were abandoning the classroom disagreement space and entered the society space. The substance of the conversation was referring to scientists, hunters, their parents, members of the parliament and other society members that hold views, take decisions and perform actions described by the issue (i.e. hunt, hold a mobile phone, clone animals) or related to the issue (prevent their children from buying a mobile phone, abandon their dogs in the nature after hunting period, select special genes for cloning). This kind of talk can be described as "social inquiry". The agents of the discussion try to understand human action, and define reasons, feelings and desires (motives) that might explain such an action. Many of the dialectical contexts referring to the societal members, resemble to reflection ones, as shown in Table 20.

Socioscientific Content: Societal Agents		
Goal of the participant	**Socioscientific Context**	**Example**
Inform the others about a society member's view or position	**View citing**	Members of the parliament are in favour of hunting
Explain why society members hold a specific view	**View explanation/defence**	Members of the parliament are in favour of hunting because they need the votes from hunters.
Inform about society members' actions	**Action citing**	Hunters abandon their dogs in nature after the hunting period.
Cite and defend explanations for society's member actions	**Action explanation Argumentation for action explanation/defence**	Hunters go for hunting because they like it. They like it because they are in advantage towards animals, otherwise they would not like it so.

Table 21: Socioscientific context related to societal agents

4.2.4 Talking about their interlocutors (classroom agents)

In the same way that the agents of the discussion talked about themselves or societal agents trying to cite, explain, and defend actions, desires, views and positions, they have talked about each other: the teacher has talked about the students, and students were talking about each other. The input for such a talk was the classroom discussion, and thus this talk rests in a meta-level. Teachers and students had used as primary data the inputs of the other students in the discussion and had reflected on them in various ways.

For example, when a student reacted in an argument about mobile phones' impact on health "that is nonsense", another student explained this reaction towards this issue -when prompted by the teacher, in his wish to buy a mobile phone for him, as shown in the following episode.

> *"243. Student: Mobile phones are good for our health, our parents told this.*
> *244. Student 2: This is nonsense!*
> *245. Teacher: Why Kyriakos do you say that this is nonsense?*
> *246: Student 3: Because we like it.*
> *247. Student 2: I do not know (Why do I say that this is nonsense)*
> *248. Student 3: He says so, because he wants to have his own mobile phone*
> *249: Student 2: I like it sir…"*

Another context in which classroom agents have talked about themselves was this of micromorality. For example, when an agent advanced and explained/defended a decision towards a personal dilemma, the other agents might need to convince him to change his mind, advancing reasons that had to do with his own psychology. For example the utterance "You might even feel sad, if you saw the cloned one and think of your beloved original that is not in life" is a speech act referring to the student, but the goal of such an act has an argumentative nature and not a reflecting one. Accordingly, there were instances in which talking about their interlocutors did not have the goal of reflection, but one of attack. Students (very rarely) used as primary data their classmates' inputs in the discussion to make inferences about their character, such as "Petros is an idiot for believing such a thing!" This type of utterance is one of attack and the dialogue might be characterized as eristic (Walton and Crabbe, 1995) as it hits the person and not the argument.

Conclusively, I can say that talking about agents, (self, classmates, society members) could be described as an effort to understand (own and other's) views, positions, desires, preferences and actions and try to explain them. As the discussion evolved, explanations had to be grounded and then argumentation chains had evolved.

Additionally, when the issue has been set in a micromorality level, intentions have been criticized under argumentation that would refer to the agents' views, desires and preferences.

4.3 How can "controversial issues" be described as context for functional scientific literacy?

A summary of the above paragraphs indicates that the discussion about an action to be taken (the issue) has provided contexts related to the issue (argumentation for persuasion, deliberation, inquiry, informative) but also explanatory contexts related to classroom and societal agents and own selves' desires, views, motives, intentions and actions, contexts that have taken the form of argumentation when those explanations have been dropped for several reasons, or needed further support. The kinds of beliefs expressed and the dialectical context described is shown in Figure 14.

When dialectical context was defined as related to socioscientific content entities, it was evident that an additional analysis might further clarify the situation of controversial issues as situated in science education, especially when beliefs about the issue were expressed. How?

The analysis that enhanced the description of the dialectical context had already described the goal of the participant in the discussion about an issue in order to describe the agent's context. Socioscientific context was described as the goal of the participant in relation to socioscientific content: when agents talked about the issue they might act under deliberative, argumentative or informative goals, but when they have talked about their selves and other societal agents they have entered an explanatory context and the argumentation sections that followed aimed to ground the truth of such explanations, or evaluate actions, views and desires already held and expressed by societal members.

At later stages of analysis though, the application of argument schemes enabled a refined description of dialectical strategies performed to achieve such goals. This description had actually used a mutual interaction between a process and a product analysis of argumentation: a process analysis enabled the application of argument schemes and extraction of arguments as products, but respectively, the products provided the means for identifying the dialectical strategies used from the agents of the discussion.

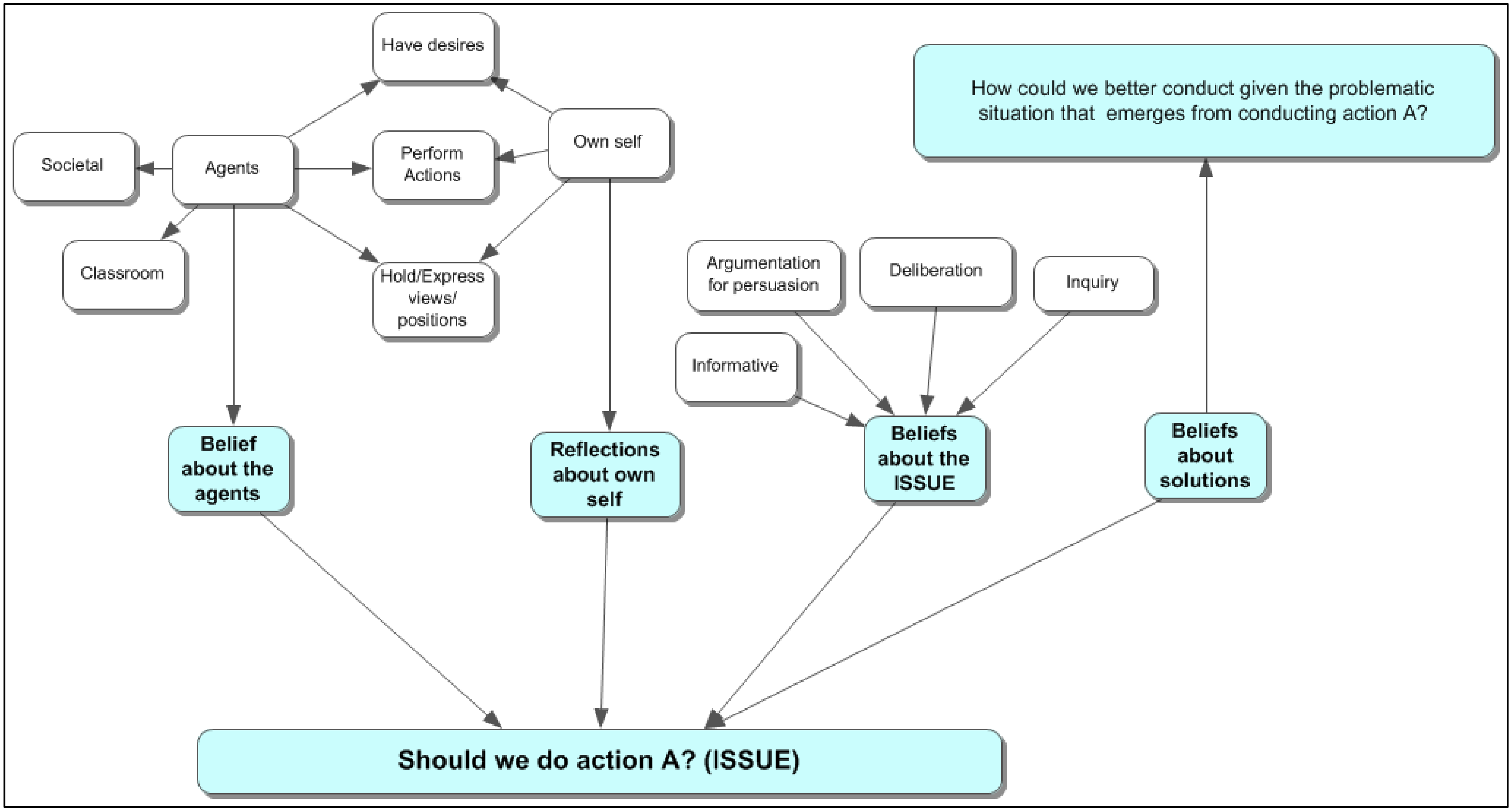


Figure 14: Dialectical contexts related to beliefs about socioscientific entities

For example, the identification of an utterance/episode as argumentative enabled the application of an argument so as to extract argument as a product, but also enabled a link up of the next utterances as related to the specific argument scheme aiming to further support components of the argument cited.

A theoretical input from the literature review revealed that practical argument schemes could be connected with special kinds of theoretical or moral reasoning/arguments that could further support them or counter them. The section that had grounded the argument typology scheme referring to practical reasoning (section 2.4.2 of literature review chapter of this thesis) also cited considerations as to how those practical judgments are related to theoretical and moral reasoning that could further ground them in an argumentative discussion. The theoretical input alongside data instances from classroom discussion revealed several instances in which theoretical and moral reasoning had taken place for establishing practical judgments. The instances are presented diagrammatically in the Figures 15, 16 and 17, whereas the rest of this section will present the dialectical strategies that were identified and organized based on the reasoning presented above: their strength to support or counter (actually establish as true/valid/relevant) a component of the argument scheme to which they referred to.

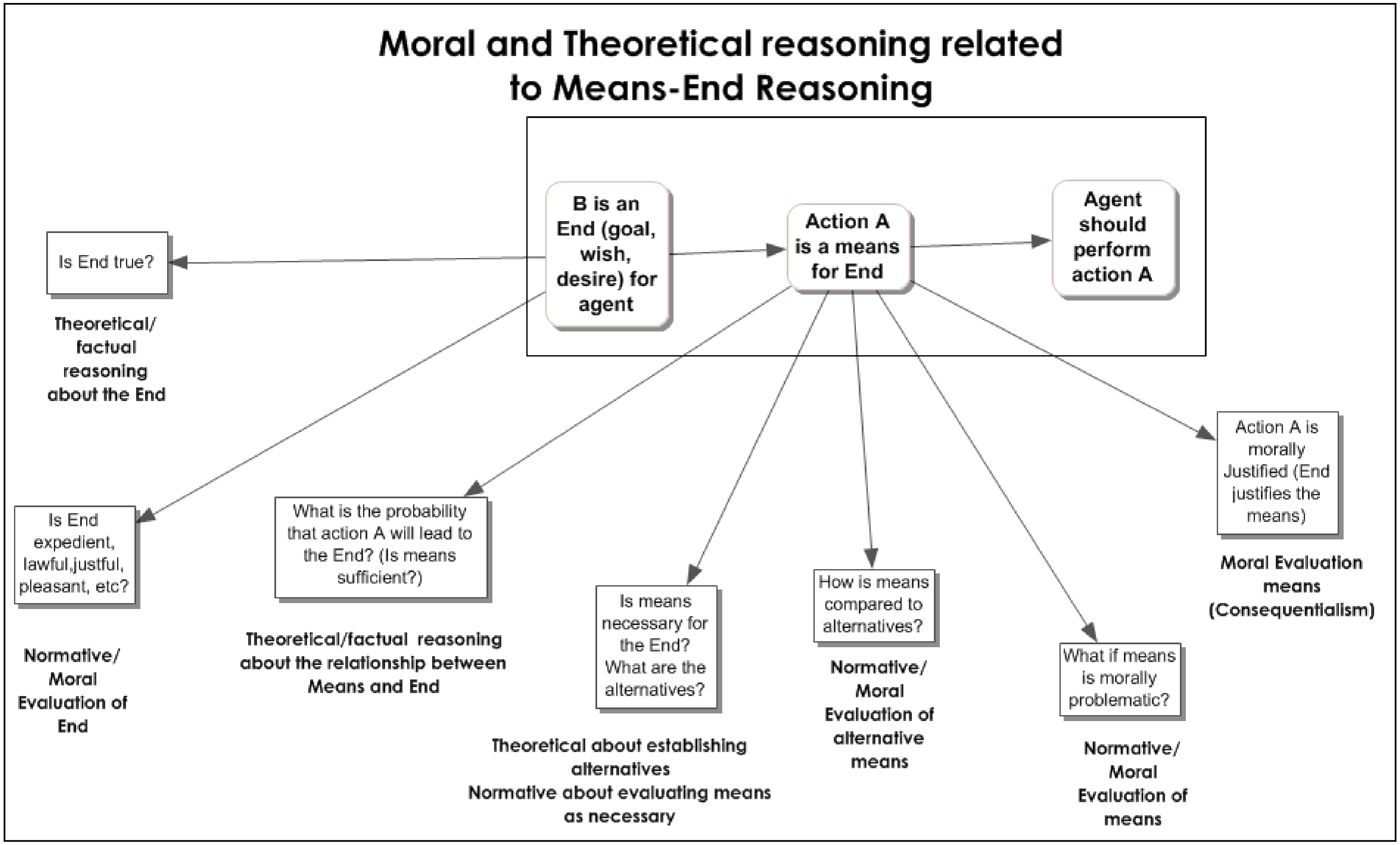


Figure 15: Moral and theoretical reasoning related to means end practical reasoning

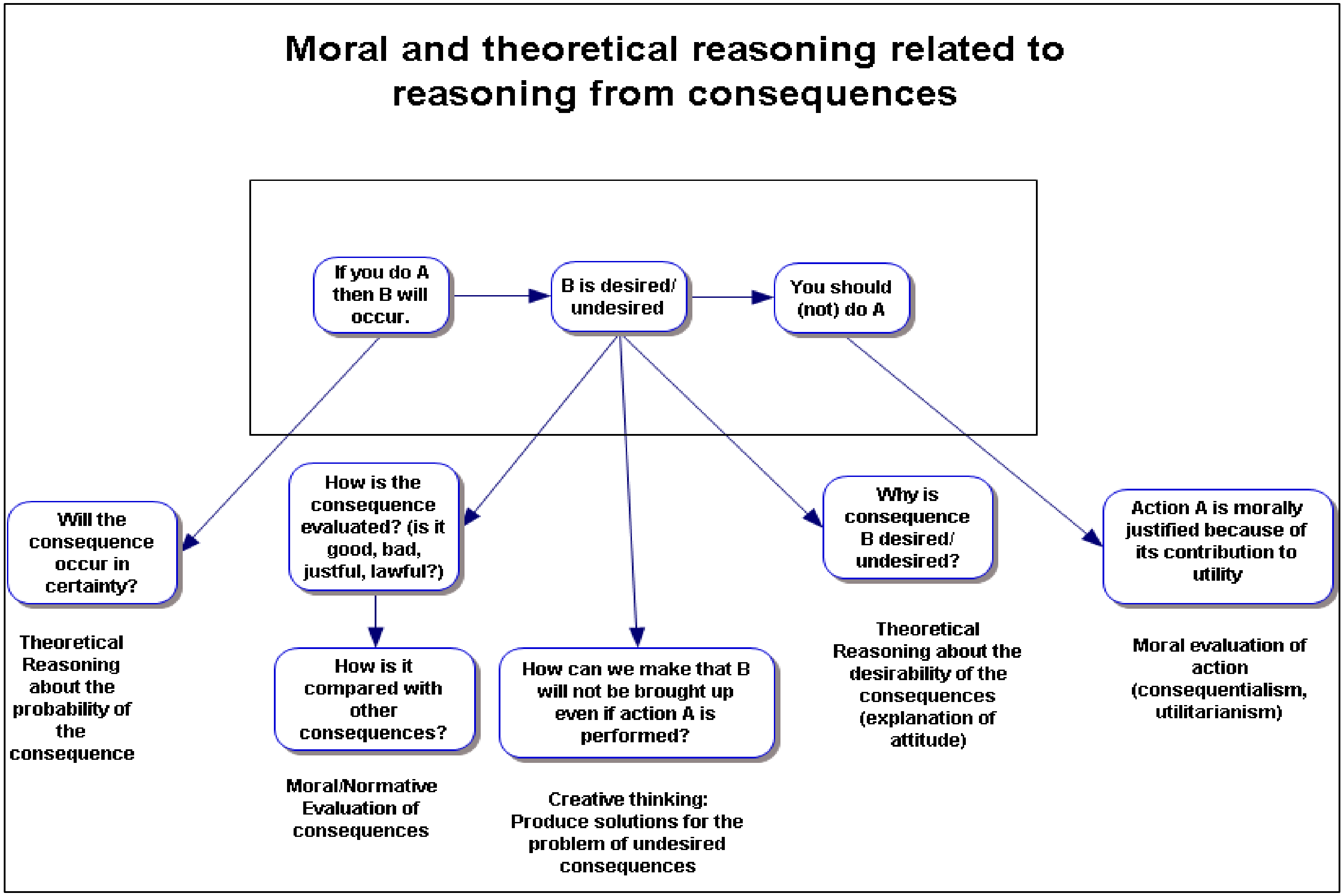


Figure 16: Moral and theoretical reasoning related to practical reasoning from consequences

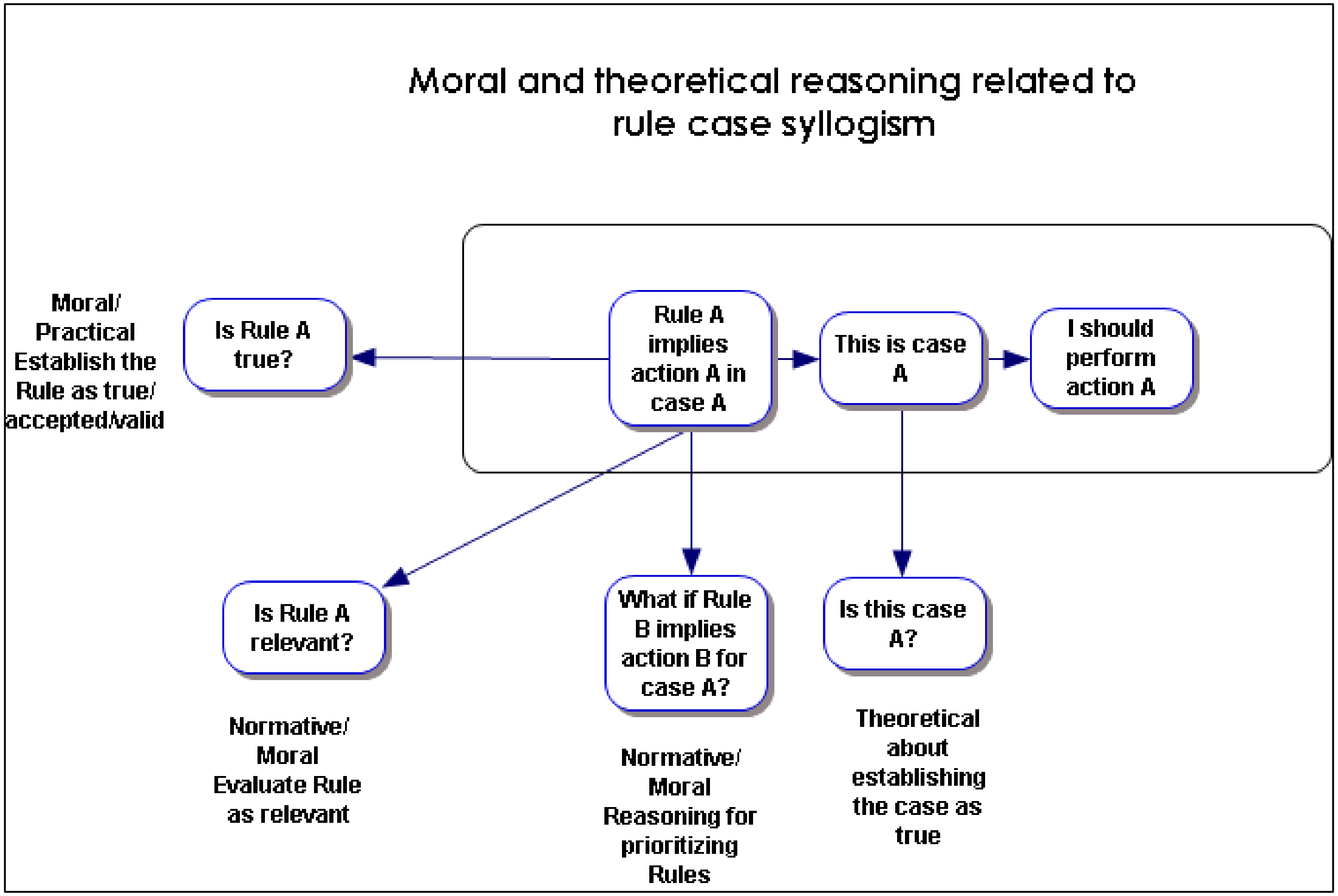


Figure 17: Moral and theoretical reasoning related to rule case practical reasoning argument scheme

4.3.1 Dialectical Practices as identified in the lessons

4.3.1.1 Argumentation for persuasion

As mentioned in the paragraphs above, the criterion that is used to classify dialectical strategies is their force towards a scheme of a practical judgment, aiming to establish/prevent a practice related to the action implied by the issue. However, in every dialogue, there are movements that are not directly related to the substance of it but refer to the formation of it as a process. Therefore, a first classification of strategies related to argumentation for persuasion has used the criterion of whether the strategy deals with the issue or the process of talking about the issue. This criterion, when applied, classified strategies in two broad categories: those that have an argumentative force, aiming to resolve the dispute, and those that do not have an argumentative force but still, essential for such a discourse to take place, as they force the start of it, and enable the agents and the chairman to effectively communicate with each other and process the products of their discussion. Table 21 shows the broad categories as described above:

Argumentation for persuasion: Typology of dialectical strategies			
General Force of Strategies	**Force**	**Category/strategy**	**Description**
Strategies aiming to resolve the dispute	Argumentative strategies that use reasons to convince	Strategies related to means end practical syllogism	Strategies aiming to establish the truth of the means, the end, the necessity and sufficiency of the means, the desirability-morality of the means and the end and accordingly, the establishment of alternatives.
		Strategies related to reasoning from consequences	Strategies aiming to establish the truth and the desirability of consequences and also the advancement and establishment of solutions related to undesired consequences. It also includes calculations of consequences to the direction of overall utility.
		Strategies related to rule case practical syllogism	Strategies aiming to establish the case as true, the rule as true and relevant.
		Meta level strategies related to the acceptance of an argument	Strategies that deal with arguments as propositions, aiming to evaluate arguments in terms of soundness, relevance, and validity.
	Rhetorical strategies that use other means than reason to convince	Personal attack	Attack the person with the aim of insulting him/her as a means of dropping the reason he/she has advanced
		Appeal to pity (emotion)	Raise emotional affection to convince the hearer towards a decision
Strategies aiming to establish the argumentation process		Sets case for dilemma	Describes the case for the dilemma to be set
		Sets dilemma/issue	Sets the dilemma/issue
		Cites claim for controversial issue/decision/definition	Announces initial decision that marks the difference of opinion
		Positioning	Takes a position that indicates difference of opinion
		Infers views/positions from discussion	Infers agents' positions from their talk
		Requests positioning	Requests from interlocutors to reveal their position
Strategies aiming to facilitate communication among members		Informs about argument ownership	Informs /reminds the group of the agent that had advanced the specific argument/reason
		Informs about the location of argument	Informs the interlocutors about the issue/branch to which the argument to be advanced is linked to. It enables a large group of agents to deal with complex argumentative structures.
		Extracts arguments from argumentative session	Performs a dialectical analysis of talk in order to extract arguments as products.
		Defends discussion analysis	Defends the dialectical analysis of talk
		Requests discussion analysis acceptance	Requests from the agent to verify/accept the discussion analysis
		Accepts/Denies discussion analysis	Accepts/Denies analysis of own talk from another agent or chairman

Table 22: Argumentation for persuasion: typology of strategies

Agents of the discussion are actually entering a process. This process has to be established; someone (in all lessons was the teacher) has to announce the dilemma or issue and the agents need to take their position for argumentation to start. Dialectic strategies like dilemma setting, positioning and positioning that, according to Van Eemeren and Grootendorst (1992) belong to the opening and confrontation stages of argumentation have been identified in the lessons (Table 22).

Argumentation for Persuasion: Strategies aiming to establish the argumentation process	
Dialectical strategy	**Example**
Sets case for dilemma	My brother is 10 years old. He goes to the fifth grade of primary school. He is a very good student. He is our young brother. He wants a mobile phone as a birthday present.
Sets issue/dilemma	Should I buy my young brother a mobile phone?
Cites claim for controversial issue/decision/definition	We should clone animals.
Positioning	I’m against cloning people.
Requests positioning	Are you in favour, or against cloning animals?
Infers views/positions from discussion	You have cited that we should clone charismatic persons to advance technology. So, you are in favour of cloning.
Requests argument ownership	Do you agree with the argument that we need to hunt to control animal population? Who had told this argument?

Table 23: Argumentation for persuasion: strategies aiming to establish the argumentation process

When the discussion entered the argumentation stage the strategies were described towards their force to ground or drop a specific practical argument scheme: reasoning from consequences, means end practical syllogism and rule case practical syllogism. There were instances that the agents have used other rhetorical approaches to “win the game” either by trying to raise emotional empathy by calling the teacher to “feel pity” for her brother that needed a mobile phone, for example, or attacking the person that advanced a specific argument by citing that “he should have been crazy to advance such a position”.

Finally, as the discussion is organized as a group discussion with a chairman (teacher in all cases), and the inputs from several groups have to be organized so that all the members can access the products of the discussion, there are other strategies in which their force does not refer to the formation of a practical judgment, but to the communication of the products of such a discussion to the members of the discussion.

The following tables provide examples of extracts where dialectic strategies have been identified. Each table presents the strategies identified for each dialectical context, and it is organized in categories according to criteria that are explained for each context. For readability purposes, examples provided are products of classroom talk analysis where permutation, deletion, addition and substitution process had taken place and therefore, do not have the form of episodes.

Argumentation for Persuasion: Dialectical Strategies related to Reasoning from Consequences		
Category	**Dialectical Strategy**	**Example**
Base Decision on consequences	Defends a decision using calculations of consequences	Since most of the arguments encountered about mobile phones were regarding negative consequences, you should not buy your brother a mobile phone.
	Defends a decision using consequences	We should not clone animals because they would lose their value of being unique.
Defend or counter the truth of a consequence	Counters consequence as false	Mobile phones do not harm health. Research does not find correlation between mobile phone use and brain cancer.
	Defends consequence as true	Mobile phones harm health. A girl had died from brain cancer, and it's believed that the cause of cancer was mobile phone use.
	Provides a solution to diminish consequences	If we clone human beings, there is a possibility to clone really bad people, imagine if we clone Hitler! There is no problem. If Hitler was cloned then we can kill him!
	Defends a solution advanced to diminish consequences(moral)	It is ok to kill bad clones, because they do not have soul.
	Drops a solution advanced to diminish consequences	A clone might be left alone in the society if the prototype that had created it for his own needs would die. There is no problem about it, we can make another clone. This is not practical. It's not that easy to make clones.
Evaluate action	Evaluates an action based on its consequences	Hunting is not a good sport; it is dangerous; you might have accidents while hunting.

Table 24: Argumentation for persuasion: dialectical strategies related to reasoning from consequences

As presented above, the agents have based their decisions on single consequences, but also moved to a meta-level and calculated the overall benefit of multiple consequences. Being in argumentative context, agents had also dropped consequences not by providing them as false but by providing-creating solutions that could actually diminish them. Those solutions were put under moral and other kind of evaluation (being practical, cheap etc) and therefore, new loops of argumentation chains have emerged. Finally, the agents of the discussion based their moral practical judgments (good or bad) that were a step for a formation of a practical judgment, on consequences.

As far as means end syllogism is concerned (table 24), agents used means end syllogism to ground a decision for performing an action: the action was evaluated as a means that could lead to a desirable end. Means were further established as sufficient or necessary. Necessity was actually questioned in the light of alternative means that could lead to the same end. This brought new chains of argumentation, where alternative means also had to be grounded as sufficient, moral, convenient, and so on. On a meta- level where multiple means were presented, those means were compared by evaluation towards common criteria that had included, among others, moral judgments.

Argumentation for Persuasion: Dialectical Strategies related to Means end Practical Reasoning		
Category	**Dialectical Strategy**	**Example**
Base a decision on means	Defends a decision using means	We should hunt because we need to control animal population.
Defend or counter the necessity/sufficiency of the means	Defends means as necessary	We need to have mobile phones as a means of communication. If we go to our grandparents for holidays, how are we going to communicate with our parents?
	Counters means as not necessary	It is not necessary to eat meat. we can eat vegetables.
	Counters means as insufficient	We should hunt to get food to survive. Hunting cannot provide us all the meat we need. we are not ancient people. Hunting can give only a small amount of meat that a family needs.
Defend or counter the truth of the end	Defends end as true	There are cases that if you do not have a mobile phone you might be in danger. Once, we have been in a trip and the bus was broken. The driver had to call for help.
Defend or counter alternatives	Defends alternative means as sufficient	Your brother does not need to have his own mobile phones for own use. Adults hold mobiles and can use them to communicate. Since he is only 10 he will always be with an adult with him, either in private lessons or parties.
	Counters alternative means as immoral	It is not fair to raise animals and then slaughter them, animals feel that you are going to protect them, love them they do not expect to slaughter them!
	Counters alternative means as insufficient	Eating only vegetables is not enough for health; vegetables do not contain proteins.
	Evaluates means	You cannot hunt for food. You have to abandon your job to do that.
	Defends alternative means as sufficient	We do not have to kill animals to control animal population. Animals can control their population. In jungles that there are no human beings animal population is controlled.
	Defends alternative means as moral	You do not have to hunt for a sport. You might go to shooting centres for enjoying the same activity. Shooting centres do not including killing live organisms.
Meta -Level: Compare alternatives	Compares alternative means	You need not hunt. You can eat chicken or beef. However, you still have to kill animals either you slaughter, or hunt them.

Table 25: Argumentation for persuasion: dialectical strategies related to reasoning from consequences

When a rule case syllogism was advanced, the agents had to establish that the case was true so the rule could be successfully applied to the situation, otherwise it might be evaluated as irrelevant to it. Additionally, the truth had to be established as true or valid in terms of moral reasoning. Those loops were actually loops of moral inquiry: the rule has been set under question and had to be established through argumentation.

Argumentation for Persuasion: dialectical strategies related to rule case practical reasoning	
Dialectical Strategy	**Example**
Defends a decision using rules	We should not hunt birds. It is unfair for them.
Defends case as true	When you clone a person you do it without his permission, and this violates his rights because he might have a bad quality of life as a clone. We should not clone. Yes, but you can ask them before cloning them No, the clone and the prototype are not the same persons.
Defends rule as true	It is unfair to kill birds because we are in advantage towards them: we are cleverer, stronger, holding guns…
Counters rule as false	It is not unethical to kill birds. In nature animals kill each other also.
Evaluates practice using rules	We are born to be hunters; it is in our nature to be hunters. Hunting is not problematic.

Table 26: Argumentation for persuasion: dialectical strategies related to rule case practical syllogism

When the discussion was moving to a meta-level the agents were not dealing with defending or grounding a premise, (consequence, case, means, end, rule) from a syllogism but actually were evaluating the argument as a proposition, either as irrelevant, relevant, sound, strong etc. Table 26 below presents those strategies.

Argumentation for persuasion: Meta Level dialectical strategies	
Dialectical Strategy	**Example**
Drops argument (meta level)	You should buy your brother a mobile phone because he wants to have one, you should feel pity for him. Yes, but I need a reason of why buying him a phone, tell me a reason.
Drops solution (meta level)	You should tell him when you buy him a phone to use it a few hours only. Yes but I did not ask for that, I need reasons of why buy him a phone or not. When I buy him one you might tell me what to do with it.
Accepts argument/position/decision/solution/ alternative (meta level)	Yes, this is a good point. I agree.

Table 27: Argumentation for persuasion: meta- level dialectical strategies

Finally, the agents, and especially the chairman, were trying to achieve better communication between them. They used strategies (table 27) that aimed to enable their interlocutors "follow" them and locate the place of the complicated structure of the issue in which they were referring to. As a two way communication, argumentation had to be clarified from both sides as mutually understood: agents, or the chairman, expressed what they had perceived/analyzed as the meaning of their interlocutors' talk and asked for verification of their analysis. On the other side, they might accept or deny such an analysis.

Argumentation for persuasion: Strategies aiming to facilitate communication	
Dialectical Strategy	**Example**
Informs about argument ownership	We should hunt to control animals' population. This is Demetris' argument.
Informs about the location of argument	What I am going to say does not refer to hunting for population, but refer to another issue, that Marios has raised before.
Communicate/ verify the meaning of talk	(Given classroom discussion) So what you are saying is that I should not buy my brother a mobile phone because it has radiation and will affect his health.
Requests discussion analysis acceptance	(Demetris: we should hunt to save food chain, and since little are needed for saving the food chain, not all animals will be the same) So Demetris, you are talking about cloning in a small population, do you mean that? Yes, I mean few animals to be cloned.
Accepts/denies discussion analysis	Valentina you have supported that we should not hunt. No, I had not supported that! But you have told that we have many alternatives than meat to eat! Yes, but I had not supported that we should not hunt.

Table 28: Argumentation for persuasion: strategies aiming to facilitate communication

4.3.1.2 Deliberation

Deliberative strategies, that did not reveal any goal of persuading the other parties, but they rather contributed in the direction of deciding which was the best action to take upon the issue, have been classified into three broad categories, that actually define their contribution to the overall discussion. The agents had to bring in arguments in the discussion, organize them and finally calculate the overall situation in order to come up to a final decision.

Even if arguments in this stage were not advanced in order to persuade any other party, they have been identified and established; consequences had to be established as true and undesired but still this kind of syllogism did not conclude to perform or not the action.

Deliberative strategies have been identified also within argumentation: while the students have been acting in an argumentative context advancing arguments in favour of or against a position, the teacher was using a parallel deliberative context, where she/he actually used the arguments as propositions, that had to be organized, evaluated, weighed and finally being calculated in order to advance a decision. In other cases, the students, even if the context was argumentative, had been actually deliberating since they just cited unlinked premises thereby identifying possible issues rather than defending or countering a position.

Additionally, actions were evaluated across different disciplines. Hunting for example, was established as a sport, cloning was established as a practice different than regular. Morality was one of those disciplines: actions were morally evaluated as unethical, good or bad, but still those evaluations were not used to prescribe or not the action.

As shown in the Table 28 below, many of the dialectical strategies are akin to those of argumentation of persuasion and refer to specific practical argument schemes (consequences, means to an end, and rules). The rest of them refer to the use of arguments as propositions.

Deliberation: Typology of dialectical strategies		
General force	**Force**	**Dialectical strategy**
Establish potential arguments	Establish consequences	Consequences - Defends a consequence as true
		Consequences - Evaluates consequence as undesired/desired
		Consequences - Identifies possible consequences
		Consequences-Inquiries about consequences
	Evaluates action	Evaluates action
		Means end - Evaluates action
		Rule case - Evaluates action
Organize arguments	Organize discussion content	Places argument in issue organization
		Compares arguments
		Groups/classify arguments in terms of content
		Processes arguments
Move towards a decision	Evaluate arguments	Weighs argument
		Evaluates argument(s) as positive/negative
		Evaluates argument(s) as sound
	Calculate arguments	Calculate arguments

Table 29: Deliberation: typology of strategies

Table 29 below presents examples of such strategies. A note to be taken about the calculation of arguments is that this practice had taken several forms. There were cases where an argument was regarded as "positive" just because it could drop a consequence as false. For example, students evaluated as positive the fact that mobile phones cannot affect brain unless they are used for more than 12 years. Those evaluations, even fallacious as far as logic is concerned, ground further the typology of the strategy as a deliberative one: the argument is evaluated as positive in relation to its contribution to the calculation of overall utility, a deliberative process that enables the agents to come up to a decision about the issue.

Force of dialectical strategy	Dialectical strategy	Example
Establish consequences	Consequences - Defends consequence as true	Mobile phones affect hearing because they have an energy called radiation that is harmful for health.
	Consequences - Identifies possible consequences	Children under 18 years old might be affected in the ear area if use the mobile phone more than two hours per day.
	Consequences-Inquiries about consequences	What if we create a clone from a prototype that had a disease? Would he inherit also the disease?
Evaluate action	Evaluates action	Hunting is a sport.
	Means end - Evaluates action	Hunting is a pleasant activity.
	Rule case - Evaluates action	It is unethical to kill birds. They are so small, trying to find their food…
Organize discussion content	Places argument in issue organization	This argument does not refer to weather we should slaughter animals or not. It refers to why we should eat meat.
	Compares arguments	What Athena says is the same that Nicolas said about animals: There is no point in cloning a beloved person since we are not going to have the same person back.
	Groups/classify arguments in terms of content	So, you are also talking about health issues. Radiation affects brain. I'll write it next to other health issues.
	Processes arguments	You have told that even if we clone a beloved person, he might die again, since he might inherit the disease. So, cloning cannot beat death. I'll write it down: Cloning cannot beat death.
Evaluate arguments	Weighs argument	I'll put two minus signs next to health issues related to cancer. I think it is a very negative argument.
	Evaluates argument(s) as positive/negative	We have found both negatives and positives. One negative is that they affect the communication between family members.
	Evaluates argument(s) as sound	The better argument from all was about
Calculate arguments	Calculates arguments	Both sides have arguments; positive and negatives; I think positives are less.

Table 30: Deliberative dialectical strategies, examples

4.3.1.3 Grounding Explanations of intentions, actions, views and desires

As noted in the previous sessions of this subchapter, agents moved from talking about the issue to talking about themselves, agents (societal agents, and classmates) and their relationship to the issue. This relationship could be described as a view about an issue, a position towards it, an intention towards a personal dilemma related to the issue and finally an action already performed (regarding the action implied by the issue or any other action related to it).

As already supported, dealing with the agents and explaining their actions, intentions, views, positions and desires is a process aiming to explain rather than defend those psychological states. However, practical argument schemes can also enter this area of analysis because actions, intentions and desires might be explained, among others, with the use of ends (needs), consequences and deontological obligations of the agent (rules). As with argumentation for persuasion, means, consequences and rules have to further be grounded and established, so new argumentation chains emerge to ground those explanations.

Furthermore, since those discussions take place within the context of a problem to be solved (take a decision about an issue) it is not clear whether ends, consequences and rules just explain the actions, intentions, desires and views, and do not serve the function of defending them as necessary or deontological. That’s why it is better to view them both as explanations but also as defence.

Table 30 below presents the phases where those explanations have been cited down whereas table 31 presents the strategies used when argumentation related to those explanations had emerged.

Action-intention-view-preference - explanation/defence: Typology of strategies			
General force	**Category**	**Dialectical strategy**	**Example**
Bring in and counter information about actions, desires, views and intentions)		Declares decision upon personal dilemma (intention)	I would not clone my dead cat.
		Informs about others' actions/views	Hunters abandon their dogs when the hunting period is over. Senators support hunting.
		Informs about own action(s)	I hold a mobile phone
		Informs about own preference	I do not like hunting
		Defends action as true	I have seen many dogs abandoned that did not look like homeless. They looked like hunters' dogs.
		Defends desire as true	My friends are always happy after hunting; hunters enjoy hunting.
		Counters action as false	Hunters would not abandon a dog after hunting period is over; dogs are so expensive, they spent so much money for them, so much time to get them trained.
Inability to express explanation		Inability to express explanation	I do not have a specific reason of why I go for hunting.
Explain (actions, desires, views, intentions)	Use means other than reason to explain	Explains/defends action	My uncle did not want her mobile phone and she gave it to me. That's why I have a mobile phone.
	Use consequences to explain	Consequences - Explains /defends intention	I would not like to clone my beloved person because if he died again I would suffer, and I do not like that.
		Consequences - Explains/defends action	My mother and father do not buy me a mobile phone because they do not want my health to get harmed.
	Use means to an end (needs) to explain	Means end - Explains/defends view	Senators support hunters because they want their votes.
		Means end - Explains/defends action	Hunting is my sport. That's why I go hunting; to get exercised.
		Means end - Explains/defends preference	I like hunting because it is adventurous.
	Use rules to explain	Rule case - Explains/defends intention	I would not clone my cat if his behaviour was not good.
		Rule case - Explains/defends preference	We are created to be hunters, we have nails, we run fast, and that's why we like hunting.
		Rule case - Explains/defends action	We became hunters because our parents taught us to be hunters.

Table 31: Argumentation for action-intention-view-preference - explanation/defence: Typology of strategies

Argumentation for **action-intention-view-preference - explanation/defence: Typology of strategies**			
General force	**Category**	**Dialectical strategy**	**Example**
Defend or counter explanations	Use meta level strategies to drop explanations	Drops explanation	Ok your uncle had given you his mobile as a present. But why did you get it? Give me a reason for that (Your explanation is not a reason)
	Strategies aiming to ground/counter a consequence based explanation	Consequences - Counters consequence as false	You would not get bored to the cloned cat. If you are not bored to the original why get bored to the clone?
		Consequences - Defends a consequence as true	The clone gets the same gene as the prototype. If the prototype was sick and had died because of its sickness its very probable that the clone will die again.
		Consequences - Evaluates consequence as not predictable	I do not have a cat. I do not know if I would get bored to a cloned cat or not.
		Consequences- Identifies possible consequences	There is a possibility that the clone might be very different from the prototype, even a monster.
	Strategies aiming to ground/counter a Means end based explanation	Means end - Counters means as false	I do not use a mobile phone for sending messages; I just need it to communicate with my mother.
		Means end - Counters means as insufficient	Cloning cannot bring your cat back. It brings you another cat.
		Means end - Defends alternative means as sufficient	You could buy another cat, or get a homeless cat, and still feel happy.
		Means end - Defends means as necessary	If you want to be a good hunter you need to be practiced with real birds, because it gives you actually the situation of hunting.
		Means end - Defends means as sufficient	Cloning might not give me my original cat back, but still could give me a cat that would be the same in sight with my original. Seeing this cat would make me feel happy.
		Means end -Counters means as false	Ministers do not need votes; they are not elected by people. Why need votes from hunters?

	Argumentation for **action-intention-view-preference - explanation/defence: Typology of strategies (continued from previous page)**		
General Force	**Category**	**Dialectical strategy**	**Example**
Defend or counter explanations (continued)	Strategies aiming to ground/counter a rule case based explanation	Rule case - Counters rule as false	It's not our parents' intervention what determines whether we are becoming hunters or not. My father was not a hunter until he became 40 years old, and he just tried one day after a friend had told him, he liked it and became a hunter.
		Rule case - Counters case as false	
		Rule case - Counters rule as irrelevant	It doesn't make sense for me if we should eat meat or not. I go hunting for pleasure; I do not eat what I hunt.
Evaluate actions	Strategies aiming to ground/counter an evaluation of action	Rule case - Counters case as false	
		Rule case - Counters rule as false	I do not go for hunting but not because of having
		Rule case - Defends case as true	
		Rule case -Evaluates action	

Table 32: Argumentation for action-intention-view-preference - explanation/defence: Typology of strategies

The previous section actually answers the first question of this study which is:

How can "controversial issues" be described as context for functional scientific literacy? The answer now can be eventually cited down.

A controversial issue is by definition an issue about which people disagree and it is always about a decision to be made. This decision is about an action. This decision is usually taken, or defended through discussion. Therefore, describing controversial issues as context can be done by describing the dialectical part of the lesson, the goals of the participants towards the discussion about the decision to be made. However, since the discussion might entail other related types of discussion, we have to identify whether agents talk about the issue -the decision to be made- or anything else. However, "anything else" can also be described as related to the issue and therefore a new construct is introduced in the analysis that refers to the socioscientific content.

Finally, dialectical strategies performed to achieve dialectical goals can be described as related to achieving the goal of establishing a practical argument which supports one position related to the issue under discussion. In this way there is a way to merge a process and product analysis of argumentation in order to situate epistemic practices and epistemic content within dialectical practices as related to practical reasoning.

In other words this study defines the situation of controversial issues in science education, as the description of how theoretical and moral reasoning is situated within practical reasoning. And this actually, in combination with the dialectical context definitions given above, answers the third question of the study. The application of such a definition has already provided a description of what is described as dialectical context. What remains is to describe the epistemic part and interrelate it to the dialectical.

4.4 Epistemic practice and epistemic content as situated in dialectical practice

Epistemic practice description has been enhanced from the application of argument reasoning schemes alongside the use of Peirce’s (1990, as cited in Pietarinen, 2006) taxonomy of the Sciences. The application of argument schemes was successful, the typology described was actually the result of a continuous cyclical process: identifying instances from data as relevant to categories provided by the literature, or seek for categories in the literature that could successfully describe argument schemes emerged from data analysis. In this sense the typology used and presented below, is actually the result of a mutual interaction between classroom data and literature review regarding reasoning and argumentation, argument typology schemes, practical reasoning, moral reasoning, scientific reasoning and explanations and so forth.

Examples of practical argument schemes are presented in table 32 below. Practical reasoning might indicate a specific moral stance, and therefore, the description and application of argument scheme has also enabled the description of the moral stance, or moral practice performed by the agents in the discussion.

Ethics and moral reasoning in general have been grasped from practical argument schemes. As discussed in the subchapter defending the argument typology scheme moral reasoning could be described as deontological when rule based reasoning was identified, whereas means end and reasoning from consequences indicated a moral stance related to consequentialism. However, whether all practical arguments can be classified as moral is an issue. The issue has been resolved when epistemic practices had to be assigned in different disciplines. A discussion that will follow in section

4.4.1, presented after this section of the chapter, further elaborates the practical-moral distinction.

Reasoning scheme	Moral Practice	Example
Means end	Defend an action as a means for another end (Utilitarianism)	Mobile phones can be used for communication when your brother is going to parties alone. You should buy him a mobile phone.
From Consequences	Defend an action based on its consequences (Utilitarianism)	Mobile phones have radiation that affects the brain. You should not buy him a mobile phone because it would affect his health.
Rule Based	Defend an action based on a rule (Deontological)	You should protect your brothers' health. Do not buy him a mobile phone.
From Analogy *	Defend an action based on an analogous example	My cousin is in the same age of your brother and he has a mobile phone. You should buy him one.
From Example*	Defend an action based on an example	Switzerland has allowed mobile phones for youngsters in schools. Cyprus should act accordingly.
Authority* (Expert, source)	Defend any type of conclusion	You should buy your brother a mobile phone if his mother says so.
*** *Free floating: can defend any type of conclusion*		

Table 33: Examples of practical argument schemes

Reasoning scheme	Epistemic Practice /Moral Practice	SDDS stage	Example
From criteria	Defend an evaluation Defend a classification Defend a moral practical judgment	Use readymade knowledge	It does not worth to clone your cat since you will give a lot of money. A clone is not a regular person since he will not have two parents. There is no problem to kill a clone since clones do not have souls.

Table 34: Example of normative argument schemes

Reasoning scheme	Epistemic Practice	SDDS stage	Example
Cause to effect	Defend a prediction Explain a fact (present or past) (D-N explanation)	Use readymade knowledge	Mobile phones create electromagnetic fields. Exposure to radiofrequency electromagnetic field causes tissue heating Mobile phones will harm your brothers' health.
Effect to cause **From sign**	Defend an explanation (I-S) of a particular fact, or a law , defend a postdiction	Hypothesis generation Inference to the best explanation- diagnosis or hypothesis evaluation	A woman has died of brain cancer. She has been using her mobile phone a lot Perhaps, the use of mobile phone was responsible for the brain cancer (generate a hypothesis)
From time to causality	Defend an explanation - a causal relation (Counterfactual account of causality)	Hypothesis generation	Every time I use my mobile phone, I have a pain in my ear. Mobile phones harm my ear.
Evidence to hypothesis (From samples) **From example***	Defend a descriptive generalization (either explanatory or not explanatory)	Hypothesis testing-Evidence evaluation	A Danish study about the connection between mobile phone use and cancer incidence was published. It followed over 420,000 Danish citizens for 20 years and showed no increased risk of cancer. An increased risk of brain cancer cannot be established from the data.
Statistical syllogism	Predict a fact Explain a fact (D-S explanation)	Use readymade knowledge to deduce a fact, or a categorical syllogism	In 1000 people that were mobile phone users in the research 20 had brain cancer. If your brother uses his mobile phone he will have 2% risk to get brain cancer.
From Analogy*	Defend a generalization	Hypothesis testing, Evidence evaluation	People that have used microwaves a lot had health problems. Microwaves use the same technology as mobile phones Mobile phones will create health problems
Appeals			
Authority* **(Expert, source)**	Defend any type of conclusion	Any stage	My doctor says that mobile phones harm health. Mobile phones harm health.
Popularity*			Many people believe that mobile phones are harmful. Mobile phones are harmful.
Emotion *			Your brother wants a mobile phone very much. After all he is your young brother! You should do him the favour… .
* free floating forms of arguments (can defend any type of conclusion, not only factual)			

Table 35: Example of theoretical factual argument schemes

As shown in the tables above, the use of argument schemes typology has served a twofold purpose for this study: on one hand it had enabled the extraction of the propositional content of the lesson, and on the other, it has been used when linked with the dialectical context to describe the epistemic and moral practice performed.

Cause to effect arguments indicate for example causal reasoning related to the form of explanations and predictions, a distinction that was made based on contextualization cues. Deciding to describe theoretical factual argument schemes in terms of scientific endeavour aiming to establish a knowledge claim, or to use a readymade one for performing predictions and explanations is grounded as a sufficient way to describe epistemic practices situated in Idioscopy (Special Sciences as described by Peirce (1990, as cited in Pietarinen, 2006) if a Weber's (1904) account of social sciences is endorsed, which accepts that differences between the natural sciences and the social sciences arise from differences in the cognitive intentions of the investigator and not from the alleged inapplicability of scientific and generalizing methods to the subject matter of human action (Weber, 1904, as cited in Coser, 1977, p.21). Even if there is a view that social sciences cannot establish objective truth in the way that natural sciences do, what both disciplines share is a method of a selection from the infinite variety of empirical reality towards theoretical generalizations. Both types of science involve abstraction (Coser, 1977) and have their focus on providing explanations for natural, social or psychological phenomena.

Furthermore, the class of normative argument schemes has been capable of describing the Normative Science category belonging to Philosophy, but also a part of Sciences of Review (Peirce, 1990, as cited in Pietarinen, 2006) as shown in Table 35:

Areas Grasped by Normative Argument Schemes			
B. Philosophy, Normative Sciences			
Group of sciences	**Science**	**Area of study**	**Example**
Aesthetics		Beauty	Animals will lose their value if all of them will be the same.
Ethics		Right and Wrong Conduct	It is not ethical to kill birds because they have soul.
Logic	Speculative Grammar	Objects and signs	What you have told is an argument because it includes reasons for accepting something else.
	Critique (Logic Proper)	Inference	It is not logical to have two claims written on the board that have contradictory conclusions, both being true.
	Methodeutic (Speculative Rhetoric)	Methods for exploring and creating submissions of truth	Scientists had made research to provide a result that mobile phones are not related to brain cancer. What you indicate is just an incident about one girl that has brain cancer and it is only people's belief that the cause is the mobile phone use.
C. Sciences of Review			
Philosophy of Science		Classification of sciences	It is not Science's job to decide about controversial issues. Other society groups have to engage and decide about this since it includes issues beyond scientific endeavour.

Table 36: Philosophy: Normative Sciences as grasped by normative argument schemes

The section that follows aims to describe the different areas of epistemic practice that have been identified in the lessons, and thereby answer research question 2 (*What is the moral, reflective and cognitive part of the lesson?*). However, since those processes have to be described in the dialectical context in which they have been encountered (research question 4: *What is the context for the moral, reflective and cognitive part of the lesson?*) and since this context has already been described in the previous paragraphs, presenting the moral cognitive and reflective alongside the dialectic would enhance better communication of the results of this study. That's why the following sections deal with presenting each epistemic area encountered in the lesson situated in the dialectical context in which it has been encountered.

4.4.1 Social/Private Policy: The base and reasoning schemes of the decisions

Ethics according to Peirce (1990, as cited in Pietarinen, 1996) is classified in Philosophy and is regarded as the normative science that evaluates practice according to several principles of conduct. The question that rises here is: Are all evaluations of actions, or prescriptions about conducting an action ethical? Are they regarded as moral?

Whitbeck (1998) supports that judgments about what the best action to take in several aspects of human conduct would be (i.e. the best way to survive in a professional environment) are not all moral or ethical ones. Examination of such codes of behaviour though, is important since they affect the opportunities of moral action (p.12). Accordingly, in another, yet unpublished version of his classification of the sciences Peirce (1943 as cited in Pietarinen, 2006) distinguishes between Ethics which is defined as the general principles of conduct, and Policy which is defined as the study of special problems arising in history, which further divides it in three distinct categories: Policy toward men, Religion (Policy toward superior beings) and Policy toward lower animals.

In this sense, deciding what to do about a controversial issue is assigned as a practice that is not situated in Ethics but in Policy, as an applied art. Deciding if we would proceed with cloning, buying or not a mobile phone, hunt or not, are practices situated in Social Policy and not necessarily to Ethics.

However, this distinction is valid only if we perceive as ethical only products of deontological moral reasoning which ground the rightness of an action based on moralities of obligation which is actually based on laws. Therefore, an action is considered as ethically evaluated if it uses laws that derive from nature ("living and acting according to rationally ordered nature" (Devettere, 2000, p.5), duties that emerge because of the rights of other people, or from our commitment to theories or religion: since we are committed to a theory or religion, then by duty we should do what this theory's principles and laws are implying. Additionally, actions are considered as ethical if they are performed according to virtues.

An example of classroom discussion about slaughtering or hunting animals might enlighten the discussion.

> *"264. Teacher: Should we hunt animals being in nature? Or should we raise them and slaughter them?*
>
> *265. Student: I think we should feed them and slaughter them because we know what we give them to eat and their food is healthy.*
>
> *266. Teacher: Fairness. Ethical. In nature. Imagine that you are the animals. Is it fair?"*

The prescription "we should slaughter animals instead of hunting them, since they are healthier" is perceived from the teacher as non-moral; that's why he asks from his students to change their context into one of moral reasoning and consider the issue in its moral dimension, as he perceives it. The teacher needs his students to discuss the moral obligation of being "fair" to animals. However, students do not base the rightness of the action (it is better to slaughter animals) on duties but on consequences.

One might support that students' reasoning *is* moral; the rightness of the action is evaluated through its consequences, and therefore it is a kind of moral reasoning, actually utilitarianism, which accepts that moral obligation arises from what will benefit the most people and not from laws or duties. However, there is no cue here that students ground the moral obligation of the action. They might ground the performance of an action when its consequences are evaluated, but they do not assume that this action is morally obligated. And in this sense, reasoning about an action to be taken cannot be classified as moral, unless moral-deontological principles are used in the syllogism, or unless the agents defend the moral obligation on consequentialism-utilitarianism, as shown in the episode below:

> *"445: Student 1: If we clone humans there is a possibility to clone really bad people like Hitler and this would be disastrous for the society.*
> *446: Student 2: Yes, but if a clone like Hitler emerges we can kill him!*
> *447: Teacher: Do you take a life so easily? Why?*
> *448: Student 3: There is no problem if we kill clones, they do not have a soul. This is my belief.*
> *449: Student 4: This is your belief, but not ours.*
> *450: Teacher: The clone will not be a human being? He will not have a life?*
> *451: Student 2: Yes, but teacher, what else could we do if a new Hitler emerged?"*

In this episode both moral practices described above are identified: Student 3 in line 448 grounds the morality of the action based on a law that regulates the rights of living creatures that do not have a soul. On the other hand, the student that has supported the solution of killing bad clones defends the moral obligation of the action in line 451 by citing that there is no alternative and the consequences that are to come are really serious for the society. In this way he evaluates consequentialism as resting above deontological considerations, thereby implying the moral obligation of action based on consequences.

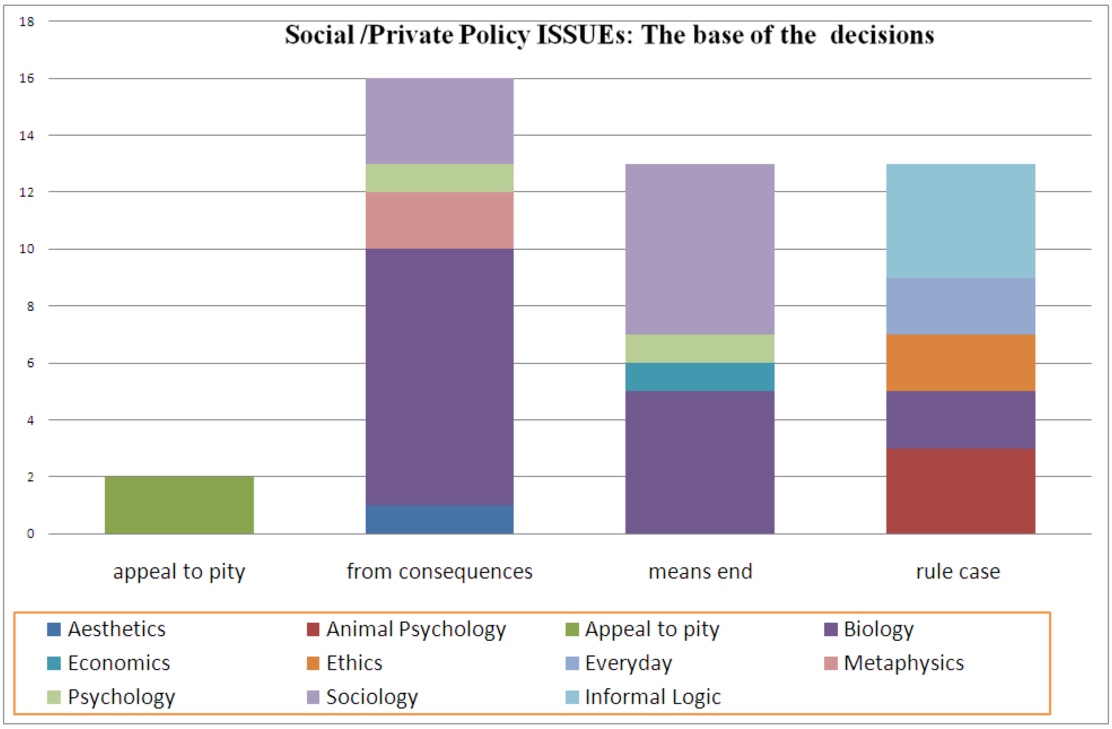
The discussion above implies the following:

1. Discussing about what to do, eat an apple, wear a uniform at school, have a mobile phone, hunt, clone people are practices situated in Social, Organizational or Private Policy as an applied art that aims to regulate conduct. These practices may be based on deontological alongside utilitarian considerations.
2. Ethics on the other hand is the science that might evaluate the performance of this action as *right or wrong.* This practice might be done either by using

established moral laws of the community to evaluate the action, or by appealing to different moral systems such as consequentialism (utilitarianism, hedonism, altruism) as superior to deontological moral evaluation.

3. Moral Reasoning describes the process of arriving to such laws used by ethics to evaluate conduct as right or wrong. In this sense discussing about Social Policy issues might be regarded as “morality in the making” akin to a “science in the making” (Kolsto, 2001a). The issue of cloning or not for example that has the status of a controversial issue of social policy might have the status of a moral law in some years. Whether women should vote or the black “race” be treated as slaves, have been controversial policy issues once. Today, they are resolved issues that hold the status of a moral law: we should not use the black “race” as slaves; we should not prevent women from voting.

Practical claims therefore, that concerned decisions about the issues set in the classroom, are captured from the category of Social/Private Policy as presented above, and are presented primarily to other sciences, as all other sciences are going to be described as part of them (decide about an issue). Graph 2 presents the bases of practical judgments related to the issues.



Graph 2: The bases of the decisions about the issues

As shown in the graph above, biological needs or biological consequences were dominant factors for students' decisions. Social needs had also been the base for their decisions; social needs actually had grounded the action under discussion as a means for attaining those needs. Rules have also entered the discussion, but as discussed above not all rules were moral. Actually, rules had the following forms:

a) *Social/Private policy - conventional rules*

Rules such "young children should get what they want", or "good students should take presents for feedback", are not actually moral even if they seem deontological in a child's sense. They are actually conventional rules that regulate human conduct in different organizations, or groups of people (family, school etc)

b) *The principle of overall utility*

There were decisions that had the form of calculations in combination with the principle of overall utility (the benefit is greater than the cost) of the type: since your brother needs mobile phones, and since evidence indicates that there is no problem if the phone is used less than 5 hours daily, you should buy him a phone. As discussed before, the principle does not directly imply moral obligation, unless further argumentation is developed to establish overall utility as superior to other rules interfering with the discussion. Additionally, the principle does not only consider consequences, it might also calculate the benefit from using the action as means for needs and therefore this kind of reasoning is classified as a rule based (which applies the principle of overall utility) rather than reasoning from consequences or means end reasoning.

c) *Moral rules*

Moral rules that establish the practice as unethical imply a moral obligation of not performing the action and therefore perceive a Social/Private policy issue as moral. Example of such a rule is “We should not treat other creatures in a way that we would not like to be treated”. This rule has been used to ground a prescription of not hunting.

However, issues (hunt or not, buy or not a mobile phone to a young brother, clone animals and humans) were not the only issues of Social or Private Policy set down during the lessons. As argumentation chains had evolved, sub-issues emerged like: Should we eat meat? Should we select the genes for the clones? Should we slaughter animals? Which is better, slaughter or hunt? Should we kill bad clones? Actually, issues like that had emerged when agents of the discussion had to evaluate and establish a solution aiming to diminish consequences or when comparing alternative means.

Examples of consequences, means, rules, calculations and appeals used for issues or sub-issues are presented in Table 36.

The table indicates that biological, aesthetic, psychological and sociological consequences had bothered students and affected their decisions, whereas the actions implied by the issue have been used in arguments as a means for fulfilling biological, economic, sociological and psychological means. Furthermore, agents have based their decisions on rules, some of which have been conventional rules regulating parents' and children's relationships, for example, or moral deontological rules. Finally, calculations of pros and cons used in arguments with Informal Logic rules have been pointed to avoid the action.

Reasoning Scheme	Disciplines that provided the data for the syllogisms								
	Informal Logic	**Ethics**	**Biology**	**Aesthetics**	**Economics**	**Everyday**	**Animal psychology**	**Psychology**	**Sociology**
From consequences			Mobile phones will harm his health; you should not buy him a phone	Animals will lose their value as all will be the same. We should not clone.				If we eat only vegetables we get bored. We need to eat also meat for a change.	If we clone humans then social confusion might emerge. We should not clone.
Means end			We have to hunt because we need to eat meat		Hunting is cheaper than buying meat to eat, and since we need money we should hunt.			We should clone so when our beloved persons die, would have the opportunity to bring them back.	We should buy mobiles to communicate with our parents when being in a place that they are not with us.
Rule case	Since negatives are much more than positives you should not buy him a phone.					He is a very good student; you should buy it as a gift, feedback for his behaviour.	Small birds struggle to find their food, life is already very difficult for them; we should not make their life harder.		
Analytical		It is unethical to kill birds. We should not hunt.							
Appeals Emotional (to pity)	Please buy him a phone, he wants it so much. After all, he is your young brother; you should feel pity for him!								

Table 37: The base and reasoning schemes for deciding about issues or sub-issues

4.4.2 Moral Reasoning

4.4.2.1 The situation of Moral Reasoning in Practical Reasoning

Moral Reasoning describes the process of arriving to moral principles/laws and the ethical reasoning which refers to the application of moral principles to evaluate conduct as right or wrong. Moral principles are not always established but have to be negotiated as true and additionally as relevant for the case to be applied.

As already indicated, an instance where moral reasoning has been identified was the case of agents expressing practical judgments (decisions) about the issues based on moral rules. In this sense the issues have been perceived as moral, and therefore moral principles were applied in order to prove the action as unethical/immoral and thereby prescribe agents perform it or not (It is unethical to kill birds and therefore we should not kill birds).

The table below presents the frequency of the speech acts that indicated a moral practice and situates them in the dialectical context in which they have occurred. As already mentioned in the methods and methodologies chapter, the numbers are not discussed in any way; there is nothing to say within this study as to *why* the morality of alternative means has been more discussed than the morality of a solution that could diminish consequences, for example.

The existence of numbers in according cells indicates the "instances" which the dialectic had provided for the morality to emerge. As numbers are results of this study are presented within the tables, as they could point to further hypotheses.

Moral Practice * as situated in Dialectical practice related to practical argument scheme				
Moral Practice	**Dialectical practice related to practical argument scheme**	**Dialectical context**		
		Argumentation for action explanation/defence	**Argumentation for persuasion**	**Deliberation**
Evaluates practice	Consequences - Defends a solution as moral		3	
	Means end - Counters alternative means as immoral		7	
	Means end - Defends alternative means as moral		5	
	Means end - Evaluates action			1
	Rule case - Evaluates action	8		
Establishes the rules	Rule case - Counters rule as false		10	
	Rule case - Defends rule as true		13	
Counters rule as irrelevant	Rule case - Counters the rule as irrelevant	1		
*Speech acts categorized as indicating a moral practice				

Table 38: Moral Practice as situated in Dialectical practice related to practical argument scheme

Moral Reasoning however has been identified in other instances as well. The table above indicates how Moral Reasoning as a theoretical practice has been situated in Practical Reasoning; in other words, in which instances of discussing the controversial issues the agents of the discussion have been engaged in moral practices.

Evaluation of several actions as right or wrong, ethical or unethical has been captured from moral normative judgments (theoretical judgments). Those normative statements might have been used in deliberative sessions indicating that the agent was considering moral issues but not being ready to form a decision yet, but also in argumentative sessions as steps in the reasoning towards a practical judgment.

Additionally, as indicated in the above table, moral reasoning emerges not only when the action that the issue implies was being morally evaluated but also in other subordinate chains of argumentation when a solution about a consequence or alternative means has been put under moral examination. Additionally, since the principles used to evaluate actions were not accepted by the participants, new loops of argumentation have been used to establish those rules as true or valid.

Another case that is described as an instance about Moral Reasoning is the evaluation of actions already performed by societal agents and even themselves. This opportunity is differentiated from evaluating an action for using this evaluation as an argument supporting or countering the decision towards it.

Argumentation for action explanation/defence has been a context in which agents had morally evaluated several actions of societal agents: either the actions implied by the issue (hunt, hold a mobile phone) or actions related to the issue (abandon dogs after hunting period, kill swallows for practice etc) have been put under moral evaluation.

4.4.2.2 The moral part of the lessons

A first conception of the morality of the lesson can be captured from the analysis of Social/Private Policy, as presented in section 4.4.1. The conclusions of the analysis indicate that deontological morality was not the main concern of agents when grounding decisions about the issues. As already indicated, the decisions were based on needs and consequences (mostly social and biological) whereas the majority of rules that have been applied have been conventional and not moral ones.

However, morality has been identified in subordinate levels of argumentation for persuasion, in deliberative sessions where the morality of an action was set as a factor to be considered as relevant for decision making and as a means of evaluating societal agents' and their actions.

The following paragraphs describe the substance of the epistemic practices evaluating a practice as moral or not. As shown in the following table, agents have used a majority of syllogisms in order to establish a moral claim concerning the morality of an action situated in different disciplines (cases).

Structure of the syllogism	**Discipline of the case**								
	Animal psychology	**Biology**	**Ethics**	**Metaphysics**	**Psychology**	**Religion**	**Sociology**	**War**	
Appeal to Divine Law						2			
Appeal to natural law				3					
Evidence to hypothesis							1		
From analogy			5						
Principled based	1	21		9	4		4	3	
Simple speech act									10

Table 39: Structure and base of moral evaluative syllogisms

Religion has been the base of syllogisms that had the form of an appeal to Divine law (Nuns eat meat. If our religion allows us eating meat then, what's the point of discussing whether we should eat meat or not?) Additionally, metaphysical considerations about the status of humans as being hunters by determinism grounded the morality of hunting when appealed to a natural law (we are created to be hunters, it's in our nature to be hunters; it is ok to be hunters).

There were instances where the morality of an action was defended by the use of an analogy of another action already accepted in the society. For example, the morality of hunting animals was defended by the fact that every day we consume animals that have been killed and therefore, if consuming killed animals is ethical then hunting is ethical too.

In other cases analogies from human morals to animals were transferred, indicating anthropomorphism. For example, an argument that there is no point discussing about the morality of hunting animals, since animals are going to die one day or another, has been dropped by the use of an analogy indicating that humans struggle for extending their lives, and therefore such a practice should be applied for animals also.

Moral rules have also been supported as valid when bringing evidence that the majority of people apply them. Taking in mind the previous example, the principle of respect to human life, has been supported as true by indicating how humans have developed medicine to help them safeguard or extend their lives. This kind of reasoning is indicated by the "evidence to hypothesis" structure of syllogism above. In this case the moral rule is the hypothesis to be proven as true. The evidence refers to the instances where this hypothesis is applied and proved as true.

Finally, several principles have been applied to evaluate actions. Actions of humans and even animals have been situated in several cases as shown in the following table. The epistemic areas presented as columns of the table indicate that the cases about which a principle was applied could further be supported as true by the discipline that names the column. Consider the syllogism below:

> *"An eagle hunts because it has no alternatives for food.*
> *(If you do not have alternatives then your action is morally defended: The right to live)*
> *An eagle is not unethical to its prey."*

The fact that an eagle does not have alternatives for food is a case that is situated in Biology, the discipline that could ground it as true or not. When an ethical principle is applied to this case, actually is a complex principle indicating your right to live as superior to the right of the other creature to live, the action is evaluated as ethical. This kind of syllogism, principle based, is akin to the rule-case syllogism explored in practical reasoning argument schemes (see chapter 2 section 2.4.2.3) with the difference that when the rule is applied to a case the result of the syllogism does not prescribe an action, but points to an ethical evaluation of that action. The following table indicates examples of cases situated in several disciplines which were evaluated in the light of ethical principles and had formed a moral practical judgment.

Moral Reasoning: cases and disciplines in moral evaluative judgments			
Discipline of case	**Case**	**Principle**	**Evaluative Judgment**
Biology	An eagle has no alternatives for food, he has to hunt and eat its preys	*Ethical Egoism*: an action is morally right if the consequences of that action are more favourable than unfavourable *only to the agent* performing the action	Eagle is ethical to its prey.
War	A human being is in advantage when hunts a bird, he holds guns, he is smarter.	*Principle of justice*: (rule of fair play) Treat people fairly: treat equals equally, non-equals unequally.	It is unethical to hunt birds.
Sociology	Human beings offer a lot to domestic animals: they provide them shelter and food	*Principle of Gratitude*: the duty to thank those who help us	It is ethical to slaughter domestic animals.
Psychology	A person that is alone might find company and be happy when hunts with other people.	*Principle of utility*: An action is right as far as it promotes happiness or pleasure	Hunting is a good practice.
Animal Psychology	Birds have (intentionally) harmed people by giving them the sickness of bird flu.	*Principle of Nonmaleficence*: Do not harm yourself or other people.	Birds are unfair to people.
Metaphysics	Clones will not have soul.	*Rights* (principle proved as not applicable, irrelevant): acknowledge a person's rights to life	Killing a clone is ethical.

Table 40: Moral Reasoning: cases and disciplines in moral evaluative judgments

As the last example of the table indicates, there were cases where the practice was evaluated as ethical, not because of an application of a moral principle, but because a moral principle that could ground it as unethical has been proven as not applicable. Killing clones has been evaluated as ethical, since a deontological principle concerning the rights of the clone to life had been countered as not applicable, as the clones would not have soul. Another example of such a kind of moral reasoning is one of a student that his action of hunting animals has been judged as ethical because the principle of “eating meat is unethical” could not be applied to his case since he hunts but does not eat the animals he hunts.

Finally, there were students that did not perform a syllogism to ground their evaluation of the action, but they had just cited their evaluations as simple speech acts: “It is not right to clone”, “It’s unethical to kill birds”, and “Slaughtering animals is bad”, are examples of unfounded evaluative moral claims, simple speech acts.

Summarizing the section about moral reasoning we might conclude that:

- Moral Reasoning has emerged as an opportunity to ground decisions about the issues, solutions about a consequence and alternative means. It has also emerged when agents had considered the morality of their own actions, or other societal agents’ actions. Finally, the morality of an action was considered as a factor to be taken into account, within deliberative sessions.
- Agents applied a variety of principles in a range of psychological, sociological, biological, metaphysical and other cases but also appealed to natural law or Divine law as methods of grounding the morality of an action. They also used evidence to support the principles/laws as valid for a majority of people and thereby ground their truth, or used reasoning from an analogy to establish an action as moral based on the ethical acceptance of another, analogical action as moral. Finally, they grounded the morality of an action by proving an ethical principle that could ground it as unethical, as irrelevant to the case.

4.4.3 Introspection (Self reflection)

The following section will explore the instances in which the agents of the discussion had been engaged in practices of Introspection. Introspection, as used in this study encompasses both the process of learning about one's own mental states or processes, but also the process of reflection on our character traits, even if there are contemporary philosophers of mind that do not believe that we can directly introspect character traits in the same sense in which we can introspect some of our other mental states (Schwitzgebel, 2010).

Even if this process could be assigned in psychology as a discipline, it is differentiated from it, in the sense that when you learn about your mind introspectively, you do it in a way that no one else can do; you are the only one to have access to such information (Schwitzgebel, 2010). Actually, introspection is a term that literally means "looking within" (from the Latin "spicere" meaning "to look" and "intra" meaning "within").

4.4.3.1 The situation of Introspection in Practical Reasoning

In some aspects the whole process of discussing a controversial issue can be regarded as an indirect process of introspection, since our beliefs are accessed, extracted and presented to the public. However, there are instances in which this process is done explicitly; agents of the discussion, apart from expressing beliefs about the issues, have explicitly talked about themselves and several aspects related to the issues. Actually this discussion has already been done within this study when contexts of beliefs about the issue have been differentiated from beliefs about own self (section 4.2.2).

The instances are categorized alongside five different categories of reflection and are related to accordingly specified contexts (see 4.2.2 within this chapter).

- Views (view citing, view explanation/defence)
- Positions (positioning-within argumentation for persuasion)
- Intentions (intention citing, intention explanation/defence, argumentation for intention explanation defence)
- Decisions (decision explanation/defence, decision making process description)
- Actions (action citing, action explanation/defence, argumentation for action explanation/defence)

A primary issue to be clarified is the description of those contexts as situated in practical reasoning aiming for taking a decision about the issue. For example positioning is an action performed with the dialectical goal of informing the interlocutors about the agent's position towards the issue, but explaining one's action does not carry any other dialectical force apart from explaining one's action and thereby one might argue that the use of "action explanation/defence" does not rest at the level of dialectical context but actually describes the epistemic practice performed.

However, connection lines might be drawn between argumentation for persuasion or deliberation, and contexts related to explaining and grounding explanations about own decisions, intentions, views, and desires.

As already explored in session 4.2.2.2 explanations had the form of practical judgments (means end, from consequences, rule based). Means, consequences and rules were used not only to prescribe an action, but as causes that could explain the agent's intention, or volition to perform such an action, and partly explain why the agent might have already performed that action.

In this sense dialectical contexts that describe self reflections are not actually situated *in* practical reasoning but they are rather parallel to it. They use common elements (means, consequences and rules) but they use them for different purposes. Practical reason uses those to ground decisions; reflective practices, on the other, use them to explain own behaviour, mental and psychological states.

I still need to clarify how those explanations emerged during a discussion about a decision to be made. For that purpose I have followed the instances in which mental and psychological states apart from beliefs about the issue of the interlocutors came up in the lesson and I have defined the connector lines between those two areas. The results of such an analysis are provided below.

1. **Positioning**
   a. **As a strategic movement**: Agents take positions before the "battle", declaring their viewpoint so the debate can start. Usually it is done after prompts from the teacher to do so.
   b. **As a communication means**: Students had to reveal their position so their interlocutors might better understand their argument to follow.
2. **Intention/action explanation defence**
   a. **When the teacher explicitly asked for explanation of students' action**

      In the hunting lesson, the teacher included a reflective session in the end of the lesson, in which he wanted to explore a claim which was actually supporting that we become hunters because our parents are hunters. In the argumentative session that followed students were engaged in practices supporting or countering such a claim by appealing to their own explanations of action as hunters.

b. When the issue was explicitly set in a micromorality mode by the teacher

There were cases in which the teacher had planned and set down personal dilemmas, as a means to put the issue into micromorality mode and give the students the opportunity to engage in the discussion from a different perspective. Such example is the cloning lesson, which explored apart from the issue “Should we clone animals/ human?” the personal dilemmas “Would you clone your own pet?” or “Your dead son?

c. When the teacher transferred the issue from macromorality to micromorality mode as a means for elaborating students’ arguments

The episode below indicates an instance where the teacher had perceived students’ engagement in the discussion as resting in personal psychological reasons.

> “*Teacher: Well, tell me arguments about why we should clone humans or not.*
> *Student: We should clone human beings because this would bring our beloved persons back.*
> *Teacher: You mean, for example, you would like to clone your dead grandfather to have him back?*
> *Student: Yes, since cloning can bring them back…*”

It is evident that in this case the teacher perceives the argument as relating to personal intentions and she furthers explores it by setting the issue to a micromorality mode.

d. When students used their explanations of actions or intentions as arguments for the discussion

There were cases in which the transfer from argumentation for persuasion to action/intention explanation was done from students: students had entered a context of explaining their attitude as means to add an argument for persuasion. Consider the following episode, which had begun with the prompt of the teacher for citing arguments in favour of or against human hunting.

> *"Student 1: We should clone human beings because we would have them back again.*
> *Student 2: Yes but if you bring a sick person back, wouldn't he get sick again, and have the same pain?*
> *(…….)*
> *As far as myself is concerned, I would not like to clone a sick person and bring him back, watching him getting sick or dying again; this would cause me a lot of pain."*

Students also used explanations of their actions as argumentation moves that could drop other arguments as irrelevant to the discussion. As mentioned in another case, a student citing that "Eating meat does not have any relation to our discussion; I do not eat what I hunt, hunting is a sport for me, it is not a means to eat", actually evaluates the rule "we should not eat meat" as irrelevant to the discussion about whether we should hunt or not, by appealing to his own explanation of action; the latter can be analyzed as an argumentative move.

e. As a pedagogical strategy of the teacher to bring more arguments in the discussion

There were cases when students had no more arguments to add to the discussion. Teachers in an effort to bring more arguments to the discussion asked the students to explain the reasons of why they had performed the action implied by the issue (i.e. use a mobile phone)

> *"Teacher: Ok, do you have any more arguments to support or counter that I should buy my brother a phone?*
> *(Students do not react)*
> *Teacher: Ok, tell me then how many of you have a mobile phone?*

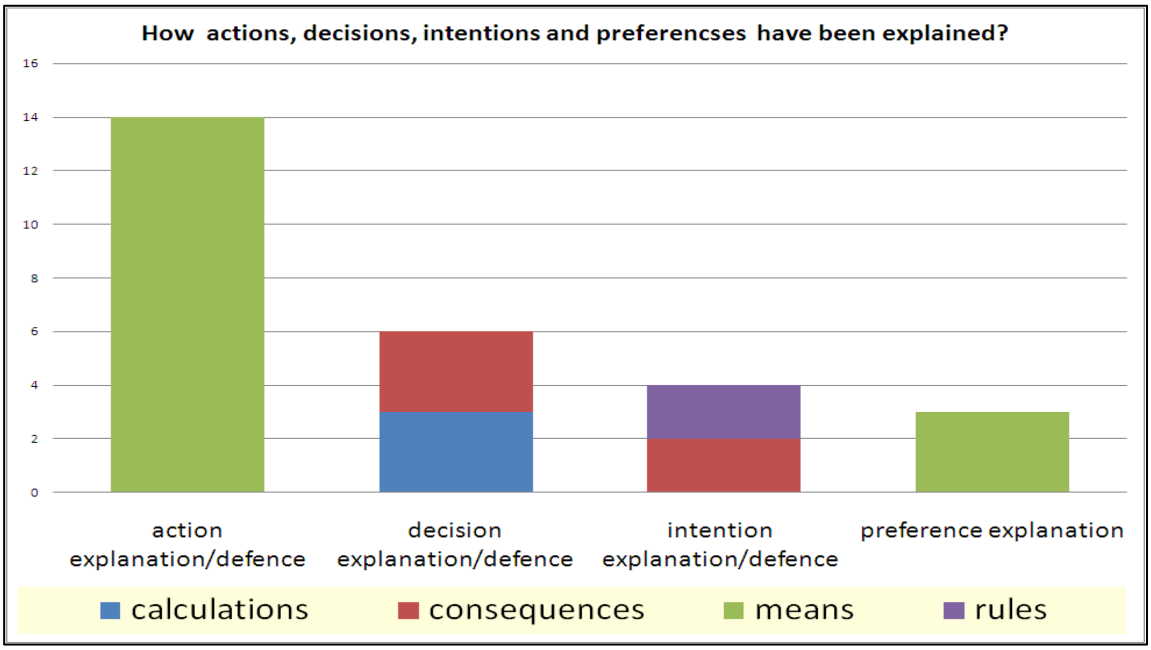
(Students raise their hands up)
Teacher: Well I can see that many of you have a mobile phone. Tell us Maria, why do you have a mobile phone?
Maria: I want to communicate with my parents, I did not want to play or send messages.
Teacher: So Maria, tells us again about communication, it's a reason already written in the board. Any other reasons? George, why do you have a mobile phone?"

As shown in the above episode, the teacher needs reasons; arguments as propositions. She does not care if those arguments come up as dialectical arguments supporting a decision, or as explanations of actions and intentions. She therefore treats explanations as reasons, as arguments.

The above instances draw a conclusion. The connecting line between argumentative and explanatory contexts (argumentation of persuasion and intention/action explanation) is evidently drawn: ends that need means to be achieved, consequences and rules explaining human action, can also ground the decision for an action to be taken and vice versa: since an argument with a psychological ground is set, it might be further explored as an explanation of intention, beyond its status as a reason grounding a decision.

4.4.3.2 The introspective part of the lessons

Introspective processes might be situated in Psychology as a discipline that studies and explains psychological facts (emotions, actions, desires etc.), grounds those explanations, and uses them as rules to predict future behaviour (intentions). As with all disciplines, those explanations are grounded in observations and in this sense self reflection processes are regarded as distinct from other epistemic practices situated in psychology: they refer to introspective strategies aiming to access information about own self by looking “inside” and their substance as related to means, consequences and rules.



Graph 3: Practical components of explanations about own actions, decisions, intentions and preferences

The above graph indicates that agents explained their actions totally by the use of means (I have a mobile phone because I need to communicate with my parents). This is not peculiar, since we talk about actions that have already been performed. Perhaps consequences might drive an agent not to perform an action and therefore be able to explain her action, but as soon as those consequences have driven an agent to perform the action, they take the form of a need, an end to be attended. For example, the fact that endangered animals are going to be saved if cloning animals is allowed, is a positive consequence of cloning establishment but since people adopt this practice, their action is explained not by consequences but by a means end syllogism: they have cloned animals to save the endangered species.

The following table further elaborates the content of introspective practices: which type of means, consequences and rules the agents used to explain their psychological, mental stages and actions.

Introspective practice	Structure of syllogism	Disciplines that could ground the means, consequences, or the case for the rules					
		Biology	**Biotechnology**	**Psychology**	**Informal Logic**	**Sociology**	**Other**
Explains/ predicts a fact (action, intention, decision, desire)	Means end			We like to discover how ancient people had lived in the past and that's why we hunt.		I have a mobile phone for communicating with my mum.	
	Rule case				Negative arguments have been much more than positive and this made me decide on the negative side.		I am a hunter because my father was also a hunter.
	Consequences	There is evidence indicating that mobile phones are related to increased danger for brain cancer; this had made me decided not to buy your brother a phone.	Cloning might produce for me a monster cat; I would not clone my dead cat.	If I had a cloned cat again I would get bored to it; I would not clone my dead pet.		Mobile phones affect the relationship between parents and children within families and this made me decide on the negative side.	
	Cause to effect		The cloned cat would by exactly as my dead cat. Watching it would make me happy.	I would get bored to the cloned cat; I do not like having the same pet for a long of time.		Mobile phones are fashionable; all teenagers hold mobile phones. That's why I like mobile phones.	We always win when hunt that's why we like it.

Table 41: Introspective practices: structure and base of syllogisms

The last row actually explains emotions and therefore is somehow differentiated from ends, consequences and rules that actually guide behaviour. Ends, consequences and rules are actually causes for the action, and according to Aristotle might raise moral emotions (actually moral rules might do that). However, explaining our emotions is based on causal rules like “When I have something for a long time I get bored of it”, or “I want to have fashionable things” which are actually psychological, introspective rules that explain attitude and emotions.

Finally, apart from explaining facts, agents also provided explanations as false for them. For example, a student had cited that “I do not have scruples for killing birds, this is not the reason I do not go for hunting” whereas there were cases where students rather justified rather than explained their actions. “I have a mobile phone because my uncle gave me his phone that he did not want” is an example of such a justification that was dropped from the teacher who asked “Yes but tell me a reason; the uncle gave it to you but why did you get it?”

Summarizing introspective practices I might conclude the following:

1. Introspection as used in this study captures more than emotional reflection. Emotions are explored through introspection, but as rules, consequences and means beyond psychological ones might guide behaviour, explaining one’s actions or intention captures more than emotions.
2. Introspection was situated in practical reasoning as a practice that could inform about the agent’s position towards the issue as a strategic movement that enables the debate to start, or as a communication means that informs the interlocutors about the force of the argument to follow. Additionally, introspection was a means of importing personal, psychological reasons into

the discussion, and this was implemented by the students as an argumentative strategy but also from the teacher as a pedagogical means of adding new arguments to the pool of reasons, or further elaborating a student's argument.

3. Introspective practices included citing and explaining actions, decisions, intentions and views with the use of means, consequences and rules. Those explanations might further be grounded by explaining emotions that consequences, or the achievement of the end would create.

4.4.4 Special Sciences (Idioscopy)

This section aims to describe epistemic practices that belong to the special sciences' category of Peirce, and include Physics and Psychics. As cited in previous sections of this study Special Sciences (Idioscopy) are classified by Peirce (1990 as cited in Pietarinen, 2006) as such since they resort to special experience or experiments in order to settle knowledge claims and are further classified to Physical (Natural) Sciences which are Physics, Chemistry, Biology, Geognosy and Astronomy and to Psychical which include Psychology, Ethnology, Linguistics, and finally descriptive Psychics (History, Biography).

All those sciences resort to experience to ground knowledge claims, "*Idioscopy embraces all the special sciences, which are principally occupied with the accumulation of new facts*" (Peirce, 1905 as cited in Bergman & Paavola, 2003)

Data analysis therefore followed the argument scheme typology to identify knowledge claims which could be situated in each discipline, and describe the epistemic practices used to establish or use such claims. A first problem to be addressed was the infusion of normative in addition to factual statements as belonging to special sciences, an issue to be discussed in the next paragraphs.

4.4.4.1 Normative or factual descriptive statements

Data analysis revealed a problem regarding a special class of normative statements regarding health, or necessity. For example, the concept of health was regarded as problematic because it was not clear at first whether statements of this kind were descriptive factual or normative ones. For example the argument “Eating slaughtered animals is healthier as you can control the type of food they get, whereas animals you hunt are not so healthy because they might access poisoned food or not good quality food” could be both analyzed as a theoretical factual but also as a normative statement.

Those kinds of statements were initially classified as normative since they reason from criteria, of what would constitute a healthy diet.

Fact: Slaughtered animals eat controlled food.
Value (criteria) Controlled food is healthy.
Judgment: Eating slaughtered animals is healthy.

Those criteria though could be connected with biological standards of being healthy, and therefore eating a good quality food and being healthy is perceived as a cause to effect factual statement that could be reconstructed as follows:

You eat good quality food (cause)
Good quality food ensures health (cause to effect biology law)
You are going to be healthy (effect)

The difference between the above structures of syllogisms is the nature of the concept of “health”. Is being healthy a quality, or is it a fact? In the second example “health” is not perceived as a quality by which facts can be evaluated but as a fact that might be true or not, an empirical statement that can be tested through reality.

The issue was further clarified with the following thoughts: the criterion of what constitutes healthy diet is one that might be established within biology as a discipline and it is an *evidence based* criterion. For example, the fact that some students had been poisoned from eating slaughtered animals' meat was used as an example that could drop the law-criterion "*Controlled food might ensure health" or "Controlled food is healthy*" used to ground an evaluation/classification of eating slaughtered animals as healthy. Therefore, criteria in this case hold the status of a natural law, which can be further questioned and established when tested through reality.

A second example of such normative statements regards the concept of necessity of an action situated in Biology, Psychology or Sociology. Establishing a means as necessary by pointing to alternatives is a practice that could be classified as reasoning from criteria:

B is an alternative action, instead of action A for attending End C. (fact)
Since alternatives the action is not necessary (criterion)
A is not necessary (value judgment)

Necessity in those cases is the normative evaluation with the use of the criterion of having alternatives. However, having alternatives or not is situated in each discipline to empirically ground it as true or false. Consider the following examples:

a) *People do not need to eat meat, they can eat vegetables*

It is not necessary to eat meat.

b) *Your brother can communicate by using other people's phone.*
It is not necessary to have his own mobile phone

c) *You could be happy by buying another homeless cat.*

It is not necessary to clone your dead cat.

If vegetables can replace meat and preserve health is an issue situated in Biology; whether people can have access to other communication means is an issue situated in

Sociology; accordingly, whether people can be happy with a new pet is situated in Psychology. In this sense, the qualities used for evaluating necessity could be regarded as evidence-based norms situated in each discipline. In other words, evaluations of necessity hold the status of a law within different disciplines and can be tested through reality. The difference with the health example above is that those evaluations have a deductive nature. Since the law within a discipline is accepted (Vegetables can ensure a healthy body) then the necessity of an alternative might deductively set down (Meat is not necessary). Both statements are subject to truth and falsification through evidence.

The discussion above has implied some considerations about Schellens' second category of normative statements. As cited in the theoretical chapter that had grounded the argument typology scheme, Schellens (1985) classifies as normative arguments "arguments based on evaluative rules" where something is evaluated by referring to a certain quality, and "arguments based on rules of conduct".

Health is a certain quality, is a standard. Necessity and happiness are other qualities. However, health, necessity and happiness can be provided as true or not within different disciplines, and therefore, citing for someone as being healthy, necessary or happy does not necessarily indicate a normative, evaluative statement; it might indicate establishing a fact as true or not (meat is necessary for the body, hunting is a pleasant activity, mobile phones are necessary for communication).

Argumentation chains that have followed such statements further support this consideration. Agents of the discussion had supported the "evaluation" or "fact" that hunting is pleasant by bringing examples of their friends that enjoy hunting and are very happy after a hunting day. Accordingly, they have brought causal arguments to support that meat is necessary for the body since it has proteins, or had grounded the efficiency of vegetables by providing examples of vegetarians that are healthy.

As a result of the above considerations this study has reconstructed as normative judgments belonging to the second class of Schellens (“arguments based on evaluative rules” where something is evaluated by referring to a certain quality) those arguments whose criterion or evaluation rule could not be settled down by evidence. Examples of such evaluative arguments are presented below:

A cloned cat might cost 5000 pounds or more to be cloned
5000 pounds are too much
Cloning a pet is an extremely expensive sport. It is not worth it.

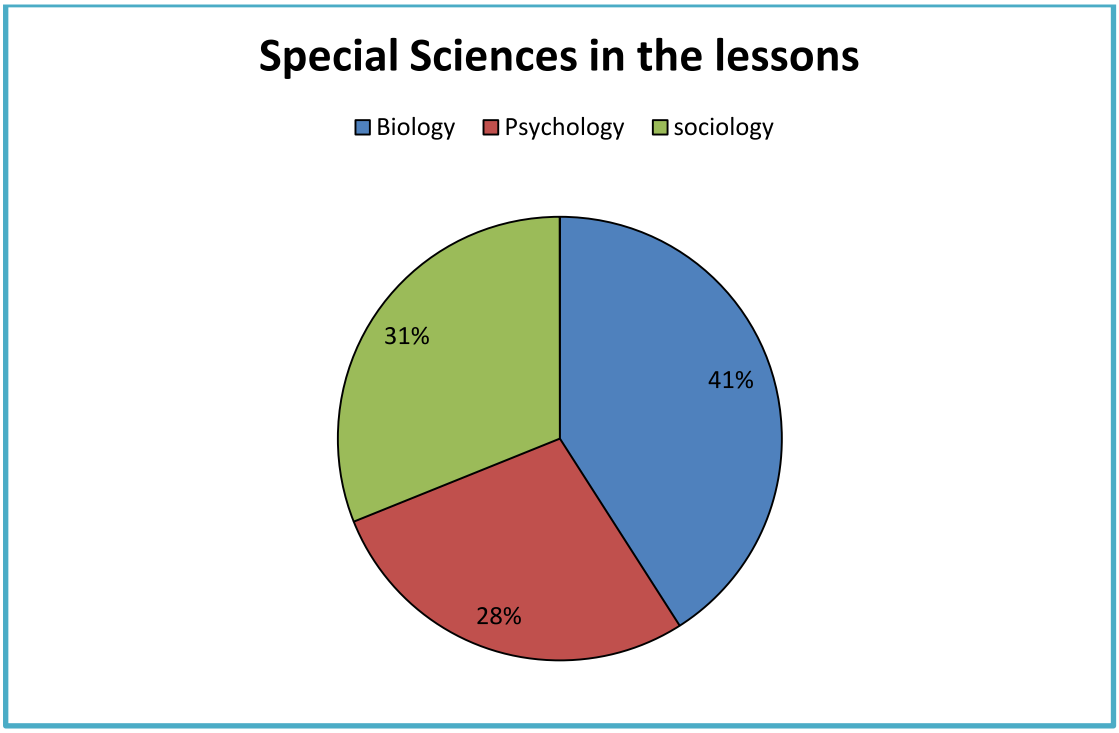
Even if Economics as a discipline might evaluate the cost of 5000 pounds, the discipline would be a normative one and not an empirical one; it has to use the norms of the economy of the society at a specific time and place and evaluate the cost of a practice.

I realize that the solution for such a problem would never be airtight. The fact-value distinction is not new and the philosophical theories behind this distinction are puzzling. However, when it comes to data analysis method decisions have to be taken so, even in a blurry environment, the description of the reasoning and epistemic areas should be as accurate as possible.

4.4.4.2 The situation of Special Sciences in Practical Reasoning

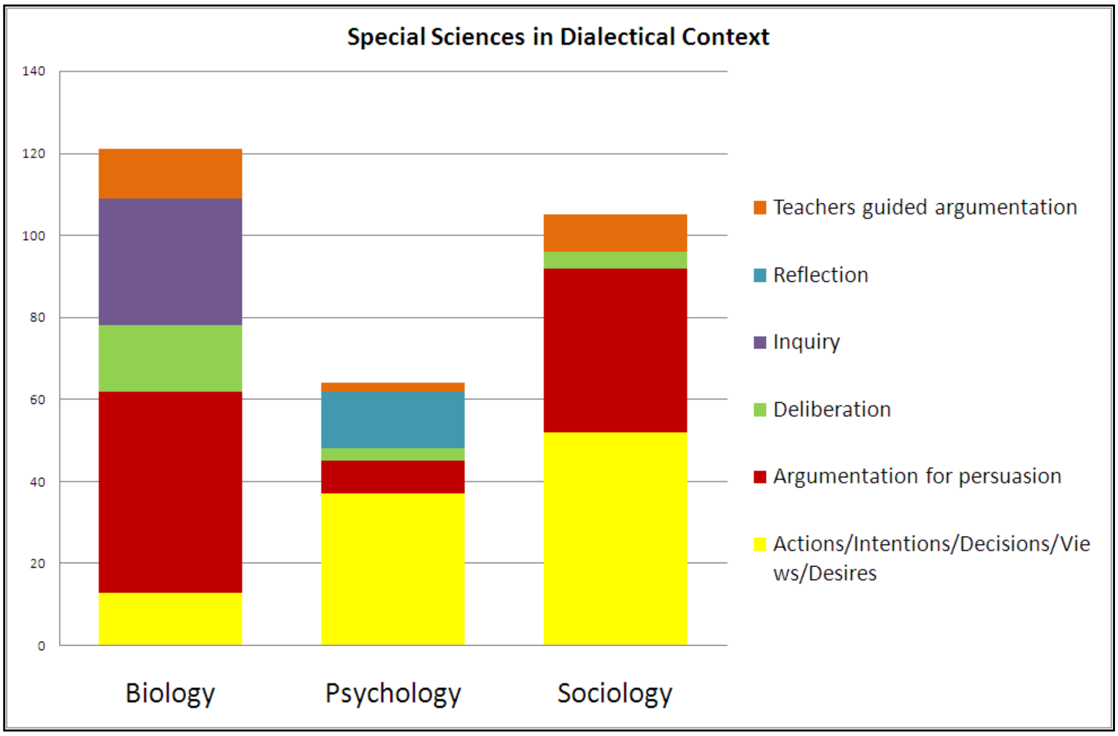
The results of this study had revealed three special sciences whose knowledge claims had entered the discussion: Biology from Physics, Psychology and Sociology from Psychics (Introspection has been elaborated in previous section)

The following graph shows the percentage of knowledge claims situated in each Science situated in Idioscopy, as identified in the classroom discussions.



Graph 4: Epistemic areas in the lesson

As shown above, Psychology and Sociology had entered the classroom almost in an equal footing, whereas Biology was more dominant in the lessons. The question to be answered is how epistemic practices emerged as a result of the discussion of a controversial issue in the classroom? The graph that follows indicates the dialectical contexts in which propositional statements classified in each discipline have been identified.

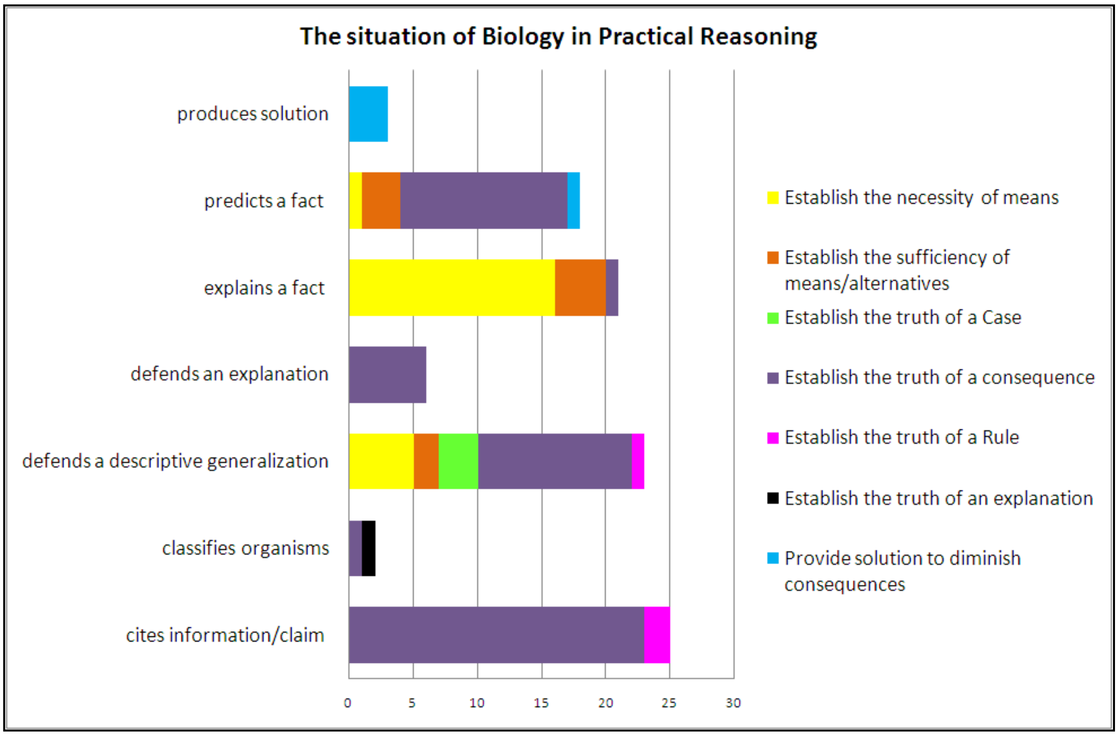


Graph 5: Special Sciences in dialectical context

A first conception that this graph provides is that argumentative context was a place for Biology and Sociology to emerge, whereas Psychology and Sociology were the sciences that had grounded explanations of actions/intentions/decisions/views/desires of societal agents. Furthermore, inquiry as a practice about factual issues was restricted only in biological and not sociological or psychological issues whereas explanations of actions might further be grounded within Biology that might evaluate those actions as true or not. The following paragraphs elaborate the situation of Special Sciences in Practical Reasoning, but also the content for each discipline individually.

4.4.4.3 Biology

4.4.4.3.1 <u>The situation of Biology in practical reasoning</u>



Graph 6: Biology as situated in practical reasoning in the classroom discussions

As the above graph indicates, the establishment of the truth of the consequence, the necessity of actions as means to a biological end and the sufficiency of means were the main instances where Biology has emerged. Another use of Biology as a discipline to establish a claim as true or not emerged when the teacher had appealed to a natural law to establish the morality of hunting:

We are hunters by nature
What is natural is good
It is ethical to hunt.

The case that we are hunters by nature had to be established by biological practices of classifying organisms by criteria. Therefore, chains of reasoning emerged to defend humans as hunters: nails, teeth, type of stomach etc. However, this was not students’ initiative. Actually the teacher had been using his students to extract information about the human body to use it as evidence to support that humans are by nature hunters. This context has been named after “teachers’ guided argumentation”. However, it points to an instance that morality that appeals to natural laws has to be further grounded by epistemic practices situated in Biology or other disciplines that study nature.

Another instance of Biology that derives from Moral Reasoning is the establishment of cases where moral rules are applied, as true or not. A human being is being evaluated as unfair to animals because of being in advantage when hunting, and additionally because he hunts without necessity. On the other hand, animals are not evaluated as being unfair because they do not have alternatives, or they do not store food for later use. If animals have alternatives and whether they store food or not are cases situated in Biology.

Actually many moral cases that had to be established through Biology were instances emerging from anthropomorphism. Students were observing animals, trying to cite inferences about their behaviour, even animals’ “motives” and “perceptions” to evaluate human actions as unethical to animals, or even evaluate animals’ actions.

Finally, an instance for Biology was when students had perceived the issue of hunting as problematic as it would be disastrous to human population. That’s why they had produced solutions for eliminating this bad consequence by citing that “human hunting should be done with limits and regulations”. More types of solutions are going to be elaborated in the Sociology section that follows.

4.4.4.3.2 Reasoning schemes and SDDS (Scientific Discovery as Dual Search (Klahr, 2000 as cited in Zimmerman, 2007) stage

The results indicate that agents had used causal reasoning (explanations or predictions) but also examples and evidence (defending a descriptive generalization) to establish the truth of a consequence or the necessity or sufficiency of means. This means that they had either used readymade knowledge to explain why a consequence is true and thereby defend its prediction, or further explain it as true, or they had perceived it as a hypothesis to be tested through reality and therefore, they had brought evidence and examples to indicate it as true.

For example the necessity of meat for the body was defended with explanatory and evidence based means. Citing that meat contains proteins which are essential for body growth explains *why* meat is essential for people whereas citing that nuns or other vegetarians are healthy actually provides evidence for defending such a claim as true. In the first case the connection between meat and health is established; the causal law that relates them is accepted and applied deductively to provide the necessity of meat as a means for health. The latter syllogism though perceives the claim that meat is essential for health as not accepted/established. It can be tested through reality and therefore examples and evidence might prove it as true or false.

An additional syllogism that was used to provide consequences as true, reasoning from effect to cause indicates an even more complex structure: there were cases in which agents had formed new hypotheses within the discussion about claims under question. For example the fact that research was contradictory about mobile phone use has been used by students as an effect indicating that some other factors might affect the results, such as the type of the organism of each person. The discussion is further elaborated with the following episode presented in Table 41.

Episode lines	Syllogism /Epistemic practice / SDDS stage
24. Student: Well, …ok I would also want to have a mobile phone but my mother and father do not buy me a mobile phone because there is an energy that harms our system.	
25. Teacher: How does it affect our system?	
26. Student: Radiation	
27. Teacher: So, mobile phones affect our system because they have radiation….	Cause to effect/use readymade knowledge
299. Teacher (after a lot of activities and when two contradictory claims were cited and written on board) So, finally…have a look at the board. Please consider the two first sentences and the last one. Do you find anything problematic there? (students do not react)	
300. Teacher: The first two sentences. Is there any problem that both of them are written there?	
301. Teacher: What does the first sentence says: Mobile phones create health problems like brain cancer.	
302. The second sentence says that there is no relationship between mobile phone use and brain cancer. Is it logical that both sentences are written there?	Prompts for hypothesis testing/evidence evaluation
376. Student: I think that may be if you go often to the doctor you might not get brain cancer. If you do not go….	Effect to cause / comes up with an alternative hypothesis given anomalous evidence /hypothesis generation
377. Teacher: No, this is not the meaning of this. Who wants to say anything else?	Drops context
378. Teacher: Health problems. Do mobile phones eventually cause them or not?	
379. Student : Both cause and do not cause -	Evidence to hypothesis/ Inability to defend a descriptive generalization
380. Student: Research indicates that they create problems that affect the brain.	Cites available evidence/Defends a descriptive generalization/ Hypothesis testing-Evidence evaluation
381. Teacher: But your team has cited that there is no relationship between brain cancer and mobile phone use.	Cites contradictory evidence/Defends a descriptive generalization/Hypothesis testing-Evidence evaluation
382. What do you mean by “it does not affect”. What should I believe now? Do mobile phones affect health or not? -	Prompts for hypothesis testing/evidence evaluation
383. Student: It might cause problems, it might not.	Evidence to hypothesis/ Inability to defend a descriptive generalization
384. Teacher: Oh, this the meaning you get? That research implies that it might cause, but it might not cause? This is the meaning?	Drops generalization
385. Student: I believe that your brother should not get a mobile phone. Since he is 10 years old mobile phones affect brain cancer, you should not buy him a phone.	Out of SDDS stage: Claim is accepted, used as negative consequence to ground decision
386. Teachers: Yes, but this research you are using now supports that mobile phones affect brain cancer until 12	Prompts for hypothesis testing/evidence evaluation

	years old, but Angelos had cited down information that supports that mobile phones might not cause brain cancer.	
387.	Student: But teacher, they had done research to prove that (mobile phones do not cause brain cancer)	From criteria/ Evaluates evidence/Hypothesis testing - Evidence evaluation
388.	Teachers: Who has cited down that until 12 years mobile phones affect brain? Is it an unfounded claim or is it a product of research? Someone has done research before telling us so?	Prompts for evidence evaluation
389.	Student: No, it does not say how they found it. It just says that there is a relationship…..	Cites available evidence/ Hypothesis testing - Evidence evaluation
390.	Teacher: They talk in general. They do not tell us how they came to support such an issue. However, in the other case they have told us in detail what they have done. They have studied what? People that had brain cancer and people that had not. And they tell us that they could not find a relationship between brain cancer and mobile phone use. So what do you believe, mobile phones affect or do not affect?	Cites available evidence Prompts for hypothesis testing
391.	Student: I believe that they affect health.	Defends a descriptive generalization/Hypothesis testing-Evidence evaluation
392.	Teacher: Even if research supports that they do not affect?	Prompts for evidence evaluation
393.	Student: Teacher, there is a woman that had died from brain cancer, and people believe that mobile phones caused the cancer.	Appeal to widespread common belief/Defends a descriptive generalization/hypothesis testing evidence evaluation
394.	Student: But they did not make research!	From criteria/Evaluates evidence/Hypothesis testing-evidence evaluation
395.	Teacher: Wait, wait tell us again what you have said.	
396.	Student: This one describes that they have taken people, observed them, checked them and they have seen that it does not affect health	
397.	Teacher: Hm….	
398.	Student: But also people to tell that they believe something it means that some type of research has been done.	From criteria/ Evaluates widespread common belief/Hypothesis testing-evidence evaluation
399.	Teacher: You want to say that people do not say something accidentally, and even if we find some claims written down there is evidence behind them even if they do not cite it down? Hm…	
400.	Student: Teacher, in my handout cites that if someone has already brain cancer and uses mobile phone, then there he is under the danger that his cancer would get bigger in faster way.	Cites available evidence/Hypothesis testing - evidence evaluation
401.	Teacher: Ok, here we have something different. It says that if I have a cancer and use mobile phones then the cancer will get bigger. -	Evaluates relevance of evidence/Hypothesis testing - evidence evaluation
402.	Student: But teacher does this mean that we, students that have mobile phones and use them are under danger to get brain cancer? -	Statistical syllogism/Predicts a fact/Use readymade knowledge

403.	Teacher: No, but it says you that there is a possibility. It says that somebody believe that that there is a possibility that mobile phones will create health problems for you, and others that they do not believe this. That is research based results.	Statistical syllogism/Predicts a fact/Use readymade knowledge
404.	Teacher: What should I do now? I need to decide….	Prompts for decision
405.	Student: Teacher, I think that I am getting what is going on….	
406.	Student: I think… it might depend on the system of each person?	Effect to cause / comes up with an alternative hypothesis given anomalous evidence /hypothesis generation
407.	Teacher: We do not know this yet. Scientists had not decided yet if it depends on each person's body.	Appeal to scientific authority/Defend a descriptive generalization/Hypothesis testing-evidence evaluation
408.	Student: Teacher, perhaps mobile phones create brain cancer, because …let's say….like this incident when this woman had died and had said that it is from mobile phones….perhaps mobile phones had created this cancer…. -	From effect to cause/Defends an explanation/ hypothesis generation
409.	Student: Teacher, I think you should not buy him a phone, because I think even if there are 90 positives for an issue and 10 negatives, and one of negatives is that you are going to die then this one should make you decide…	Out of SDDS stage: Defends a decision using calculations of means and consequences

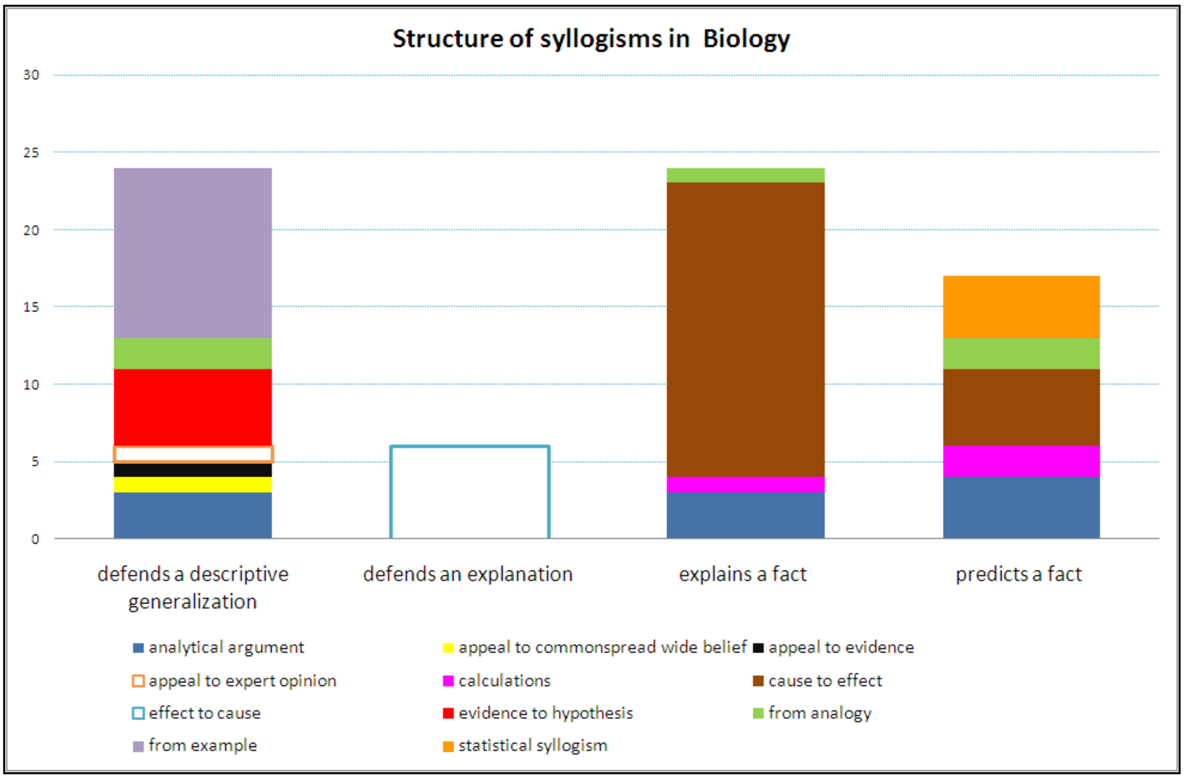
Table 42: Agents of discussion being in different stages of scientific inquiry

The consideration of the episode above implies the following:

- Contradictory evidence might not necessarily drive students to evaluate evidence across epistemological criteria.
- Contradictory evidence can be the data which an agent might use to come up to a new explanatory hypothesis that identifies other variables as relevant to the issue
- Contradictory evidence might not be evaluated, even ignored, in the light of other explanatory hypotheses that support one of two sides of contradictory evidence.
- Contradictory evidence might lead students to conclude a claim of "yes and no", in other words making them unable to draw a descriptive generalization which was a hypothesis that had driven evidence collection.

- Additionally, agents might accept one of the two contradictory claims without a problem and therefore use them as readymade knowledge and engage in the following practices:
    - Perform a statistical syllogism for predicting or explaining facts (What about us that we have mobile phones? We might get brain cancer!)
    - Use it as a fact (consequence) to ground decisions (You should not buy him a phone since health effects are very serious).

Evidence based syllogisms were not the only ones used to defend a descriptive generalization. As shown in the following graph agents of the discussion had used several means to support a fact as true or not.



Graph 7: Structure of syllogisms in Biology

Analytical arguments imply the use of readymade knowledge that had been advanced to drop a prediction or an explanation as false. The modification of Schellens' (1985) category to include analytical arguments was a step that actually derived from the instances presented above. Deductive disjunctive arguments (of the type Either A or B; A; not B) have been used to establish necessity as true or false for several biological cases (either hunting or Nature can control animal population; nature can control animal population; therefore hunting is not necessary), to evaluate the efficiency of several means to an end (the cloned cat would be the authentic or a different one; cloning cannot bring back your authentic cat; cloning cannot bring your cat back) or evaluate the possibility for a consequence to occur (either something is definite or possible; research indicates that there is a possibility that mobile phone use is going to create health problems; it is not definite that you are going to harm your health if you use mobile phones)

Furthermore, the truth of a fact has been established through appeals. The graph above indicates three different appeals:

- **Appeal to expert opinion:**

  Scientists have decided that the meat or milk of cloned animals would not be a threat to health.

  There is no problem with cloned animals' meat or milk.

- **Appeal to widespread common belief:**

  I believe that mobile phones create brain cancer because there is a girl that died from brain cancer and people believe that the cause was mobile phone use.

In this case there is a loop. The student appeals to a widespread common belief but he does not appeal in a type of “I believe that mobile phones harm because people say so” but he actually explains the widespread belief in an effect to cause reasoning. In this sense, the belief is grounded, but still the case is classified as an appeal to common belief.

- **Appeal to evidence**: (continuing the previous argument)

  But teacher, they have done research to prove that mobile phones do not create brain cancer!

  The use of appeal here does not have the meaning of appealing to authorities or emotions and not to reasons to establish a claim. However, the term appeal here indicates that the explanation or hypothesis is defended not by a statistical syllogism, or an evidential support descriptive generalization but it specifically addresses the authority of evidence upon other sources of knowledge and thereby is classified as an appeal.

Analogies were also a means of providing the truth of a statement. An analogy for example has been used to defend the efficiency of alternative means for controlling animal population, other than hunting. A student advanced the reason that “Animals will die one day or another, they are going to be extinct; there is no reason to hunt them to eliminate their population”. This argument has been dropped by the analogy that human population is not controlled by physical death and therefore, by analogy, animal population cannot be controlled by physical death. Even if the analogy might be evaluated as fallacious since humans do not eat each other (at least in literal level) it still indicates a specific type of reasoning.

Finally, agents have used examples to ground the truth of a statement. “I am a vegetarian and I am fine”, an argument cited to establish the truth of the claim that “Meat is not necessary for the human body”, alongside other examples such as “In jungles that there are no human hunters animals are not overpopulated” are instances of arguments from examples that use an instance as critical to be used to prove the truth of a number of instances (Arguments from example).

The following table summarizes the discussion above and provides examples of reasoning schemes, epistemic practices and dialectical practices assigned to Biology as a discipline.

Biology in the lessons: Epistemic practices situated in dialectical practice			
Epistemic Practice	**Structure of syllogisms**	**Dialectical Practice**	**Example**
Predicts a fact	Analytical argument	Establish the truth of a consequence	(There is a possibility that cloning might produce for me a monster cat. I would not clone my cat.) Yes, but cloning uses DNA to create identical cats. There is no possibility to get a monster cat.
	Cause to effect	Establish the truth of a consequence	If we clone an endangered animal it will be able to reproduce itself and thus raise a critical number When animals are above critical number they will be able to reproduce themselves We will not clone a lot of animals to save the food chain. (to drop the consequence :All animals will be the same and therefore they will lose their value)
	Statistical syllogism	Establish the truth of a consequence	There is evidence indicating that mobile phones might cause cancer if used from children under 12 years old, so there is a possibility that your brother might get brain cancer if he uses a mobile phone.
	Calculations	Establish the truth of a consequence	There is evidence indicating that mobile phones do not harm if used less than 5 hours per day. Your brother spends more time at schools where mobiles are forbidden, and so many hours doing other things, so there is no possibility to use it more than 5 hours per day. Your brother is not going to be harmed if he will get a mobile phone.
Explains a fact	Analytical argument	Establish the necessity of means	(We should clone to control animal population.) Yes, but physical death can control animal population, so hunting is not necessary.
	From analogy	Establish the necessity of means	Human hunt and control animal population in the forest. Other animals act as humans, are hunters and control animal population in jungles.
	Analytical argument	Establish the truth of a case	An eagle eats only what it needs, it does not store food for later use.
	Cause to effect	Establish the truth of a consequence	Mobile phones have radiation. Radiation affects human brain. Mobile phones harm human brain.
	Cause to effect	Establish the necessity of means	Meat provides proteins which are not included in vegetables. Proteins are essential for body growth Meat is necessary for our health.

Biology in the lessons: Epistemic practices situated in dialectical practice (Continued from previous page)			
Epistemic Practice	**Structure of syllogisms**	**Dialectical Practice**	**Example**
Defends a descriptive generalization	From example	Establish the necessity of means	I am a vegetarian and I do not have any health problem. Meat is not necessary for being healthy.
	From analogy	Establish the necessity of means	Physical death cannot control human population; therefore Physical death cannot control animal population.
	Analytical	Establish the necessity of means	We can eat vegetables for surviving. There is no need to eat meat.
	Evidence to hypothesis	Establish the truth of a consequence	There is evidence that mobile phones affect hearing after 5 hours daily use. Mobile phones will harm your brothers hearing.
	Appeal to common spread wide belief	Establish the truth of a consequence	I believe that mobile phones cause brain cancer because a girl had died from brain cancer and people believe that the cause was mobile phone use.
	Appeal to expert opinion	Establish the truth of a consequence	I believe that weather mobile phones affect health depends on each person's organism. No, scientists have not decided yet about such a claim.
	Appeal to evidence	Establish the truth of a consequence	I believe that mobile phones create brain cancer. Yes but they have made research to cite such a claim (that mobile phones DO not cause brain cancer)
Defends an explanation	Effect to cause	Establish the truth of a consequence	The evidence about mobile phones and brain cancer is conflicting. There might be another factor affecting the study, which is each person's organism.

Table 43: Epistemic and dialectical practices in Biology

As a summary I can cite that Biology was the discipline to establish the truth of the consequences, the truth of natural laws used in moral appeals to natural laws, the necessity or sufficiency of means to biological ends and finally, an area in which solutions of negative consequences have been established. It has also been used to establish as true cases in which moral laws have been applied to evaluate an act as immoral. Agents of classroom discussions had applied several reasoning schemes when concluding in Biology claims: reasoning from criteria, causal reasoning, evidence to hypothesis, appeals to authorities, widespread common belief, evidence, effect to cause reasoning and calculations are the schemes that describe students' reasoning. Students accordingly have been engaged in several epistemic practices: they had used readymade knowledge to perform predictions and explanations, they had formed explanatory hypotheses and had defended explanations and descriptive generalizations. Results also indicate that agents of the discussion have been simultaneously, within the same episode, in different stages of SDDS (Klahr, 2000 as cited in Zimmerman, 2007) with others being in the hypothesis generation stage, others in hypothesis testing and evidence evaluation, and finally, others that did not enter the space at all, and without a problem used non-established claims as established to defend predictions or ground decisions.

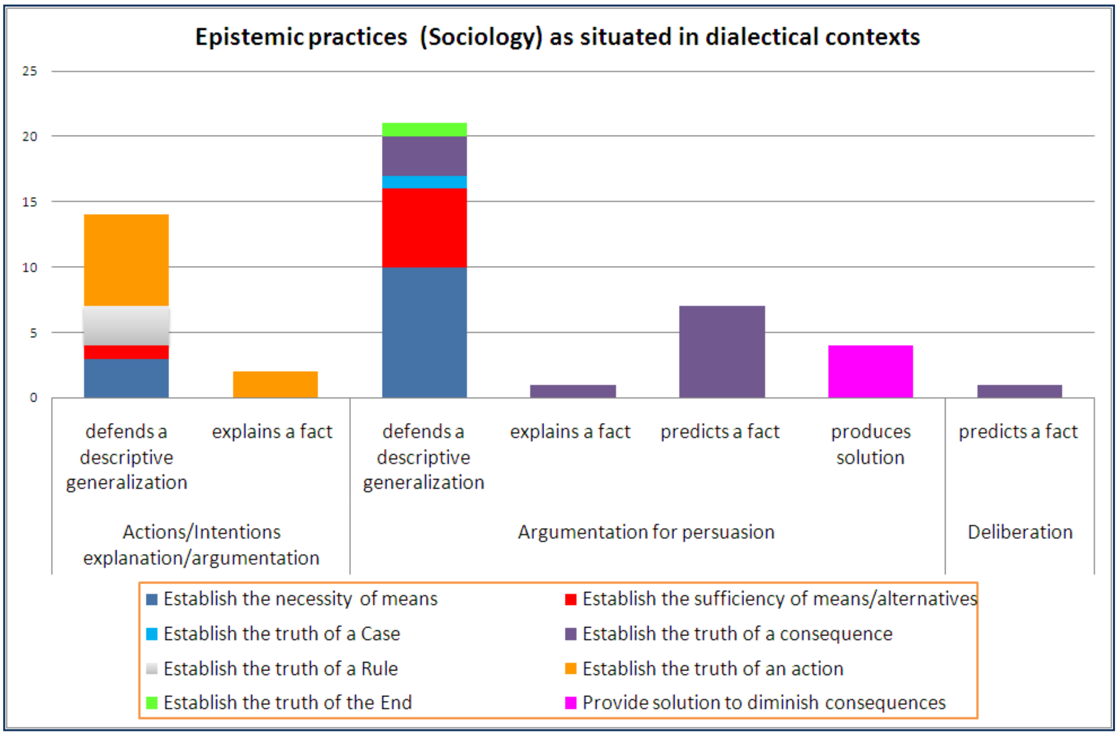
4.4.4.4 Psychics: Sociology

4.4.4.4.1 The situation of Sociology in practical reasoning

Sociology has been identified in argumentation for persuasion and argumentation for action explanation/defence (Graph 8). I regard that the first instance describes how

Sociology *is situated* in practical reasoning whereas the second describes a *parallel emergence* of Sociology, for explaining societal agent's actions.

The following paragraphs aim to describe the situation of Sociology in practical reasoning and also identify the instances in which Sociology has emerged.



Graph 8: Sociology within or parallel to practical reasoning

As shown in the graph above, Sociology has been the discipline in which the truth of sociological consequences, the necessity and sufficiency of means to social ends (needs) had been established as true. Additionally, instances appeared when social needs were put under consideration and agents had to provide them as true or not.

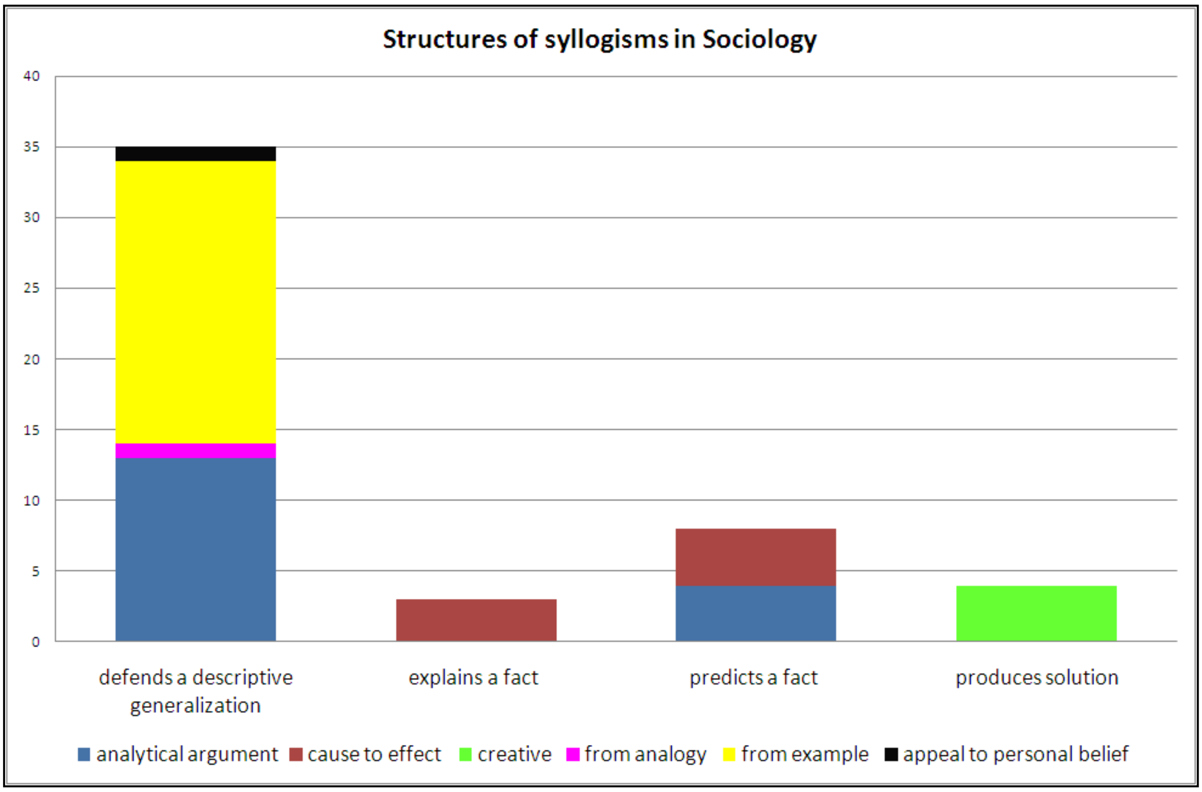
There were cases where social consequences were perceived by students as a problem to be solved. For example, the fact that there is a possibility to clone really bad people like Hitler had driven students to cite solutions of the type "Governments should decide who to clone so this is a controlled process; with this process it would be impossible to clone people like Hitler" or, "If a bad clone emerges, then we can kill him!”. The creative type of thinking here rests to the fact that from a problematic situation a solution is created (actually not one but a number of solutions might emerge to solve the same situation). This type of thinking though is complex and includes beyond the proposition of the solution, its test towards its capacity to diminish the consequence. This latter kind of reasoning could be therefore reconstructed as a syllogism of the type “Governments should decide who to clone; governments control process and do not make mistakes; there is not a possibility to clone Hitler again”. However, it was not possible to assign to a single utterance a double type of syllogism. In this sense I regard that the epistemic practice of “producing solutions” both encompass creative thinking of producing the solution, but also critical thinking to test its effectiveness. That’s why the truth of the statement “if governments decided, then Hitler would not come up again” is regarded as a fact situated in Sociology, and the fact that “if we hunt with limits animals would not be extinct” in Biology.

Another case where Sociology has emerged was when agents were turning the context into one of explaining human actions/intentions/views and preferences. Human actions are social facts; in the lessons there have been cases that not all agents of the discussions believed those facts as true. For example students countered the fact that hunters abandon their dogs after the hunting period, or defended that children use their mobile phones for playing games by the use of personal experiences as examples. Those practices are assigned to Sociology as a discipline that could provide them as true or not (Do hunters really abandon their dogs? Do children really misuse mobile phones?). Actions’ explanations though are a practice situated in Psychology and therefore the way by which this parallel context emerged is going to be discussed in the Psychology section.

However, there were cases where the explanations of actions or views were based on social facts and the needs of humans. For example the explanation that parliament members support hunting because people in that country are poor and therefore they need hunting for survival was countered because the country referred in the argument was Greece, which was not regarded as a poor country (at least was not some years ago when the lessons had been taught). In this instance, explanation of action has a means end structure of syllogism: people have certain needs and that's why they hunt. Sociology is the discipline to establish the necessity of means and the sufficiency of means for social groups. In this case means are not used to ground a decision about the issue, but they are used in an effort to reach a true explanation for human action. In this sense, action/ explanation/defence might be a form of Psychological inquiry in which Sociology is the discipline that can provide the truth of the facts (actual needs) that drive people to actions.

4.4.4.4.2 Epistemic practices and syllogistic forms within Sociology

Epistemic practices situated in argumentation for persuasion have already been analyzed in the Biology section; the practices situated in Sociology are akin to those of Biology with the difference that the facts that are to be established are not biological, but sociological ones.



Graph 9: Structures of syllogisms in Sociology

A first remark about the graph above is that evidential support is completely omitted from students' generalizations of social facts. Evidence has not been brought up as to whether societal members perform actions, or if the actions are really necessary or sufficient for enhancing the ends, or for performing predictions of future consequences in the social pane.

Social facts have been established by the use of examples which actually were students' experiences, and analytical arguments which actually indicate the deductive use of already accepted social facts/laws. For example, students had defended the fact that mobile phones affect human relationships by pointing to instances from their personal life where children do not spent time with their parents because of using mobile phones as games; they had also defended the truth of an action, i.e. the fact that policemen do not apply the law for hunters from personal experiences. The necessity of means has been done by appealing to other social facts/laws that were actually indicating another action as sufficient to fulfil needs and therefore when used deductively countered the necessity of the action as means to an end (needs).

It is interesting to mention the instance of "appealing to personal belief" above, even a single one. A student grounded the truth of an action by just pointing "I believe that such a thing happens; this is my belief" to ground the action that hunters abandon their dogs in nature.

Causal explanations were used to ground the truth of social consequences. Causal laws of sociology have been applied to several cases to provide a social consequence as true or not. The following table indicates such examples:

Structure of causal explanations used to predict social consequences			
Area that supports the case as true	**Case (Cause)**	**Social (Cause to effect) Rule**	**Social Fact (Effect)**
Biotechnology	The clones need time to grow up; they come up as newborn babies.	Social confusion rises because two persons are identically the same	There is not a possibility to have social confusion.
Sociology	Adults spend a lot of time talking to mobile phones with associates when being at home and they do not spent time with their children.	Spending time with someone is a factor affecting human relationships	Mobile phones destroy family relationships
Sociology	Children might talk to their parents when those travel abroad or be in their jobs	Spending time with someone is a factor affecting human relationships	Mobile phones strengthen family relationships
Politics	Governments will decide who to clone	When governments decide then mistakes are avoided	There is no possibility to have Hitler as a clone to the society.

Table 44: Structure of causal explanations used to predict social consequences

As in the case of Biology where the use of science as technology (clone, hunt, use of mobile phones) was causally connected with certain effects in the natural world (animal population, health), the use of technology in the above cases was related to certain social effects. This has been done when the case of possible use of technology was regarded as a cause that under social norms would provide some effects.

The examples in the table above concerning human relationships show how the same causal law might point to contradictory conclusions when applied to different cases. The fact that family members might strengthen their relationships or not with the use of mobile phones was supported with the same law (spending time affects human relationships) that the fact that family members lose their relationships because of the use of mobile phones has been used to point to the contradictory conclusion. The law about human relationships has been applied to different cases and therefore had produced a different outcome. As the teacher in the classroom has recognized:

> *"You are talking about the same thing, but under different circumstances".*

Furthermore, causal explanations were used to defend the truth of an action (Hunters would not abandon a dog in nature for which they had paid a great amount of money).

Finally, agents of the discussion did not come to form any new explanatory hypothesis by which a social fact would be explained and they did not reason from effect to cause or from signs to form an explanatory hypothesis for social facts.

Summarizing the Sociology section I cite down the following:

- Sociology has been the area that had validated social consequences, established the necessity and the efficiency of social needs.
- However, as the lessons moved from argumentation for persuasion to contexts aiming to explain societal members' actions and views, Sociology

has been the discipline to ground those actions as true, or establish the cases used to support explanations of actions as true.

- The structures of syllogisms used in Sociology reveal that actions and explanations had been defended by the use of causal and non causal links; however evidential support was limited to the use of personal examples and not evidence. The results indicate that agents have used readymade knowledge to explain and predict facts alongside examples and deductive syllogisms to support social facts or explanations as true.

4.4.4.5 Psychology

4.4.4.5.1 The situation of Psychology in Practical Reasoning

Psychology was not a discipline that enabled argumentation for persuasion in terms of establishing consequences, means or rules. As indicated in Graph 2 (The bases of the decisions about the issues) there was only one case where a psychological means has been provided as a reason to ground decision about hunting: “We have to hunt, because in this way we feel like great men, it is a means for us to feel that we have achieved something!”

The table below indicates this fact: Psychology is not situated within Practical Reasoning but is situated in contexts aiming to explain human action and desires that actually are contexts *parallel* to those of grounding decisions about an issue.

Dialectical Practice	Dialectical Contexts					
Dialectical practice	**Action explanation/ defence**	**Argumentation for action explanation/ defence**	**Argumentation for intention explanation/ defence**	**Preference explanation**	**Reflection**	**View explanation/ defence**
Establish the sufficiency of means/alternatives		2	2			
Establish the truth of a consequence			1			
Establish the truth of an explanation		5	2			
Establish the truth of means		3				
Evaluate the relevance of the rule			3			
Explain preference				1		
Explain/defend action/intention/decision	15	2				6
Infer students' views/decisions/positions					5	
Describe students' views/decisions/positions					10	

Table 45: Psychology in dialectical contexts

However, there was a case where Psychology was a discipline that has been used within argumentation for persuasion. Agents of the discussion had to identify the position of their interlocutors in cases where this was not apparent. Inferring the other's position or comparing the other's positions from their initial positions are practices situated in Psychology that hold argumentative weight. The teacher and the students have been observing each other; they were considering others' arguments and accordingly had drawn conclusions about their views towards the issue. The following example describes such an instance:

> "*You have told us that mobile phones harm health; so you are against buying my brother a phone*"
>
> "*Most of you have been against human cloning in contrary with your position about animal cloning, where most of you have cited a positive position*."
>
> *"None of us has voted for an argument as being the best argument that was lying in the opposite side of his /her position."*

The above examples describe agents of classroom discussions as psychologists in the field: agents either collect evidence, or join it with psychological laws to form explanations of interlocutors' behaviour. The fact that a student had cited a negative consequence drove the teacher to the conclusion that the student was against buying a mobile phone for her brother (a conclusion that might be questioned if we accept that the student might act under a deliberative context). Additionally, the fact that students did not recognize the strength of arguments beyond those supporting their own position can drive us, or the teacher to draw conclusions about children's cognitive psychology.

However, reflection, as this context was named after, was not the main domain where Psychology was identified. Psychology has been the discipline to explain and ground explanations about societal members' actions. In which instances though did such contexts emerge in the classroom?

The instances identified for Psychology were akin to those identified and described about Introspective practices. Actually, explanations of actions have been used as argumentative moves to evaluate other arguments as irrelevant and as a means to bring arguments into the discussion, as indicated by the following episode.

> *14. Teacher: I want you to tell me what you think about this issue, before reading anything. Should I buy a mobile phone for my brother?*
> *15. Teacher: Alvinos, tell us what you think.*
> *16. Student: No, you should not buy him a phone because he is young and mobile phones affect young children.*
> *17. Teacher: What do they affect Alvinos?*
> *18. Student: His hearing.-*
> *19. Teacher: Ok, they harm hearing. Next student please.*
> *20. Student: Ok….I would like to have a mobile phone but my mother and father do not buy me a mobile phone because there is an energy affecting the human system...*

In this episode the student actually explains her parents' actions in order to cite an argument in the discussion. (Of course she acts in a deliberative mode, she adds reasons but not with a strong argumentative force of convincing others not to buy a phone, but to consider them along with other issues). There were cases though, where others' explanations of actions were used to drop arguments as irrelevant, and thereby move the discussion to another sub issue.

For example, in the hunting lesson, when students were in an argumentative session trying to defend hunting or not by discussing the necessity of hunting as a means to control animal population, a student cited:

> *But teacher, I think it is an activity that people really enjoy!*

This input of the student turned the discussion into one of exploring hunting as a sport and grounding explanations about why people really hunt. The student's input into the discussion can be either evaluated as a fallacious movement, but also as an indirect argumentative move: he actually evaluated the issue of controlling animal population as irrelevant for the issue of hunting or not. The student perceives that hunting is not a means of animal population control but as a means of pleasure, and therefore evaluates the discussion as irrelevant. The argumentative force of the utterance can also be grounded by the use of the term “But”. This cue actually lets us perceive the move as argumentative.

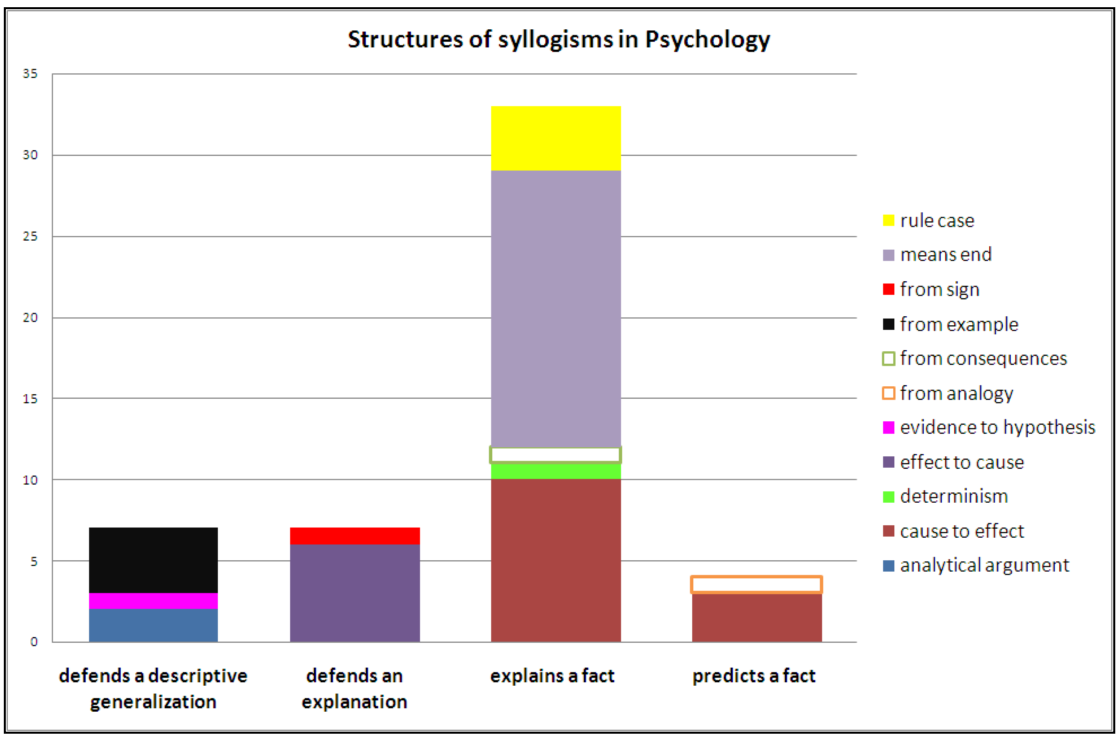
There were cases where informative sessions about an issue had proven not as neutral as they had the potential strength to turn explanations of actions into reasons for supporting decisions. For example, the teacher of the cloning lesson had included in her informative session explanations of the type “Scientists clone because they want to save endangered animals” and “Another reason that drives people to clone recently, is because this practice can bring them back beloved pets”. Such information/explanations were turned into arguments when the argumentative session started.

Actually students used the teachers’ information as reasons to support cloning animals (we should clone to save endangered animals, have beloved pets back). This instance does not carry any dialectical strength and does not situate explanations of actions into practical reasoning; however, it indicates that the two contexts, explanations of actions and argumentation for persuasion hold the same structural components - real needs that drive societal agents to perform actions (means to an end) and use them with different dialectical strength (counter-defend or explain). Therefore, one context might be a feeder for the other: action explanation feeds argumentation with reasons supporting actions, whereas argumentation provided by agents might reveal reasons that guide behaviour of societal members.

A final instance where Psychology emerged was when the teacher had explicitly set the issue under a micromorality mode and the students had to explain/defend their intentions towards the issue. For example when a student explained his intention of cloning a beloved pet because of his need to have his own pet back to be happy, other students countered the efficiency of cloning as a means that could make the other agent happy, as the cloned animal would not be the original with which they had common experiences. Conclusively, the sufficiency of means to a psychological need, or the truth of psychological consequences have been explored when the issue has been put in a micromorality mode; chains of argumentation that had the purpose to support or counter intentions about a personal stated dilemma have been evolved indicating epistemic practices situated in Psychology.

4.4.4.5.2 <u>Epistemic practices and syllogistic forms within Psychology</u>

Psychological facts and explanations have been defended by the syllogistic forms presented in the graph that follows:



Graph 10: Structures of syllogisms and epistemic practices in Psychology

As shown above, a variety of syllogisms have been employed to explain or predict psychological facts, defend descriptive generalizations (either explanatory or not) and even defend psychological explanations.

A primary consideration is to refine the role of Psychology as explaining human action. Psychology is regarded as the discipline to ground the truth of explanations such as “People hunt because they want to experience the ancient way of life, to get the excitement of being a primitive man”. However, it is not clear whether “Scientists clone to save endangered species” is actually a psychological fact. This study reconstructs them as belonging to Psychology, because motivations are actually psychological in the sense that they drive us to action, even if they do not always aim to achieve a psychological end. In other words, examining motivation, or explaining human action is assigned in Psychology as a discipline, but this does not exclude that human action can be explained as resting on social or personal needs that fell beyond psychological ones.

The following table shows the components of such explanations of human actions:

Types of explanations of societal members’ actions			
Type of explanations	**Disciplines**		
	Biology	**Psychology**	**Sociology**
From Consequences	My parents do not buy me a mobile phone because it harms health		
Means end	Ancient people had to live; they hunted to survive.	People need their beloved pets back; that’s why they spent so much money to clone dead pets.	My friends go for hunting because they find company; they have a good time with friends.
Rule case	Human beings *are by nature* hunters; that’s why they hunt.	People have criteria and that’s why they keep some animals for pets and some for slaughtering.	We become hunters because our parents are hunters

Table 46: Types of explanations of societal member’s actions

Consequences and needs have been cited to explain human behaviour. There were also instances where rules were cited as guiding human behaviour. For example, the teacher who set down the claim in the hunting lesson "We become hunters because our parents are hunters" had actually provided a rule to explain human behaviour, which was further grounded in an argumentative session that had followed.

Motives have also been explored within classroom discussion. Consider the following episode:

> *500. Student 1: Teacher, I want to talk about something different*
>
> *501. You might die, and the new cloned man still exists and nobody would like to use this man because he was useful only to you. You might die….*
>
> *502. Student 2: Yes, he would stay alone*
>
> *503. Student 1: Yes...*
>
> *504. Student 3: After a few years…*
>
> *505. Student: No problem! We can create another clone to keep him company!*
>
> *506. Teacher: Ok now. The super defender of cloning people has made the process of cloning a human akin to making a sandwich.*
>
> *507. "We can make another one, another one, another one"*
>
> *508. We have said that we might use cloning to bring our beloved persons back, but we haven't said that this process is the simplest in the world. It is not so easy to make clones and animal cloning entails a lot of unsuccessful efforts…*

The teacher somehow attacked the student that had advanced the solution of "creating another clone in case the prototype dies and the clone stays alone" by inferring that his reason is actually a way to support cloning, in that "You are so much in favour of cloning that you made cloning seem so easy". In this sense the teacher actually interprets and evaluates the rhetorical strategies applied from the students on a psychological basis.

Furthermore, Psychology has explained and grounded explanations of human sentiments, and used such explanations to defend predictions.

> *When you kill an animal and you go to get it…you feel great, because you feel that you have done an achievement. You feel that your bullet has been used for something….*
>
> *You are going to see the cloned cat and remember your own one, but still not being able to have it…the original I mean. You might even be sad to look at the cloned cat.*

Explanations and predictions had also been defended or countered in the light of available evidence that most of the times had taken the form of examples, (experiences), analogies and deductions from other accepted psychological facts. The following examples present some instances where explanations or predictions were defended as true or false:

> *Almost all hunters I know personally have their fathers as hunters. I believe that it is the fact that our fathers are hunters that drive us to such an action (*Evidence to hypothesis)
>
> *You have not been bored of your cat until now, why would you get bored of the cloned cat?* (From analogy)
>
> *I am a hunter but my father is not a hunter. I just went one day with my uncle and I liked it so much that I continue to go, even if my father does not go (*From example*)*

Finally, there were cases where the practices employed within Psychology had the form of forming a hypothesis. The fact that students and teachers were drawing conclusions about their interlocutors' positions when they appeal to their arguments is a form or reasoning from sign. Agent A uses argument B. Agent C perceives the use of argument B as a sign of a specific position of Agent A. In this sense this practice is classified as one of hypothesis generation within Psychology. Another case in which agents moved from an effect to an unobservable cause was when some of the students' arguments were processed to ground further hypotheses. For example, the fact that a student mentioned that "you might even be sad when you see the cloned cat" drove the teacher claim/hypothesize "So, we never forget our old cat, even if we have a new, cloned one".

Summarizing the results about Psychology which actually terminate the discussion about Idioscopy, I can say that:

- Psychology emerged when agents of the discussion observed and analyzed their interlocutors' behaviour, when the agents used explanations of actions as means to bring reasons into discussion that would evaluate an argument as irrelevant, or add arguments to the pool of reasons in a deliberative mode, and finally, when the teacher explicitly set the issue under a micromorality mode and the students were acting as psychologists trying to predict their classmates' psychological states when they would perform the action implied by the personal dilemma, and therefore drop or support the explanation/defence of their intentions.
- The structures of syllogisms used in Psychology reveal that actions, intentions and emotions had been defended by the use of causal and non causal links. Actions were explained by the use of means, consequences and rules whereas psychological rules were used as causing human emotions in different cases. The explanations provided though have been further defended or countered by the use of analogies, examples and evidential support.

4.4.5 Other disciplines

4.4.5.1 Informal Logic

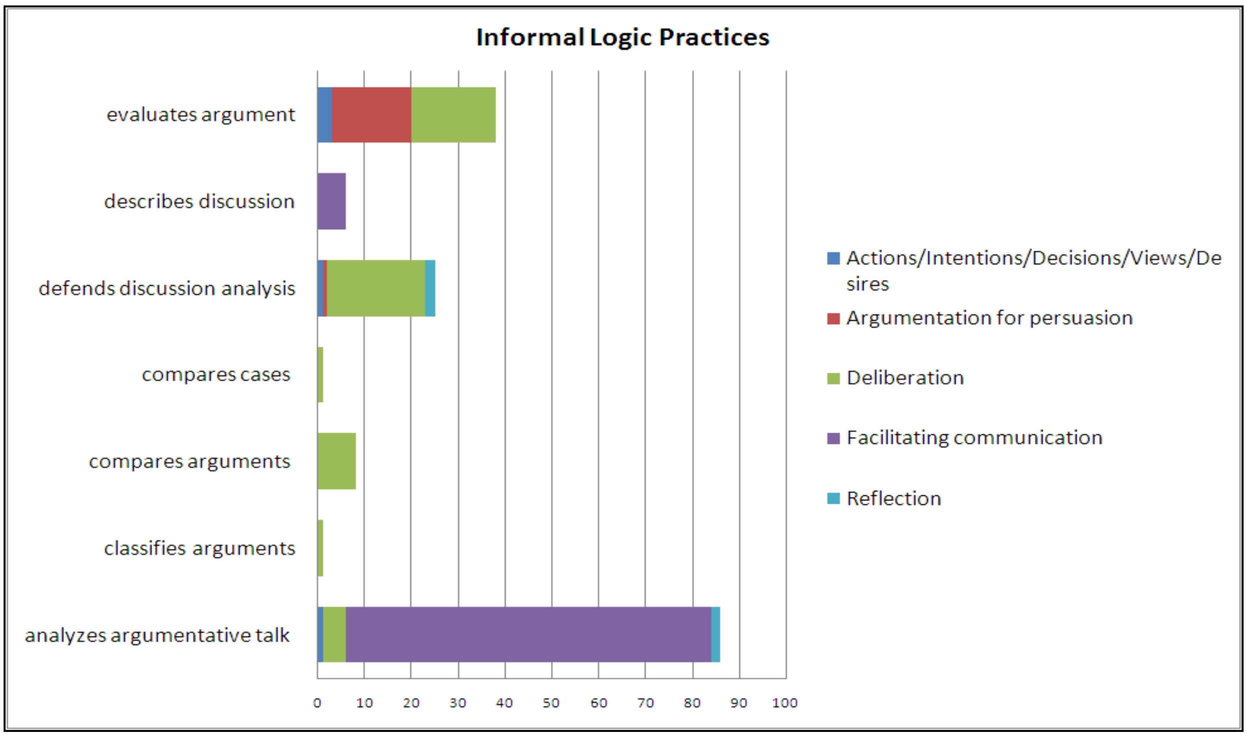
The branch of Informal Logic encompasses both the branch of normative logic as perceived from Peirce (1990, as cited in Pietarinen, 2006) which can evaluate the truth and soundness of arguments, but also what we call as "Rhetoric". As Blair and Johnson (1987) define, Informal Logic is the branch of logic whose task is to develop non-formal standards, criteria, procedures for the analysis, interpretation, evaluation, criticism and *construction* of argumentation. A slight difference from Peirce's category of Logic Critic, the first branch of normative logic is that Informal Logic includes the norms of argumentation construction. According to Peirce's taxonomy though, argumentation construction norms would be a branch of Methodeutic. Actually, the difference is slight as Informal Logic and Methodeutic are described as normative sciences that use criteria to evaluate the products or the processes of inquiry. Since a decision is to be made, methodeutic about argumentation and decision making process is not included in the description of the practices of Informal Logic.

Informal logic was a discipline practised more by the chairman of the discussion, the teacher, who was taking the role of analyzing classroom discussion, organizing its content and sending it back to the classroom for better comprehension. However, it is not regarded as a pure teacher's strategy because it holds a dialectical beyond its pedagogical dimension: analyzing what an interlocutor had said is a step in our reasoning when we are engaged in an argumentative discussion and we have to counter or further support our interlocutor's sayings. Additionally, as a communication means, we have to make sure that what we have understood is what the interlocutor really meant.

Finally, argumentative discussions are complex structures; we need processes of organizing their content so as to move i.e. from an argumentative session to a deliberative one where arguments collected need to be organized, evaluated and calculated.

The practices described above were not performed only by teachers; actually, students had also been engaged in such practices. However, since this study presents the results as opportunities, I would support that Informal Logic is an opportunity when discussing a controversial issue; whether this area could be achieved by students as well it is rather a matter of pedagogy (i.e. assigning the role of the chairman to students, or do not have a chairman at all) but also of Psychology (are the students capable of doing it?). However, describing the Informal Logic part of the lessons does not rest in the area of Psychology or Pedagogy. It rather rests on the curriculum level: Informal Logic is a part of the cognitive charge of the lesson either performed by the teacher or the students.

Data analysis describes Informal logic practices as being situated in Practical Reasoning as follows:



Graph 11: Informal Logic as situated in practical reasoning

The results indicate that the analysis of argumentative talk was mainly done for the purposes of facilitating communication between group members, a practice that did not carry any dialectical weight beyond this. However, there were cases where this analysis was not accepted by the interlocutors; analysis of argumentation from one party was therefore perceived as a manoeuvring from the other party that rejected the analysis as not true (I did not say that!).

An issue that is of interest for further analysis is the kind of analysis performed by the agents and especially the teacher, the way that forces this analysis to students and students' reactions towards such an analysis. Actually, an analysis of this kind falls within the scope of pedagogy which is not further explored here.

Arguments have been evaluated for several purposes. A careful consideration of argument evaluation instances had provided the following cases:

- **Argument evaluation: an argumentative meta-level strategy of dropping arguments**

Arguments have been evaluated mostly about their relevance to the topic under discussion. The following episode provides example for such an instance.

8. Student: I think we should hunt because in such a way we control animal population
9. Teacher: Anyone else who wants to tell us something related to Nicholas argument?
10. Student: I think that we have to eat, to survive, that's why we need to hunt.
11. Teacher: Yes, but Nicholas had said something else. He told us that we have to control animal population. Any other arguments on this issue?

However, there were cases were the teacher's analysis had evaluated the arguments of students as not being guided by reason and therefore had rejected them as "not reasons". An example is provided below:

34. Student: Please teacher, buy him a mobile phone, he is piteous….
35. Teacher: Why Petros, why do you tell me to buy him a phone?
36. Student: Because…if he is a good student….
37. Teacher: He is a very good student. And his exams are excellent. Beyond this.
38. Student: If his behaviour is also good, why not?
39. Teacher: He is well behaved also. Does this mean that I have to buy him a phone? I need you to ***justify*** *why I should buy him a phone or not*

40. *Student 2: No teacher, do not buy him a phone.*
41. *Teacher: Petros, I want you to tell me a **reason** why I should buy him a phone or not.*

This episode indicates that the teacher does not perceive appeals to pity as reasons and therefore rejects the student's arguments as not being reasons by asking him to cite reasons for buying or not a phone for her brother. However, after the student's pressure she wrote on the board the reason "Because he is a good student".

- **Argument evaluation: a deliberative method of identifying their relationship towards the issue and their weight**

  Within deliberation parts of the lesson teachers asked students to explicitly evaluate arguments in terms of being "positive" or "negative" for the decision towards the issue, or as being very important, or less important. The two lessons that employed such practices followed a similar path: both teachers used the argumentative sessions of their lessons as a method to create a pool of arguments that had to be evaluated, weighed and calculated somehow in order for a decision to be made. Since this activity had to follow argumentation sessions, only a few minutes were left for that and therefore we do not have any information of how arguments were evaluated; we had the evaluations (I believe that the most important argument is the argument about having our beloved persons back-cloning lesson) but we did not have explanations or further support for such evaluations.

Beyond argument evaluation agents used arguments as propositions to group and organize them according to several criteria. For example, teachers acting as chairmen grouped arguments when those were cited by the students in argumentative sessions so deliberation might be enhanced in the following parts of the lessons. The episode below provides an example of thematic grouping of arguments.

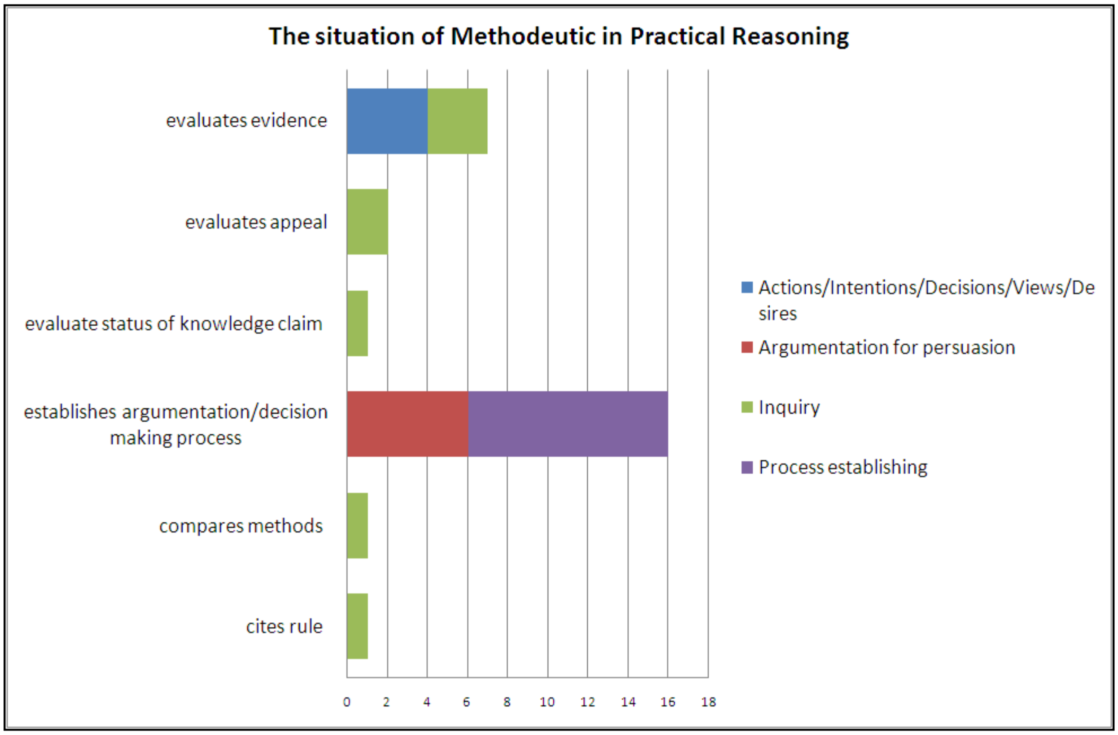
> *65. Student: No, because mobile phones might harm him.*
> *66. Teacher: So, you tell us no because of health issues. I therefore write down: Health reasons. Andrew.*
> *67. Student 2: If he plays all day with his mobile phones it might affect more his brain and ….*
> *68. Teacher: So, you also cite health reasons.*

Finally, there were cases when arguments were grouped because of being similar, or being evaluated as "opposite".

Summarizing, Informal Logic has been used to reconstruct and analyze argumentative talk as a communication means that the chairman had provided for group members and as a means of accepting or rejecting such an analysis. Furthermore, it was the discipline that evaluated arguments as irrelevant, reason-based within argumentative sessions, or as positive-negative, strong-sound in deliberative sessions. Deliberation also used Informal logic for comparing and grouping arguments according to thematic criteria, and finally for weighing arguments in terms of importance as a means for thoughtful decision making.

4.4.5.2 Methodeutic

Methodeutic is defined by Peirce (1905 as cited in Pietarinen 2006) as the third branch of Normative Logic, "the study of the proper way of arranging and conducting an inquiry". The results had revealed two types of Methodeutic within the lessons: one referring to norms about conducting a scientific inquiry, and the other about conducting a thoughtful decision making, establishing a decision or argumentative process.



Graph 12: The situation of Methodeutic in practical reasoning

A first issue to clarify is the establishment of the argumentation/decision making method as done explicitly in the lessons and as done within argumentation for persuasion. In the first case, the teacher had informed students about the structure of the task and had informed them about how decisions were to be made, or argumentative sessions would start and move on.

For example the teacher that taught mobile phones had said "I need more information to decide whether I should buy my brother a mobile phone. Do you get it? The issue here is *knowledge*. Decisions need *knowledge*". Accordingly, students cited in latter sessions of the same lesson that "It is not the number of arguments that is of importance, but the weight of them. If there are hundreds of positive arguments but the one negative is that I would die if I used mobile phones, then what's the point of counting them?" This place of Methodeutic in this case is akin to what Van Eemeren and Grootendorst (1984) describe as the opening stage of argumentation where the interlocutors, among others decide how to solve their difference of opinion, even if teachers used this kind of reasoning in latter stages of the lessons as concluding remarks."Those issues (controversial) are too complicated; it's not so easy to form an opinion about them and keep it stable; we always have to get into inquiry about them" (cloning lesson) or "Now I am going to my house I am going to consider all those arguments, weigh them, calculate them and take a decision; I hope you follow the same process".

However, there were cases that Methodeutic was used as a norm to evaluate arguments and therefore is situated within argumentation for persuasion, in the confrontation stage. Agents of the discussion, and especially teachers, evaluated arguments as not following a proper method of argumentation or decision making process and therefore this practice is akin to those of Informal Logic's ones. For example, when a student in the cloning lesson advanced a question-argument about whether scientists could clone humans from dead persons, the teacher ended the session by advancing the reason "We should not discuss issues about which we are not sure". In this sense she advances a rule for decision making or argumentation "Talk about what you are sure about" which is further used to drop argument as not "discussable". In another case, the same teacher evaluated a student's claim that "there is no possibility that such an action happens" with the methodeutic norm "Never be sure about anything".

Finally, there were cases that instead of individual arguments, the decision making process was evaluated. When a student cited that "We should ask his mother for buying him a phone or not", the teacher had advanced the norm "His mother does not have a problem. However we should provide arguments for her". In that way she describes a decision making process that should be based on arguments rather than authorities' decisions, she cites a methodeutic norm and applies it to evaluate an argument or a suggestion from students.

The second instance of methodeutic refers to the evaluation of methods of acquiring evidence. Though small in scale, there were instances in which students had evaluated the source of evidence as indicated in the Biology inquiry episode as presented in Table 41 (*Agents of discussion being in different stages of scientific inquiry)*. Evidence has been evaluated as valid because it has been a result of research, and widespread common belief was evaluated as not valid because of its not research-based nature. Accordingly, in the cloning lesson the teacher explained why the claim of “Consuming cloning animals’ meat or milk is safe” could not be established as true or not, since nobody has consumed at least for a decade such meat or milk, thereby using methodeutic norms to evaluate the truth of knowledge claims.

Summarizing the Methodeutic part, I conclude that Methodeutic was used to establish and use norms for argumentation and decision making process and for evaluating knowledge claims. Norms about argumentation and decision making process have been advanced in the opening stage of argumentation to establish the process. They have also been used as evaluative means of argumentation and decision making process in several cases. Finally, norms about scientific inquiry have been applied to evaluate the validity of contradictory evidence.

4.4.6 The start of any inquiry: Asking questions

This final part of the results chapter aims to describe a non-propositional epistemic practice that marks the start of inquiry for several disciplines: the practice of asking questions. Those questions do not refer to prompts of the teacher that had the pedagogical goal of engaging students in the discussion. The questions that this session describes resemble what Chin and Malhotra (2008) describe as the cognitive process of generating research questions, which is classified as an authentic inquiry process.

The results indicate that students generated potential research questions while being in informative sessions and had actually started to deliberate about issues.

Teacher, can you take two persons and put them into one with cloning?

The above question is potentially a research question: it might spark a whole discussion, or even experimentation stage if expressed by a scientist in a laboratory. The context that the question has raised is a deliberative, or even an argumentative one: the student gets informed about cloning practice as a problematic situation, since clones might not have parents in the conventional form that we are used to, and she wonders whether cloning might include a two parents' DNA donation.

Similar questions have been raised in argumentative sessions also. Students have set down research questions, given the problematic of the situations:

- Would the milk and meat of cloned animals be of good quality? Dangerous for health? (cloning lesson)
- Are we going to suffer from brain cancer because we are using mobile phones? (mobile phones lesson)
- Can natural death control animal/human population? (hunting lesson)

Even though the last question has been stated from the teacher, it was set down as a start of an inquiry cycle, in which the teacher participates in equal footing. As he says:

"It was a subject (physical death as capable of controlling animal population) that was raised from a student and I have to say that I was not prepared for this argument. I had to explore it with students, hear their thoughts, and come up to a conclusion…." (Teacher of hunting lesson)

Sociological and psychological inquiry also started with the use of similar questions by classroom agents.

-*Why do adolescents need mobile phones?*

-*What are the consequences in society if cloning is allowed?*

-*Why do we enjoy hunting?*

Questions like the above have been raised from teachers and students as well, marking the start of an inquiry session that could serve the purpose of establishing parts of a practical claim as true. In the same way that students were engaged in practices such as defending or generating explanations and predictions in order to establish components of practical claims (needs, rules and consequences) they also generated research questions that their answer would establish a knowledge claim capable of being used to those argumentative chains.

The inquiry though was not restricted in factual issues situated in the natural, social or psychological world. Students and teachers identified potential conflict points, thereby marking the start of a social policy inquiry, or a moral inquiry:

-*Who will decide who is going to be cloned?*

-*Which criteria should we use when selecting who to clone?*

- *A person might be a brilliant scientist, but how can I know if he is of a good character?*

The cognitive process described above is one of identifying potential problematic situations; it actually sparks the start of a discussion of a minor controversial issue resting on a lower level in relation to the general issue of cloning that has been stated as a central issue. And it is in this sense that those questions are regarded as an authentic practice of entering a Social Policy inquiry, which is actually a deliberation about an action to be taken.

In analogy, agents of the discussions identified moral issues that had to be further inquired into:

-How did we end up treating some animals as pets but others as food?

-Should we eat meat?

-What should we do if a really bad man emerged as a clone?

This kind of inquiry might be named as a “moral inquiry” according to a cognitivist view of moral reasoning, where moral rules are products of latest inquiry in the same way that natural rules emerge from scientific inquiry.

As already discussed in the theoretical part of this thesis, argumentation and inquiry have interchangeable roles: argumentation provides the claims that have to be inquired into, but as inquiry starts new chains of argumentation emerge so as alternative explanations are to be excluded and knowledge claims are established.

The results of this study just verify the connection between argumentation and inquiry stated above: the controversial issues discussions have been a place where scientific (natural, social, and sociological), social policy, or moral inquiry had sparked because agents had to establish knowledge, practical or moral claims. Those claims might have already been used in the discussion as arguments grounding decisions and students had put them under question; others had to be established as true so as they would successfully be used in following arguments (inquiry was preceding argumentation and its role was to establish components of arguments). As soon as those claims were put under question though, new chains of argumentation emerged.

In the same way that the agents of the discussion engaged in epistemic practices of generating and defending explanations, hypotheses and predictions, being situated in different stages of the scientific inquiry cycle, they also sparked the beginning of those cycles: they generated questions - subjects of inquiry either for Natural or Social Sciences, Ethics, or Social Policy.

A final note for obstacles for such an analysis had to be taken. Differentiating “pedagogical” from “dialectical” questions was really difficult, and in many cases, I had the perception that teachers’ questions had both dimensions. Defining the border lines between Pedagogy and Inquiry is far from blurry. I have to cite that for the purposes of this study, a “minimally” pedagogical analysis had taken place: since what I need to describe is the “cognitive charge”, the epistemic practice performed within the discussions, I need to analyze a lot of teachers’ questions as inquiry, because the teacher (even for pedagogical purposes) as an individual needs to make an analysis of the issue and come up with questions- identify knowledge claims that are not established, or for which science or morality is still in the making and need further exploration. Put in its simplest form, my argument supports that the identification of claims to be further investigated is an epistemic practice that is described as the initiation of any inquiry cycle. Even if this practice is performed for pedagogical purposes, it precedes pedagogy and might somehow be distracted as a standalone practice of the teacher holding a specific cognitive charge.

5. Discussion

The aim of this chapter is to discuss the results in relation to their capacity to answer the questions of this study. Furthermore, it aims to discuss the implications of the results in the light of different frameworks that relate to controversial issues and the science curriculum. The contribution of the study that rests on a methodological level regarding tools for situating controversial issues in the science curriculum and reconstructing argumentative talk in science classrooms, alongside its theoretical contribution to the discussion about controversial issues and the science curriculum is going to be explored. Finally, limitations and suggestions for further research are going to be discussed.

This study has been designed within the problematic situation of implementing controversial issues in science curriculum as a means to provide information from classroom based practice, that would be a result of teacher's designed and implemented curriculum, and interpret such information with the use of theoretical conceptualizations from disciplines that philosophize about scientific enterprise and study discourse and practices beyond science education.

The problematic of the situation as being narrowed in this study, refers to the different perspectives regarding the situation of controversial issues in science curriculum, the goals and priorities of such an implementation, though the results of this study might also be used as hypotheses for investigating issues of pedagogy.

However, this study had to address two major methodological problems, which finally were added as purposes of this study: the first one was to conceptually define "the situation of controversial issues in the science curriculum" as a construct of distinct epistemological areas and the second one refers to the use of appropriate tools that would enable such a description.

Both methodological problems have been examined within this study through a process of mutual interaction between analyzing classroom data, search in the literature about conceptual tools that would be able to describe the emerging categories and on the other, by identifying new areas implied by the literature and apply them in data analysis. The mutual interaction between data analysis and literature review has finally created the theoretical construct presented in the data analysis and results of this study.

The questions of this study have been addressed so they could describe the methodological alongside the conceptual orientation of the study. The following section will discuss the theoretical implications that derive from the results, thereby fulfilling the aim of this study: inform the discussion about the implementation of controversial issues in the science curriculum with insights from implemented curriculum in authentic classroom environments.

5.1 What do the results say about implementing controversial issues in the science curriculum?

The following paragraphs aim to analyze the results and interpret them within the main frameworks that relate controversial issues and the science curriculum. In this sense, the discussion of the results takes also the form of implication about theory related to controversial issues and the science curriculum, as will be shown in the next paragraphs.

A note however, has to be taken before the discussion: a critical discussion about the limitations of each framework in a theoretical level is already done in section 2.2 of the literature review of this study. What is to actually discuss here are the theoretical and practical implications related to each framework that the results of this study draw. Therefore, this section actually discusses the results as related to specific frameworks; it thereby contributes to the discussion presented in section 2.2 by providing instances from classroom data that could affect our theoretical conceptualizations about sub issues, thereby enhancing our critique about several frameworks related to the implementation of controversial issues in the science curriculum. That's why the results are examined through the lenses of each theoretical framework separately.

5.1.1 Science education for citizenship: Science view for thoughtful decision making

According to this perspective, teaching with or about controversial issues is done under the use of science as a lesson, unique and indispensable, that could make a significant contribution to citizenship education (Wellington, 2004, p.34; Crick Report, 1998, p.35; Ractliffe & Grace, 2003). Students should base their decisions on science, according to this framework, which is interpersonal, and rooted in a community of scholars, based on accumulated evidence, open to scrutiny and falsification (Wellington, 2004, p.36).

A first implication of this study that derives from theoretical conceptualizations about moral reasoning is that such a view is actually moral, and could be described as utilitarianism. Basing our decisions solely on science, can be interpreted that we base our decisions on issues that can be answered by science: factual issues that can be resolved with the use of evidence. As Wellington (2004, p.36) argues, all the ethical and moral decisions we have to make about the distribution of resources, feeding the world's population or preserving the ecosystem of the planet are grounded in the physical and natural world and therefore are grounded in science.

However, the results of this study reveal the obvious: agents of the discussions based their decisions not only on factual issues, (consequences and necessity of means) but also on moral issues (the obvious refers to the fact that controversial issues are *by definition* issues that cannot be resolved by the use of evidence alone). By which means can we ground utilitarianism as the core moral stance, and move-convince students to adopt it as superior to other moral stances? Would we like to do it?

The results of this study actually, indicate that utilitarianism *is* a moral stance of a lot of students. Actually, deontological, moral rules did not dominate, and they were not a part of students' arguments grounding decisions about the issues presented in the lessons, even if the two of them carry a heavy moral charge (cloning and hunting) in the society. Actually, in the cloning lesson there was not a moral consideration about cloning. Moral and metaphysical considerations came up when solutions had emerged.

Those results are contradictory with other results about students and socioscientific issues. The influence of values in the decision making process is evident in primary school (Lymbouridou and Constantinou, 2003), middle school (Hogan, 2002), high school (Zeidler et al, 2002), college students (Sadler, 2004, Sadler and Zeidler, 2004) and adults as well (Bell & Lederman, 2003). Studies have shown that values and ethics embedded in the circumstances the students faced had a primary impact in their decision making. The research in other words indicates what Sadler & Donelly (2006) have also documented: students construe the controversial issues under the consideration as moral problems.

In this study however, biological and sociological needs and consequences were dominant in students' decisions. Furthermore, even if some issues have been presented from the teacher to be elaborated as ethical, like "Should we eat meat?", "Should we kill small swallows for practice?" they have not been perceived as moral by students (moral in the deontological sense). Students had established such actions as right or wrong based on the calculation of their consequences, or their capacity to fulfil human needs (the need to be healthy, the need to have a good and effective practice).

I cannot assume that the results of this study hold a generalization force and can ground a psychological result of the type: *Students do not perceive issues as moral*. However, they indicate that such a stance is probable, or that not all issues that concern students and are related to the issue under discussion are moral. The results support that there is a room for such a framework to be applied.

However, if the term “science” in the above framework refers to natural and not social or psychological sciences then the scope is narrowed in a great sense. How can the social part be distracted from the physical one? How can one be more concerned with the consequences that affect the environment or his health but not for social consequences that might affect his relationships with other people? Why someone should be concerned with biological and not social needs? I do not have an answer to present, but I would like to mention that such an effort might be unnatural, and difficult to achieve in classroom settings. How can “*Informed decision making*” be narrowed as a term, so as to include only issues that refer to needs and consequences that might be grounded by natural sciences?

A different implication about this framework that the results draw, is that if such a shrinkage takes place -eliminate the discussion in factual issues situated in natural sciences - then we really lose a great opportunity to deal with factual issues that could be grounded by natural sciences, but do not actually emerge as biological/environmental needs or consequences. The results pointed to several instances where Biology has been used as a discipline to ground facts as “true”. Social consequences were based on facts that could be grounded in Biology or Biotechnology as a discipline. For example, whether the clone would come up as a baby, or would carry the diseases of its prototype are issues that Biology has been used to ground them as true. However they might not come up if students did not perceive issues as social to cite the social consequence of confusion, or as emotional so as to be concerned with how they would feel if their beloved person -coming as a clone- would die again. To put it in a general statement, our emotions and social consequences are based on facts. Those facts though have to be established in an argumentative environment. In this way by bringing our emotional or social concern into the disagreement space we allow science to take its place and provide the truth of the causes that might affect our emotions or the wider social space.

Additionally, there were specific types of moral reasoning that needed Biology to ground their components as true. Naturalism moves syllogistically by looking at nature, implying laws and evaluates human action accordingly to those laws as moral or not. Naturalism needs also to be grounded in Biology.

In this way this study contributes to our understanding about Ethics, Natural Sciences, Social Sciences and emotional issues by implying that those are actually intersected: facts are used with emotions or moral rules to imply, evaluate or explain action. Those facts might be questioned in an argumentative session and therefore have to be established within the Natural, Social or Psychological sciences. Additionally, moral rules might be established in facts and therefore have to be further elaborated in natural or social sciences. In other words, the existence of emotions, or morality might be an authentic opportunity for Natural and Social Sciences to appear in the lesson.

There is a view that the demarcation of curriculum in disciplines is not children oriented, since children regard the world as a whole and they do not separate their thoughts in a way a curriculum developer might do. This line of thought actually situates controversial issues as multidisciplinary, or rather interdisciplinary; the discussion of controversial issues is an inseparable construct of epistemic practices situated in several disciplines that all contribute to the formation of the decision about an issue. Again, separating the natural sciences’ part from all other parts might constitute a shortage of cognitive charge used to perform epistemic practices situated in other disciplines, that rest on empirical data not deriving from the natural, but from the social or psychological world.

5.1.2 Controversial issues for science education: Epistemological issues in focus

According to this framework, controversial issues are a means of fostering epistemological issues in science education. Students should be able to ask for evidence and clarify whether a claim is supported by evidence at all, or whether it is merely a guess, an assumption, or personal opinion or impression (Kolsto, 2001a, p.309). Additionally to the previous framework, socioscientific controversial issues are regarded as a fine opportunity for the teacher to initiate a discussion on the differences between knowledge claims from frontier sciences and established consensual scientific knowledge and on the different aspects of the nature and epistemology of scientific knowledge (Kolsto 2000; Ryder, 2001).

The results of this study that refer to epistemological understanding can be grasped from the Methodeutic science. The results had revealed two types of Methodeutic within the lessons: one referring to norms about conducting a scientific inquiry, and the other about conducting a thoughtful decision making, establishing a decision or argumentative process.

It is remarkable that evidential support was not the main engine that has driven classroom discussions. Most evidential support to descriptive generalizations had the form of examples, students' experiences.

Students considered evidential support only within the mobile phones lesson which was explicitly designed so as to include contradictory evidence, and students had not dealt with the issue until the teacher had insisted on deciding between two contradictory claims regarding brain cancer and mobile phones relationship. The results indicate that when students came across contradictory evidence, they were simultaneously, within the same episode, in different stages of SDDS: some students were in the hypothesis generation stage and others in hypothesis testing and evidence evaluation stage. Finally, a group of students did not enter the hypothesis space at all; without considering contradictory evidence they perceived used non-established claims as established and actually had used one of the two contradictory claims to defend predictions, or ground decisions about the issue.

There are studies that perceive akin reactions of students towards evidence as shortcomings. For example, students are described as distorting scientific evidence to adjust to their prior beliefs without being aware of doing so (Sodian et al, 1991, p.759, Bell 1995, p.13), or dismissing scientific knowledge as irrelevant to decision making when reasoning about controversial issues (Zeidler et al, 2002), ignoring data that they ought to consider when evaluating claims or assimilating such data in ways that do not damage their current theories (Sandoval 2001, p.1, Chinn and Brewer, 1998, Klahr et al, 1990; Kuhn et al., 1998 as cited in Sandoval 2001, p.15). In contrast, this study perceives those instances as potential opportunities, expected routes that the discussion might take if contradictory evidence is presented.

This study does not have the means to question the claims provided by scholars above as true or not; however it questions the evaluative weight they put on such practices. If scientists might come up with a new hypothesis when confronted with contradictory evidence, why should children not do so? And if contradictory evidence is always tested against current theories, why do students' naïve theories have to be (if they can be) ignored when evaluating contradictory evidence? How might alternative hypotheses, that might hold the status of accepted knowledge by participants, be used in the light of contradictory evidence? Is there ever any scientist collecting evidence about a hypothesis without holding beliefs about the issue or other related issues? How would he come to form a hypothesis at all if such a conceptualization would not exist?

The practical implication from above considerations is that epistemological issues concerning evidence evaluation are only a part of hypothesis testing and have to be reconsidered alongside other practices situated in this stage, which are testing the results in relation with previous theories or alternative hypotheses, or coming up to new hypotheses that might explain contradictory evidence. Evidence can only be judged as plausible or implausible in relation to current knowledge, theory or belief (Zimmerman, 2005, p.36). Designers of curriculum cannot assume that the evidence evaluation phase can be seen as a standalone phase of hypothesis testing.

Furthermore, as the results show, participants might ignore the issue about which evidence is contradictory since other reasons might be more relevant or stronger for them towards a decision about an issue. Agents might even resolve it in one way or another in order to move on with their decisions about the issue. In other words, the claim for which evidence is contradicting might not be their main concern. In this sense the socioscientific might be a distraction for the epistemological.

I am not sure if I would advise someone who really wants to deal with issues concerning evidence evaluation to use socioscientific issues as a context (socioscientific issues in the sense we are using it here: a process of discussing about a decision to be made for an action). Controversial issues might be used as the spark for such a discussion but I am not sure if a result of the discussion “Should I do A?” could explicitly lead or enhance an inquiry or evidence evaluation environment where the claim “Does A really causes B?” is explored. This route could be taken if we are really situated in a utilitarian moral stance and therefore we need to define the truth of the consequences or means, and additionally, if the consequence or need we explore is so important that it diminishes all other consequences or needs that this action might create or fulfil.

On the other hand, really considering the truth of consequences in a map of needs, consequences and moral stances are attitudes that science education is called to cultivate within the notion of "thoughtful decision making". Using controversial issues as a context is an opportunity of assigning authenticity in science classrooms. However, how one might survive in such a situation is a pedagogy issue, and cannot be answered within this study. Perhaps new research, aiming at this specific point, the exploration of epistemological issues, as a matter of pedagogy and curriculum and not explicitly as a matter of students' abilities (because there is a considerable piece of evidence referring to the latter, i.e. the cognitive processes when examining anomalous evidence (Chinn & Malhotra, 2002), skills in coordination of theory and evidence (Kuhn, 1989), the influence of values in decision making (Hogan, 2002; Sadler, 2004, Sadler and Zeidler, 2004; Zeidler et al, 2003; Gray and Bryce, 2006)) would give further instances that could draw useful implications for curriculum developers and pedagogues. This piece of research should not derive from students' interviews; we do not need to draw conclusions about how students come to decisions. We would rather investigate how evidential considerations are explored within controversial issues in classroom settings, a process which actually might be a special focused replication of this study.

5.1.3 Focusing on the ethical aspects of Science: Moral development of students

This framework derives from the need for "humanizing" science education since traditionally it is not related to ethics and morals. Teaching has been described as "moral by nature" meaning the very essence of good teaching involves the ethical and moral development of young people (Loving, et al., 2003, p.183) and therefore students should be given opportunities to explore beyond scientific understanding (what we know, we can do) and ethical judgments (what we believe we should do), which could contribute to the moral development of students (Fullick & Ratcliffe, 1996; Hall, 2004).

The results of this study indicate that such a humanization can be done when students consider the morality of the action for which the decision has to be made, but also when they enter the wider societal space and evaluate actions already performed by societal agents or themselves. Additionally, since the principles used to evaluate actions were not be accepted by the participants, new loops of argumentation have been used to establish those rules as true or valid.

Furthermore, even if students might not perceive the issues as moral at first, the results indicate that there are also other instances where morality can be explored: when consequences are diminished by solutions, those solutions might be put under moral consideration. Additionally, alternative means have to be established as moral to be accepted as alternatives. Clones as creatures with souls that have the right to live, were only considered as an issue when a student had cited the solution that “There is no problem if a bad clone emerges, we can kill him!” No one had mentioned the issue of the status of the life of a clone as an argument supporting cloning or not.

The results above can be used for other frameworks as well in a diverse way: either you include it in initial lesson plans or not, morality might emerge from anywhere! In this sense it is an unavoidable aspect of the issues that might come up one way or another.

Another implication of the results is that not all students perceive issues as moral and a moral question might be answered in terms of utility. Whether we should eat meat or not, or slaughter animals was not perceived as moral by all students. Even if the teacher had advanced such questions in a need to explore morality in deciding what is the right thing to do, deontological was replaced by the utilitarian. However, as already explored, utilitarianism is a moral stand, and ethical egoism - deciding if something would be beneficial for us without regarding others' benefit- is another. How can we survive when moral stances contradict with each other? How would we explore situations where utilitarian demands contradict with Divine laws, natural laws, or other deontological principles?

In the lessons there was not a meta-level discussion which would lead to a hierarchy of moral stances, or to morals as contradicted with means and consequences. However, this would be a core of moral reasoning or a moral character education. Those instances were not encountered in the lessons.

However, there was room for a meta-level discussion, especially when arguments from deliberative or argumentative sessions have been collected and organized, but still not explored in order to point to a final conclusion. Specifically, the argument evaluation, or argument weighing activities in the end of the lessons of cloning and mobile phones could be further extended so those evaluations and weights would be used to ground a final decision. When arguments are there and agents act in a deliberative mode, they have to weight, calculate and prioritize consequences, needs and moral rules to reach a decision. In the case they act in an argumentative mode they have to use those calculations and priorities to defend their decision or position. This activity though was not included in the lessons due to the limitation of time and therefore we do not have information of how it could go further.

A final remark about morality and the discussions is that the whole process of discussing what to do about a societal issue is an instance of "morality in the making". Since the issue of what to do is set under question, and students are called as equals to contribute to the formation of the decision to be taken, rather than subjects to which ready-made solutions would be forced, they participate in the process of establishing morality that can be applied to contemporary issues that previous generations might not have encountered.

5.1.4 Socioscientific discourse for the cognitive, psychological, social and emotive growth of the child

The main difference between this framework and the others refers to the engagement of students' emotions not as obstacles but as essential in a notion that implements socioscientific issues in science curriculum since students should not decide about what *should* or *should not* be done under a notion of macromorality (Rest, et al., as cited in Zeidler, et al., 2005, p. 359) but they rather engage in the resolution of socioscientific controversies in a level of micromorality: their emotions alongside their beliefs are considered as important in the decision-making procedure.

The results indicate that students entered personal reflection not only when the issues were set under a micromorality mode but also when they themselves switched the context into one of micromorality as a means to evaluate the relevance of the discussion for themselves or for societal members, and also as a means to add arguments in a neutral based discussion that were related to their own psychological state.

The switch of the teacher to a micromorality mode is evaluated as a successful means of enabling emotional reflection and personal conjecture with the issues. But as shown above this was not the only instance of such a personal involvement. And as with all results of this study, this implication can be read upside down: even if you turn the issue to a micromorality mode, or not, students might perceive it as such in their need to express how they locate themselves within the issue.

An additional context that has emerged from this study is that of explaining not only one's intentions but also other societal members' actions, views and desires. Actually both contexts, micromorality and action explanation/defence hold the same purpose within the discussions: they make the discussion relevant to the person engaged in the discussion or the societal agents of a specific time and place that have to decide or already perform actions related to the discussion. Hunters do not hunt to eat meat to survive nowadays, and therefore this explanation can be turned into an argument that evaluates the discussion about the necessity of hunting as a means for food as irrelevant. Additionally, emotions of students created by special experiences (a girl that had lost her mother because of brain cancer) might drive them to be very careful in future decisions as they are afraid to have the same pain again.

Another implication drawn from the results of this study is that micromorality, action/decision/view/desire explanation and argumentative contexts, are interrelated: the connector line between argumentative (about the issue) and explanatory (about self or other agents) contexts rests on the basic blocks that both contexts hold: ends (needs), consequences and rules. Those elements explain human action but they can also ground the decision for an action to be taken and vice versa: since an argument with a psychological ground is set, it might be further explored as an explanation of intention, beyond its status as a reason grounding a decision.

The practical implication of such a claim is that, even being fallacious, or being evaluated as "subjective" or "emotional" in contrary to "factual", or "objective", reasons that guide us to action or raise emotions to us, can also be used to ground a decision about an issue. In this sense the pedagogical use of those contexts (micromorality, action/decision/view/desire explanation) might be a feeder of arguments that could enrich classroom discussion under special circumstances.

The results also indicate that not all reasons used to explain human action are of emotional character. People base their intentions and actions also on consequences and needs that fall beyond psychological ones. And it is in this sense that those contexts might feed the argument with more reasons, psychological or not.

A final, but not minor implication has to be presented down. As curriculum developers we might include those issues for cultivating critical thinking, moral reasoning, and epistemic reasoning but students might perceive them as personal. This implies that apart from their minds we distort their sentiments also; and this might be harmful in cases that we might cause them fear and even panic about issues under discussion. The students' anxiety about them as users of mobile phones was explicitly cited: "But teacher, are we going to get brain cancer because of using mobile phones?" Whether such anxiety is useful or not is a matter of discussion, but this could be an argument that could even prevent the discussion of issues that might create such emotions, especially for young ages.

A final, concluding remark about the contribution of the study to the theoretical discussion of controversial issues in the science curriculum is that this study had revealed the basic structural components in which the complexity of controversial issues teaching is built: consequences, needs (ends) and rules. The goals of the participants when referring to needs, consequences and rules have been identified and described: agents in classrooms discussion have used rules, needs and consequences to ground decisions about an issue, to explain societal agents' and own selves' actions, desires, decisions, views and positions, or own intentions, or to ground solutions in problematic situations.

The study has also shown that those components are actually the driven force that had changed the context in the classroom discussion from argumentative to explanatory of human action as those contexts might be familiar and could provide those components or establish their truth as perceived by individuals, societal groups and own selves. Actually, this contribution of the study is important for pedagogy; identifying potential consequences, rules and needs related to the action implied by the issue might be a safe way to plan lessons, to predict students' behaviour towards possible connections to personal and social issues. It could also help the teacher identify the reasons behind the change in the context in the classroom discussions and thereby be able to survive within the chaos of the situation. In other words, if as educators we interpret the change in the context from students as the need to elaborate rules, needs and consequences in the social or personal pane, then we might easily be able to catch up with the change and find ways to bring the discussion back to what is of interest in terms of functional scientific literacy.

Summarizing the above paragraphs I conclude that:

- This study has decomposed controversial issues into their component parts: consequences, needs and rules. By doing this it has shown that:
    - The different disciplines come up because they have the capacity to establish the truth of structural components of practical reasoning (consequences, needs and rules).
    - Disciplines are intersected within controversial issues discussion: facts are used alongside emotions and rules to imply, evaluate and explain

> action. When put under question, those facts have to be established within Natural, Social or Psychological Sciences. Even morality might be grounded on facts.Since we know the reasons of the intersection of the disciplines we have a means of resolving the complexity that emerges because of the interdisciplinary nature of controversial issues. We can also use this information when designing curriculum either for humanizing science curriculum, use science as a discipline that could answer specific questions, or focus on epistemological issues.

An additional implication of those results is that teachers *can* be used as curriculum designers. I have to suggest that I regard the results presented above, among others, as the contribution of teachers in the implemented curriculum. In other words, I believe that the teachers who were not necessarily committed to a framework of science education for citizenship or any other framework, had allowed instances of emotional reflection and social consideration that pointed to instances as opportunities of factual claims subject to verification or falsification. Those results might not have come up if teachers had to implement a readymade curriculum that might have been narrowed in Natural Sciences.

Another contribution of the teachers is that they specifically addressed social and psychological issues within the lessons. This provided instances that reveal that students might perform practices with the same epistemological status, i.e. predicting and explaining facts, use examples to ground descriptive generalizations or form new hypotheses based on observational data, but they have used those practices within the discipline of Sociology or Psychology, instead of Natural Sciences.

This study therefore provides an example of a small scale innovation that implies that teachers' contribution in curriculum development is vital; teachers, due to their pedagogical knowledge, or any other personal or professional orientation, might perceive any innovation in different terms than a curriculum developer might do. This difference can not only be interpreted as a shortcoming, or as a simple transformation of the proposed innovation. Teachers' input, as shown in this study, might also enlighten the designer's perspective by providing further aspects of the innovation that the designer's commitment to specific theoretical frameworks might not provide.

Furthermore, this study is an example of a professional development model that uses teachers in the innovation phase as designers and not as subject to top-down delivery from "experts". (Gray &Bryce, 2006) Unfortunately, the limits of this study do not allow the analysis of teachers' reflections during the video stimulated recall sessions, so as useful results about their professional development might be described. Even if this study had provided teachers with opportunities to identify and clarify their own beliefs about teaching science (Lumpe et al, 2000) the study uses this model of professional development as a priori principle to be applied in its setting, rather than a field to be tested. However, the data collected during the study allows further analysis towards this direction, and this points to a route for further research.

Concluding the session about the theoretical contribution of this study I have to cite that the discussion above has been enhanced because data analysis has been capable of providing the categories necessary for such a description and interpretation. The following paragraphs aim to discuss the methodological contribution of the study towards its capacity to provide the theoretical and methodological tools sufficient to describe the situation of controversial issues in science education.

5.2 Methodological contribution of the study

This study had to address two methodological problems: the first one was to describe controversial issues and functional scientific literacy as distinct epistemological areas so the first could be described as context for the latter, and the second one was to find appropriate tools to describe the two areas and their relationship. The following paragraphs aim to discuss the answers that this study has given for the epistemological differentiation between controversial issues and science education and also describe the methodological contribution of the study for the description of those areas.

5.2.1 How can "controversial issues" be described as a context for functional scientific literacy?

The answer that has been given to this question is one that actually defines the two areas (controversial issues and science education) as resting in different epistemological levels: the functional scientific literacy is perceived as a concept resting in an epistemological level, whereas the controversial issue has been equated with the discussion about a controversial issue and therefore is perceived as an entity resting in the dialectical level.

This answer is not actually new in the science education area, since there are studies that have already made a distinction between argumentative process and epistemic actions (Pontecorvo and Girardett, 1993; Jimenez-Alexandre et al., 2000) A primary fact that had to be noted is that those distinctions were not apparent to me, and therefore the conceptualizations from such studies could not actually be used, unless struggles in describing the context of this study had emerged.

However this study has a main difference between Pontecorvo and Girardett (1993) or Jimenez-Alexandre et al (2000) studies. The studies mentioned above do not actually describe processes, but products of talk. Actually these scholars use warrants, claims, and backings as “argumentative operations”. Whether an utterance is a claim or a warrant is a result of a product analysis of argumentation and actually does not inform us about the dialectical strength of the utterance; it cannot describe the goal of the participant towards the issue, or the pre-stated argument. Therefore “argumentative operations” are not capable of describing the dialectical aspect of the lesson.

This study captures the dialectical aspect as the goal of the participant towards a pre-stated claim or argument. The answer was given after insights from areas that describe argumentation as a process like Rhetoric (Aristotle (*Rhetoric*); Mbasakos, 1989), Pragma Dialectical Argumentation Theory (Van Eemeren & Grootendorst, 1989; Van Eemeren & Houtlosser, 2000; Van Eemeren, et al., 2002) or situate the decision about controversial issues into specific types of dialogue (Walton 1990; 1992; Walton & Crabbe, 1995).

The contribution of the research in this direction is valuable: it both defines controversial issues as the dialectical context, a decision that can be further grounded on the fact that controversial issues are by definition issues that involve discussion about a decision to be taken, and also reveals and uses some tools that were not apparent in science education research, like the types of argumentative talks that actually describe the goals of the participants (Walton & Crabbe, 1995)

Those tools however, were not tailor-made for use in educational settings; they could not be easily applied in classroom discussions where the participants were not committed to any role, or they did not equally participate, since a teacher was also interfering in the process. This study had also solved this problem by mapping the issues that classroom discussion has taken and by relating them to the main issue under discussion, therefore finding a way to describe as distinct the process of discussing a controversial issue from anything else that has been discussed in the classroom.

The knowledge gained from studying argumentation as a process has defined the term of the "socioscientific content" used in this study. The term actually defines the components of the argumentative process (agents, issue, process, products) and enables the description of the content level of the discussion. Agents might talk about the issue, about themselves, about the process they have to follow or they are following, and might also engage in a meta-level discussion manipulating the products of their discussion. This kind of analysis has enabled the situation of specific types of argumentative dialogues (argumentation for persuasion, deliberation, inquiry, informative) to talk that was referring about the issue.

An input from moral reasoning literature and practical reasoning has enabled the description of what actually the agents have been doing when not talking (arguing, deliberating, informing, inquiring) about the issue. Controversial issues always involve an action to be taken; agents might perform actions, have beliefs about the implementation of such actions, or desires. The input of the literature was really helpful in distinguishing argumentative from explanatory sessions, and also in distinguishing between explanations/defences of actions, intentions, views, and desires.

The contribution of the study in this area is of great importance as it provides a means of decomposing the discussion in its component parts and thus provides a tool for making simpler complex argumentative discussions. The figure below that describes the results about the dialectical contexts related to beliefs about socioscientific content entities (already cited in the results chapter) is a tool to be used to identify the goal of the participant in a complex, multileveled and multilayered discussion that takes place in classroom settings. All three lessons presented in this study, even different in a lot of aspects, could be described (actually had provided) the following map-construct.

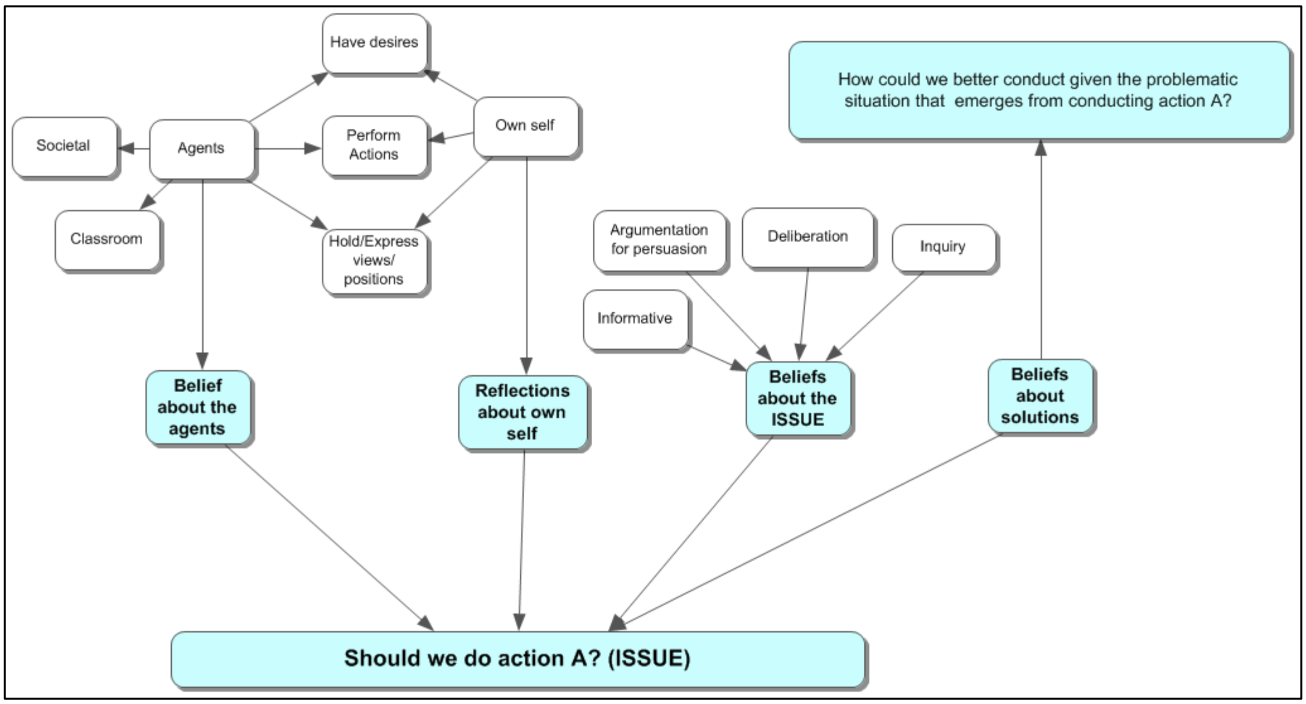


Figure 18: Proposed tool for analyzing complex argumentative discussions in classroom settings in terms of dialectical context categories

In this sense, the above theoretical construct is available to be used as a tool for analyzing in a primary level a complex argumentative discussion that takes place in classroom settings, though it has to be tested and modified with the use of further data.

5.2.2 *How can moral, emotional-reflective and cognitive processes be described in socio-scientific lessons?*

The answer to this question was extremely difficult to find due to my limited engagement with issues related to moral reasoning, Psychology and other areas beyond science education. Defining the border lines between the disciplines was extremely difficult due to different philosophical orientations related to the place of emotion and reason in moral reasoning and the definition of the moral aspect of practical reasoning. Conceptualizations from literature review carry the limitations of the conceptual means of the reviewer and in this case, trying to define and describe the moral or reflective part of the lesson while being in the science education area, was difficult. This difficulty was revealed both in the data analysis chapter, but also to the results chapter where categories were further defined and described.

However, argument schemes' typology alongside Peirce's (1905, as cited in Pietarinen, 2006) classification of Sciences have been successfully applied to classroom data and had enabled the description of the sciences-disciplines which the agents of the discussion have used to ground their claims; Philosophy (Moral Reasoning-Ethics), Logic (Informal Logic and Methodeutic), Introspection and Idioscopy (Biology, Sociology, Psychology) and the applied art of Social/Private Policy were the areas described to capture and "decompose" the interdisciplinary into its component parts.

Zeidler's and Keefer's (2003) theoretical construct about the situation of socioscientific issues in scientific literacy, though really helpful for the initial steps of data analysis for this study, could not be used as exact because its components (moral reasoning, emotional reflection, cognitive development) are considered as overlapping categories: personal reflection (Introspection) includes studying internal states beyond emotions and moral reasoning is based beyond emotion and volition to cognition as well and therefore cannot be excluded from cognitive development.

The answer to the above question therefore is the following: epistemic practices assigned in different disciplines can be described with the use of argument schemes which capture the type of reasoning. The type of reasoning alongside the dialectical context might indicate the exact epistemic practice performed by the agent (i.e. the reasoning scheme of cause to effect might indicate an explanation, or a defence for a prediction of a fact). The type of the reasoning captured (practical, theoretical normative, theoretical factual) is further used as a criterion to identify the type of the discipline -science in which it can be situated, since there are disciplines that are by definition normative (Ethics, Logic) or factual (Idioscopy), always according to Peirce’s (1905) classification.

The use of argument schemes typology as a tool to capture epistemic reasoning and assigning it in different disciplines with the use of Peirce’s (1905) taxonomy, is regarded as one of the results and contributions of this study since the selection and modification of Schellens’ typology (1985) has derived from a mutual interaction between literature review import about several argument typologies (Aristotle (*Rhetoric*); Hastings, 1963; Schellens, 1985; Van Eemeren & Grootendorst, 1992; Freely & Steinberg, 1965/2008; Walton, 1996, 2008), and instances derived from classroom data. Furthermore, the connection between syllogistic forms, epistemic practices and the SDDS stage is also a contribution of this study which was based on conceptualizations from theories about moral reasoning, scientific reasoning, the nature of scientific explanations and accounts of causality as those are presented in Appendices A, B and C.

In this sense the argument typology scheme, sufficient to describe epistemic reasoning and practice, was the result of theoretical thought done within this study which actually refers to the merging of different disciplines, so that the tools of one discipline (Dialectics, Informal Logic, Logic) might be modified to describe practices that were of interest in another discipline (Science Education).

This study therefore, has actually fulfilled one of its initial aims: it has used theoretical conceptualizations from disciplines that philosophize about scientific enterprise and study discourse and practices beyond science education. In this way this study contributes to the area of science education research related to argumentation and controversial issues teaching by proposing a modification of an existing methodological and conceptual tool (Schellens (1985) typology of arguments) and connecting it with certain epistemic practices situated in different areas of scientific inquiry (with the use of the SDDS model (Klahr, 2000 as cited in Zimmerman, 2007), relating it to epistemic practices. This is a tool that can be used for grasping epistemic processes within a lesson, but also for reconstructing argumentative talk in complex classroom discussions.

Even if there are a lot of typologies used within science education studies, I believe that Schellens' modified typology has main advantages compared to other, similar typologies that deal with reasoning schemes (i.e. Means & Voss, 1996; Duschl et al, 1999 modified Walton's (1996) typology):

- It distinguishes between practical and theoretical reasoning in a primary classification level and therefore it is suitable for describing the relationship between controversial issues and science education since the former relates to the practical and the latter to the theoretical.

- It provides a classification for practical argument schemes which refers to means, rules and consequences which is very helpful in decomposing argumentative discussions about controversial issues that include a decision about an action to be taken.
- It follows a consistent classification criterion: the nature of the conclusion. It therefore allows the analyst easily to apply it, even if this claim has to be grounded by other analysts rather than me.

The fact that the typology has been modified so as to include analytical arguments enables the analyst to use the argument scheme as unit of analysis for complex argumentative discussions. This solves the problem of distinguishing what would be a warrant and what a backing if a Toulmin's (1958) argument pattern is to be used for analysis: backings are regarded as arguments supporting the warrant, qualifiers as arguments countering the generalization of the argument (taken as proposition) .

The use of the typology, finally, has enabled the description of argumentative operations as related to the type of argument scheme to which they were referring. For example, a move from a participant aiming to drop an argument concerning consequences has been described in detail as the process of countering the truth of a consequence; a move aiming to further ground a means end argument has been described as one of defending the necessity of means and so on. This kind of description has actually merged the process and the product part of argumentation and had enabled the answer of a vital question of this study: describing the situation of controversial issues in science education. What has been described actually was the vice versa: what epistemic practices -situated in different disciplines- have been used by students when performing moves such as the establishment of the necessity of means, the truth of the consequences, or the relevance of the rule to a case.

Finalizing this session, I would suggest that the tools that this study provides can be used to analyze classroom talk in science classrooms that is not necessarily connected to a discussion about a socioscientific controversial issue. The aims of the study required distinguishing between practical and theoretical reasoning. The argument schemes used to capture theoretical epistemic reasoning and the connection of those schemes with specific epistemic practices within the scientific inquiry are applicable in any science lesson in which theoretical knowledge claims are explored, either in the hypothesis or in the experiment space.

Evidence evaluation, for example, is a practice that takes place not only when contradictory evidence about a controversial issue is presented, but also when alternative hypotheses are used to explain a single phenomenon, or when contradictory evidence from classroom experimental data might emerge. Identifying the argument scheme in a specific classroom episode allows the researcher to access and analyze the syllogism of the student(s), locate the student in the according stage of scientific inquiry and accordingly evaluate the syllogism within the context of the discussion.

The above conceptualizations might point to an implication about teacher development: being able as a teacher to analyze classroom talk is a vital skill that could contribute to several domains. This study suggests that since argumentative talk analysis has enabled the researcher to analyze and describe epistemic within the dialectic, the skills for such an analysis might be useful for pedagogues in their effort to survive in the chaotic of classroom discussions and accordingly react to students' contributions in the discussions. In other words, this study suggests that argumentative talk reconstruction might be a useful component in teachers' professional development towards the dimension of controversial issues implementation in science education. In a more generic form this argument suggests that enabling teachers to act as analysts of classroom talk in categories relevant to epistemic practice would help them improve their pedagogy related to functional scientific literacy. This argument however, does not emerge as a direct implication of the results of this study. It is rather a hypothesis to be tested with teacher development programs that will aim to enable teachers understand, analyze and evaluate classroom talk in terms of its epistemic quality – argumentative or not.

Summarizing the above paragraphs I suggest that this study has managed to define and describe the situation of controversial issues in science education. The study has adapted tools that are used to analyze argumentation in informal settings and had modified them so they could be applied in classroom settings and provide information that could be valuable for science education research,

5.3 Limitations and suggestions for further research

This research has dealt with the description of the situation of controversial issues in science education, and therefore had to adopt a general view that could identify and define Natural alongside Social or Psychological Sciences, Ethics, Logic and other disciplines within the discussion about a controversial issue. Due to its general orientation though, it might have missed a focused special scope that could give information that would be of interest of researchers looking for specific aspects of scientific argumentation, or for quality in argumentation.

A shortcoming of this research also, related to the above statement, is that it does not have a lot to say about evidential considerations since teachers had not dealt in great depth with issues related to evidence in the lessons. On the other hand, if teachers had dealt only with evidence based issues I might not have been able to create the tools and constructs that this study proposes for analyzing a controversial issue discussion in a science classroom. However, as cited in a previous section of this chapter, new research, aiming at the exploration of epistemological issues, as a matter of pedagogy and curriculum and not explicitly as a matter of students' abilities, would give further instances that could draw useful implications for curriculum developers and pedagogues. Further research might investigate how evidential considerations are explored within controversial issues in classroom settings, a process which actually might be a special focused replication of this study.

The tools presented above are created and applied within the limitations of this study. A question about the applicability of such tools though, refers to their complexity. There is a need for presenting those tools to the science education community, so they can be available for use, and therefore be criticized both in theoretical but in practical terms as well. Other researchers need to apply such tools to provide information about the difficulties and their limitations.

The typology of argument schemes, for example, is a tool to be tested by processes of application by other researchers, with different conceptual frameworks, to other lessons so that missing categories might be indicated or problematic categories might be identified. The same remark stands for the socioscientific content and context construct and for the adaptation of Walton's and Crabbe's (1995) typology of argumentative dialogues.

As noted in the beginning of this section, this study had to provide a general framework in which functional scientific literacy would be described. However, I realize that the tools presented above might not be of special interest for those who are really interested in specific aspects of scientific argumentation and especially about quality in argumentation. The tools used in this study might be merged with other typologies that examine for example the levels of complexity in the arguments (i.e. Erduran et al., 2004), the type of evidence used and so on.

Summarizing the discussion of the results I can cite that this study has fulfilled its aims to solve the issue of situating controversial issues in science curriculum and describe this situation as to contribute to the discussion about the implementation of controversial issues in science curriculum, by using teachers as designers of the proposed curriculum. This process has successfully implemented conceptualizations from other disciplines and therefore it contributes to the need for science education research to be informed by other disciplines that deal with same issues but from different perspectives. Due to the general orientation of this study, further studies that would concentrate on special issues that have been raised, such as the place of epistemological issues in the decision making, could further contribute to the aims of this study.

The study is situated in the hypothesis space: it has used classroom instances as primary data which would lead us to conclusions related to our questions. We still need more instances to further collect data about such a complex environment and contribute to the discussion about pedagogy. This study has contributed to the start of this process: it has broken down the complex into its structural components. We still need research to cite suggestions about how those components could be synthesized in ways that serve our aims as science educators.

As a final remark, I would say that what is presented is one part of the story. Unfortunately, this study has not explored the results from the students’ lenses. I believe that a rich investigation of the way that the discussion had affected students’ beliefs and understandings about the issues, might further enlighten us about silent changes that take place because of the discussion of a controversial issue in the classroom. We might have observed students defending a particular standpoint and analyzing their utterances at a specific time and place, but we do not know how the beliefs of their classmates might affect their beliefs and positions.

We might find it extremely difficult to find methodologies to grasp such an internal process. However, those silent processes might be one of the strongest arguments for including controversial issues in the science curriculum, as one of the teachers had suggested in the interviews:

> "*It is very important to feel the democracy; the freedom to express myself under no criticism and the opportunity to hear others expressing a contradictory to me claim that I could not think before. I might stand to support my thesis because my commitment assigns me such a role, but in the end of the discussion I might already start to change my mind…After all, we can never know how the participation of such a democratic process might affect them, not now, but in future years when they will act as future citizens*"

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APENDIX A: Moral Reasoning

Moral reasoning is one of the areas of functional scientific literacy related to the teaching of controversial issues, as explored in the chapter “controversial issues and the curriculum”. For methodology, but also discussion about pedagogy reasons I need to explore concepts related to *meta-ethics*, theories explaining where our ethical principles come from, dealing with the role of reason in ethical judgments and the meaning of ethical terms themselves (Fieser, 2006).

This exploration will provide insights into the process of moral reasoning and enable us to describe this process in order to capture the “reasoning” aspect of moral reasoning. I also need to deal with normative ethics, as those might help us explain the moral standards that students and teachers use in the classroom in order to regulate right and wrong conducts. The exploration that follows is an insight into meta-ethics and normative ethics conceptualizations needed to describe a process of applied ethics: the discussion of a controversial issue in a classroom.

i. Meta-ethics

a) Objectivism and Relativism

A very first issue concerning moral reasoning is the metaphysical question whether moral values are eternal truths that exist in a spirit-like area, or are simply human conventions. Two directions, objectivism and relativism provide different answers to this issue. Proponents of objectivism hold that moral values are objective in the sense that they exist beyond subjective human conventions; they additionally claim that moral values are absolute, eternal, stable and universal insofar as they apply to all rational creatures around the world and throughout time (Fieser, 2006).

Objectivist views have impacts on the epistemological status of moral judgments. Moral realism for example, suggests that facts about what is morally obligatory - moral judgments - and facts about what the case is, are not distinct: facts about what ought to be the case are facts of a special kind about the way things are, and thus a process of making certain moral judgments is an example of a process of discovering moral facts (Jacobs, 2000, p.141).

Within objectivism one might find Divine law theories. Those theories assume that moral values exist, but those are related to an authority that produces those values. The divine command theory is inspired by a notion of a powerful God who wills all moral values into existence (Fieser, 2006).

On the other hand, relativism suggests that morality does not exist independently of humans. Relativists view morality as a human construction. Not only norms about good and bad but also other fundamental concepts such as rationality, truth and reality are regarded by relativists as relative to a specific conceptual scheme, theoretical framework and paradigm, form of life, society, or culture (Bernstein, 1983, p.8). Consequently, there is no overarching framework by which we can rationally adjudicate or univocally evaluate competing claims of alternative paradigms.

b) Cognitivism

Moral reasoning has been described under three different dimensions: thinking, feeling and willing (or cognitive, affective and volitional). Those three dimensions have been appealed to as basis for making moral decisions (Poole, 1995, p.18).

Cognitivists assume that a moral judgment is a product of inquiry, a reasoned guided process.

They share the view that moral sentences are subject to truth or falsity, and that the state of mind of accepting a moral judgment is typically one of belief (Van Roojen, 2009). Cognitivists do not deny that there is indeed a role for sensibility in the account of morality. They rather share the view that feeling and desire have a role in moral judgment but not a role that is clearly separable from the role of cognition (Jacobs, 2000, p.134).

According to cognitivists view, ethical beliefs are part of inquiry. Even if ethical wisdom embedded in our traditions is a rich source for discerning what is good or bad, moral traditions fail to guide us because our predecessors never experienced or even thought about challenges regarding new techniques and technology: we are on our own, as we are the first generation to encounter these situations (Devettere, 2000, p.5).

The process of establishing and using moral judgments is parallel to what Toulmin (1958) has described as warrant establishing and warrant using arguments. Principles and duties sometimes dictate a particular judgment and the particular judgments will sometimes modify, revise, or supplement the prima-facie principles and duties (Devettere, 2000, p.15). A true belief, is defined as one that, “no matter how much further we were to investigate and debate, it would not be overturned by recalcitrant experience and argument” (Peirce, 1901 as cited in Misak, 2004). Moral judgments then fall within the scope of truth, knowledge and inquiry and our ethical beliefs might well aspire to truth, as our beliefs in science, mathematics and other disciplines do.

This view for establishing moral beliefs also has an experimental grounding. Psychological experiments provide findings that distinguish moral rules - products of “late inquiry” - when compared with conventional rules.

- Moral rules have an objective, prescriptive force; they are not dependent on the authority of any individual or institution. On the other hand, conventional rules are viewed as arbitrary or situation-dependent, and can be suspended or changed by an appropriate authoritative individual or institution.
- Moral rules are taken to hold generally, not just locally; they not only proscribe behaviour here and now, but also in other countries and at other times in history. Conventional rules are often geographically and temporally local; those applicable in one community often will not apply in other communities or at other times in history (Nado, et al., 2009).

One might easily parallel the process of establishing a moral belief to that of establishing a natural law in science. Established moral laws are analogous as established natural laws, whereas discussion that establishes moral principles resembles the "science in the making" process.

Accordingly, moral beliefs can be used to provide explanations for social policies and actions. As Humphreys (2006) cites,

> *"if a woman is stoned to death because of a cultural attitude, for example, these laws, policies, and customs must be taken as givens - they were in place when the events occurred and they play a central role in explaining them" (p.44).*

c) Non-cognitivism

Non-cognitivist theories do not agree that there are moral properties or moral facts that could be true or false. Moral judgments, according to non-cogntivist theories are rather expressing desires, approval or disapproval.

We can find two main theories within non-cognitivism: emotivism and prescriptivism

(Marturano, 2006). Emotivism interprets the process of moral judgment as one of depending on feeling and desire. Therefore moral assessments involve our emotions and not our reason. According to Hume (as cited in Jacobs, 2000, p.131) moral judgments are based on moral emotions: emotions that recognize the situation as morally relevant by identifying morally relevant features in ones' environment, in order to be reasoned about. Reason might be of service in giving us the relevant data, but, in Hume's words, "reason is, and ought to be, the slave of the passions" (Hume, 1739-1740 as cited in Fieser, 2006).

Emotivists think of moral terms in grammatically assertive utterances that function primarily to express emotion and perhaps also to elicit similar emotions in others; they thus assume that moral evaluation such as "right", "good" or "virtuous" signs a non-cognitive pro-attitude such as approval or preference (Barnes, 1933; Ayer, 1952; Stevenson, 1946 as cited in Van Roojen, 2009). However, there are views that confront that those assertions might not have a true or false value: if moral assertions can accurately or inaccurately reflect our feelings, assertions of this type can be true or false (Arrington, 2001, p.135). In this sense emotivism might be compatible to moral subjectivism.

On the other hand, prescriptivists hold that a normative sentence is used for uttering overriding universalizable prescriptions (such us: You should not steal!) (Marturano, 2006). Those prescriptions do not bear any cognitive meaning such an assertion or a description (of the kind it is not right to steal) but they are just used to utter prescriptions.

ii. Normative ethics

Normative ethics involve arriving to moral standards that regulate right and wrong conduct. The key assumption in normative ethics, according to Marturano (2006) is that there is only one ultimate criterion of moral conduct, whether it is a single rule or a set of principles.

Moral theories, as Pettit (2002, p.95) supports, involve two different components: first they put forward a view about what is good or valuable, though they do not all make this explicit and may even resist talk of the good and then, they provide a theory of the right. A distinction made by Pettit, is that theories of right are not concerned with which properties are valuable but with what individual and institutional agents should do by way of responding to valuable properties.

a) Deontological theories

Deontological theories are related by the emphasis they place on moral obligation, or duty. Behaviour in accordance with our moral obligation is considered morally right; behaviour not in accordance with our moral obligation is considered morally wrong (Devettere, 2000, p.17). Deontological theories are sometimes called non-consequentialist, since principles in these theories are obligatory, irrespective of the consequences that might follow from our actions (Fieser, 2006). Moralities of obligation are moralities of law. Those laws appear in different forms.

Natural theories view nature as permeated by a rational order, and therefore conclude that ethics is “living and acting according to rationally ordered nature” (Devettere, 2000, p.5). Naturalism claims that by looking at the nature of the world and the nature of humankind, certain moral truths can be discerned (Poole, 1995, p.18). In this sense universal principles are derived from the law of nature and known by all. Therefore, actions contrary to the natural law are seen as immoral (Devettere, 2000, p.7).

Right-based theories support that our moral obligations come from individual rights, the right to life, the right to choose, for example, possessed by all people (Devettere, 2000, p.8). In this sense, rights have the epistemological status of a law. Agents justify ethical judgments on the basis of such rights: if someone has the right to live, then a rights based theory obliges us to respect that right. Rights and duties therefore, are related in such a way to the rights of one person and the duties of another person (Fieser, 2006).

Theories of autonomous law support that we act according to the moral law we give to ourselves. Within this theory one might find Kant's theory of a single categorical imperative which can be expressed as "Treat people as an end, and never as a means to an end" (as cited in Fieser, 2006).

Finally, there are theories that appeal to laws from authorities such as God's laws, as those create the moral obligation in our lives (Poole, 1995). Those are views of commitment and assume that since you are committed to a theory or religion, then by duty you should do what this theory's principles and laws are implying. Christians are committed to Christian law and Jewish to Jewish law, communists to communist principles and so on.

b) *Consequentialist Theories*

Consequentialism is the view that normative properties depend only on consequences (Sinnot-Armstrong, 2006). The moral rightness of acts depends only on the consequences of that act and therefore, correct moral conduct is determined solely by a cost-benefit analysis of an action's consequences (Fieser, 2006). Fieser, (2006) refers to three different types of consequentialism:

- *Ethical Egoism*: an action is morally right if the consequences of that action are more favourable than unfavourable only to the agent performing the action.
- *Ethical Altruism*: an action is morally right if the consequences of that action are more

favourable than unfavourable to everyone except the agent.

- *Utilitarianism*: an action is morally right if the consequences of that action are more favourable than unfavourable to everyone.

Utilitarianism, shares the view that moral obligation arises from what will benefit most people. In that sense, the moral worth of an action is determined by its contribution to overall utility: an act is morally right if that act maximizes the good, that is, if the total amount of good for all minus the total amount of bad for all is greater than this net amount for any incompatible act available to the agent on that occasion (Moore 1912, as cited in Sinnot-Armstrong, 2006).

c) Virtue theories

Theories of this group are related by the emphasis they place on the good of the person performing the action. Instead of obligation, the key notion in ethics of the good is virtue. Virtues are the feelings, habits and behaviours that do in fact create good life (Devettere, 2000, p.17). Aristotle (Nicomachean Ethics) has described a man who was not seeking to identify the fundamental principle of right, but one who exercises practical reasoning enabling him to lead a flourishing or excellent life. What lead such a life, are certain enduring states of character (the virtues) that enable him to understand moral judgment and action (Jacobs, 2000, p.134).

Virtue Ethics however, place less emphasis on learning rules. They rather stress the importance of developing good habits of character assuming that once one acquires such habits he will then habitually act in a virtuous manner (Fieser, 2006). Aristotle (as cited in Fieser, 2006) argued that virtues are good habits that we acquire, that regulate our emotions. He also distinguishes moral virtues from intellectual virtues: moral virtues have to do with feeling, choosing, and acting well, whereas intellectual virtue is identified as a kind of wisdom acquired by teaching.

APPENDIX B: Scientific reasoning

Defining scientific reasoning is difficult and for some scholars like Laudan (1984) is even impossible, as “the aims of science vary, and quite appropriately so, from one epoch to another, from one scientific field to another, and sometimes among researchers in the same field” (as cited in Regt & Dieks, 2005). Scientific thinking has been described under different approaches and scholars do not agree to a single definition.

According to Zimmerman (2005) there are two main approaches for scientific reasoning determination: one focused on the development of conceptual knowledge in particular scientific domains, and a second focused on the reasoning and problem solving strategies involved in diverse activities, such as hypothesis generation, experimental design, evidence, evaluation and drawing inferences (p.4).

i. Stages of scientific inquiry

According to the second approach, scientific thinking involves the application of the methods or principles of scientific inquiry to reasoning or problem-solving situations (Koslowski, 1996 as cited in Zimmerman, 2007).

Inquiry is a central entity that describes scientific endeavour and is described as “a knowledge building process in which explanations are developed to make sense of data and then presented to a community of peers so they can be critiqued, debated, and revised (Driver, et al., 2000; Duschl, 2000; Sandoval & Reiser, 2004; Vellom & Anderson, 1999 as cited in Sampson & Clark, 2008, p.450). The main goal of scientific inquiry is the acquisition of knowledge in the form of hypotheses or theories that can serve as generalizations or explanations (Zimmerman, 2006).

Klahr (2000) has proposed a framework (the SDDS model: Scientific Discovery as Dual Search) for scientific discovery. According to this model, scientific discovery is accomplished by a *dual-search* process that takes place in two related spaces: the hypothesis space and the experiment space. The third process of the SDDS model involves evidence evaluation, where a decision is to be made for the acceptance, rejection or modification of the current hypothesis given the evidence gathered (as cited in Zimmerman, 2007).

This view is compatible with Peirce's (1900 as cited in Flach, 1996) perception of scientific inquiry as having three stages, each one representing three distinct forms of reasoning:

Stage of scientific inquiry	Reasoning engaged
Coming up with a hypothesis to explain initial observations	Abduction
Form predictions from a suggested hypothesis	Deduction
Estimating the credibility of that hypothesis through its predictions	Induction

Table 47: Stages of scientific inquiry and reasoning engaged

The process has been represented diagrammatically by Flach and Kakas (2000b):

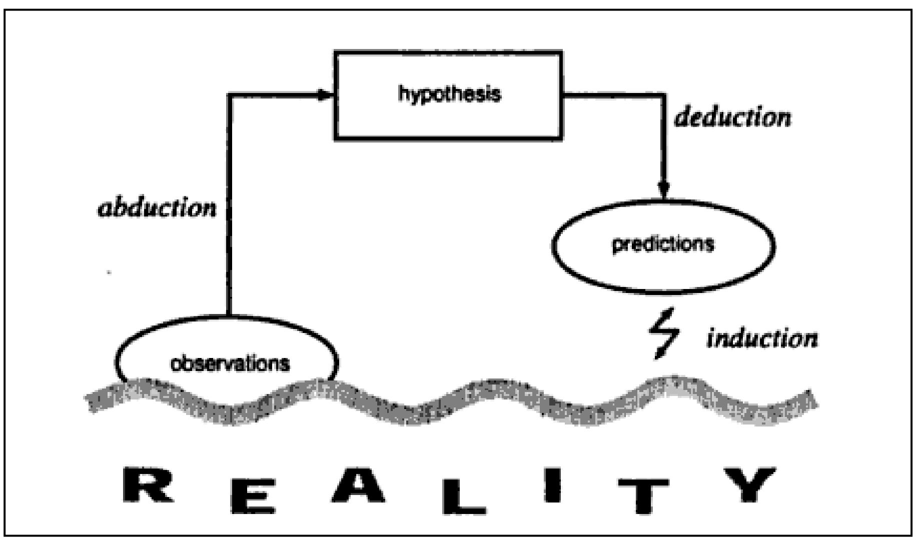

Figure 19: The three stages of scientific inquiry (source: Flach and Kakas, 2000b, p.7)

What is missing from such models though is the process of communicating the results and validating them through criticism of a community of peers. A process to be added therefore, is one of argumentation: a knowledge building and validating practice in which individuals propose, support, critique, and refine ideas in an effort to make sense of the natural world (e.g., Driver, et al., 2000; Kuhn, 1993 as cited in Sampson & Clark, 2008, p.456). Additionally, in order to have a full account of scientific reasoning, one has to describe the application of products of scientific discovery, theories, laws and principles as those used in new situations.

The processes of hypothesis generation, prediction generation, evidence evaluation and explanation generation, and finally argumentation, as well as reasoning types engaged in each stage are going to be discussed in the following paragraphs.

a) Hypothesis space

According to Peirce's theory (1900 as cited in Flach, 1996), abduction is the process of forming an explanatory hypothesis, given a number of observations (Flach, 1996, p.3), a kind of guessing by a process of forming a plausible hypothesis that explains a given set of facts or data (Walton, 2001, p.148). The process is described as non algorithmic, as the abductive suggestion might come up like a flash, however it is a logical inference since it has a logical form of:

> *"The surprising fact, C, is observed; But if A were true, C would be a matter of course. Hence, there is reason to suspect that A is true."(Peirce as cited in Flach, 1996)*

Another view of hypothesis generation is that of the "best explanation" given a set of data: Abductive inference has often been equated with inference to the best explanation (Harman, 1965, pp.88-89) and has the following syllogistic form:

"H is a hypothesis.

D is a collection of data.

H explains D.

No other hypothesis can explain D as well as H does.

Therefore H is probably true" (Harman, 1965, as cited in Walton, 2001, p.147).

A case described by Harman (1965) that describes abduction as the best explanation, is that of a scientist inferring the existence of atoms: "When a scientist infers the existence of atoms and subatomic particles, he is inferring the truth of an explanation for various data he wishes to account for" (p.89).

On this perspective, no restrictions are put on the form of the hypothesis: it may be either a particular fact or a general rule (Flach, 1996, p.3). Additionally, this notion of scientific hypothesis describes a non linear process of hypothesis generation, experimentation and evidence evaluation. As Zimmerman (2007) cites, either prior knowledge, or some observations (via experimentation) are taking place before constructing an initial hypothesis. Flach (1996) also cites that there might be several intuitions regarding hypothesis from the inferential perspective: they can be explanatory, accounting for part of the evidence, or confirmatory, extracting regularities implicitly present in the evidence (p.5).

b) Hypothesis testing - evidence evaluation

The third process of the SDDS model involves evidence evaluation, a process that is described as the decision made on the basis of the cumulative evidence to accept, reject, or modify the current hypothesis (Zimmerman, 2007).

Peirce (1900 as cited in Flach, 1996) describes this stage as "induction" and describes it as the process of confronting a hypothesis, through selected predictions, with reality:

> *“(…) an experiment (…) is a question put to nature (…). The question is, “Will this be the result?” If Nature replies “No!” the experimenter has gained an important piece of knowledge. If Nature says “Yes,” the experimenter’s ideas remain just as they were; only somewhat more deeply engrained.” (p.3)*

This process is what Toulmin (2003, p.113) has defined as a “warrant-establishing” argumentation, a process that Newton (as cited in Toulmin, 2003) describes as “rendering a proposition general by induction”, “using our observations of regularities and correlations as the backing for a novel warrant”. In a simple sense, covariation is one of the bases for making inductive causal inferences: if a factor and effect have a covariation, then they are likely to be causally related and if not a causally between the two is less likely (Koslowski, et al., 1989, p.1316).

Anomalous data might be reconciled with an explanation or theory, often by modifying the explanation to account for the anomaly. Kuhn (1989) has argued that the heart of scientific thinking lies in the skills at differentiating and coordinating theory (or hypotheses) and evidence, a process that involves a comparison of results obtained through experimentation with the predictions derived from the current hypothesis (as cited in Zimmerman, 2007). As Toulmin (2003) cites:

> *“We begin, by establishing that a particular relation holds in a certain number of cases, and then, “rendering it general by induction”, we continue to apply it to fresh examples for so long as we can successfully do so: if we get into trouble as a result, he says, we are to find ways of rendering the general statement “liable to exceptions”, i.e.*

to discover the special circumstances in which the presumptions established by the warrant are to rebuttal" (p.113).

The process of accepting, rejecting, or modifying current hypothesis however, goes beyond a simple inference between data and hypotheses, events and phenomena. Both children and adults have rich theories and beliefs that are used interdependently to make inductive causal inferences in a scientifically legitimate manner (Zimmerman, 2005, p.42). The objects of scientific discovery are not "objects of nature", are not "revealed in an obvious way by reading the *book of nature"*, but rather, "they are constructs that have been invented and imposed on phenomena in attempts to interpret and explain them, often as results of considerable intellectual struggles" (Driver, et al., 1994 p.5). A hypothesis testing process therefore moves to an evidence evaluation one, a coordination of theory and evidence.

If we deny this process of coordination, we leave apart a great part of reasoning and might conclude, like Peirce (1990 as cited in Flach, 1996) that hypothesis testing- as solely empirical- cannot be included in the "reasoning", "logical part" of scientific inquiry. Reasoning in scientific discovery, according to Peirce's latest theory, is entirely carried out by abduction (to come up with a hypothesis) and deduction (to make predictions). Induction does not have an analogue in the syllogistic perspective, since the process of evaluating a given hypothesis against reality is not reasoning at all (Flach, 1996, p.3). In Peirce's words (1990):

"Induction consists in starting from a theory, deducing from it predictions of phenomena, and observing those phenomena in order to see how nearly they agree with the theory'; it 'does nothing but determine a value" (as cited in Flach, 1996).

Koslowski (1996), among others (Chinn & Brewer, 2001; Zimmerman, 2007) rejects an empiricist framework for scientific discovery where when covariation obtains, hypothesis is seriously taken, but when it does not, hypothesis is either adopted, or refined. Even if covariation is evident, covariation might not be seen as an indicating cause but as merely artifactual; without the availability of a plausible process, causation is unlikely to be seen as taking place (Koslowski, 1996, p.12).

Evidence can only be judged as plausible or implausible in relation to current knowledge, theory or belief (Zimmerman, 2005, p.36). There are cases where theoretical considerations dictate rejecting (or at least questioning) the data themselves, i.e. as resulting from unsuitable measures (Koslowski, 1996, p.14). In this sense, explanations are not evaluated in isolation; they are judged in the context of rival alternative accounts.

Josephson and Josephson (as cited in Walton, 2001, p.141) define the factors upon the judgment of likelihood of a hypothesis, as associated with an abductive inference is based upon. Those factors are listed:

1. How decisively the hypothesis surpasses the alternatives

2. How good the hypothesis is by itself, independently of considering the alternatives (we should be cautious about accepting a hypothesis, even if it is clearly the best one we have, if it is not sufficiently plausible in itself)

3. Judgments of the reliability of the data

4. How much confidence there is that all plausible explanations have been considered (how thorough was the search for alternative explanations) (as cited in Walton, 2001, p.141).

This process is not identical to evaluating deductive or inductive inferences; it is not a linear process of testing hypothesis, accept it if “nature says yes” or “reject it if nature says no”. As Walton (2001) cites:

> *“collection of new facts may suggest a new explanation that may even be better that the one now accepted. The conclusion is an intelligent guess based on what is known at some point in an investigation that, in many cases, should continue” (p.142).*

Another issue that is to be discussed about hypothesis testing is one between covariation and causation. In real scientific practice, scientists are concerned with causal mechanism - the process by which a cause can bring about an effect, rather than rely on covariation of the cause and the effect. As Koslowski (1996) has pointed out:

> “*We live in a world full of correlations. It is through a consideration of causal mechanism that we can determine which correlations between perceptually salient events should be taken seriously and which should be viewed as spurious”* (as cited in Zimmerman, 2005 p.3)

Brewer et al. (1998, as cited in Russ et al, 2008) describe the mechanical explanations as causal models that go “beyond the original regularity” of the phenomenon (p. 127)).

Nevertheless, causation cannot always been established. A direct causal connection might be impossible in cases where the two correlated events are too far apart in space and too close in time for a signal to connect them; an explanation of such correlations in terms of a common cause is impossible (Regt & Dieks, 2005, p.145).

The relationship between causation, statistical relevance and types of explanations is going to be further explored in Appendix C.

c) Scientific argumentation

Argumentation in science is regarded as a knowledge building and validating practice in which individuals propose, support, critique and refine ideas in an effort to make sense of the natural world (e.g., Driver, et al., 2000; Kuhn, 1993 as cited in Sampson & Clark, 2008, p.456).

A model of scientific argumentation is given by Pera (1994 as cited in Bricker & Bell, 2008):

A scientific debate has three key participants:

> *"a proposer who asks questions, nature that answers, and a community of competent interlocutors which, after a debate hinging on various factors, comes to an agreement upon what is to be taken as nature's official voice", a process that is constrained, although not dictated by nature (p.481)*

Sampson and Clark (2008) conceptualize a scientific argument as having three interrelated components: an explanation (similar to Toulmin's claim), evidence (similar o Toulmin's data), and reasoning (a combination of Toulmin's warrants). Their framework, as they cite (Sampson & Clark, 2008, p. 406) is a Toulmin-inspired framework similar to frameworks adopted by a number of other researchers in science education (e.g., Kuhn & Reiser, 2005; Lizotte, et al., 2004; McNeill & Krajcik, 2007; Osborne, et al., 2004 as cited in Sampson & Clark, 2008, p. 406) and is presented in the figure below.

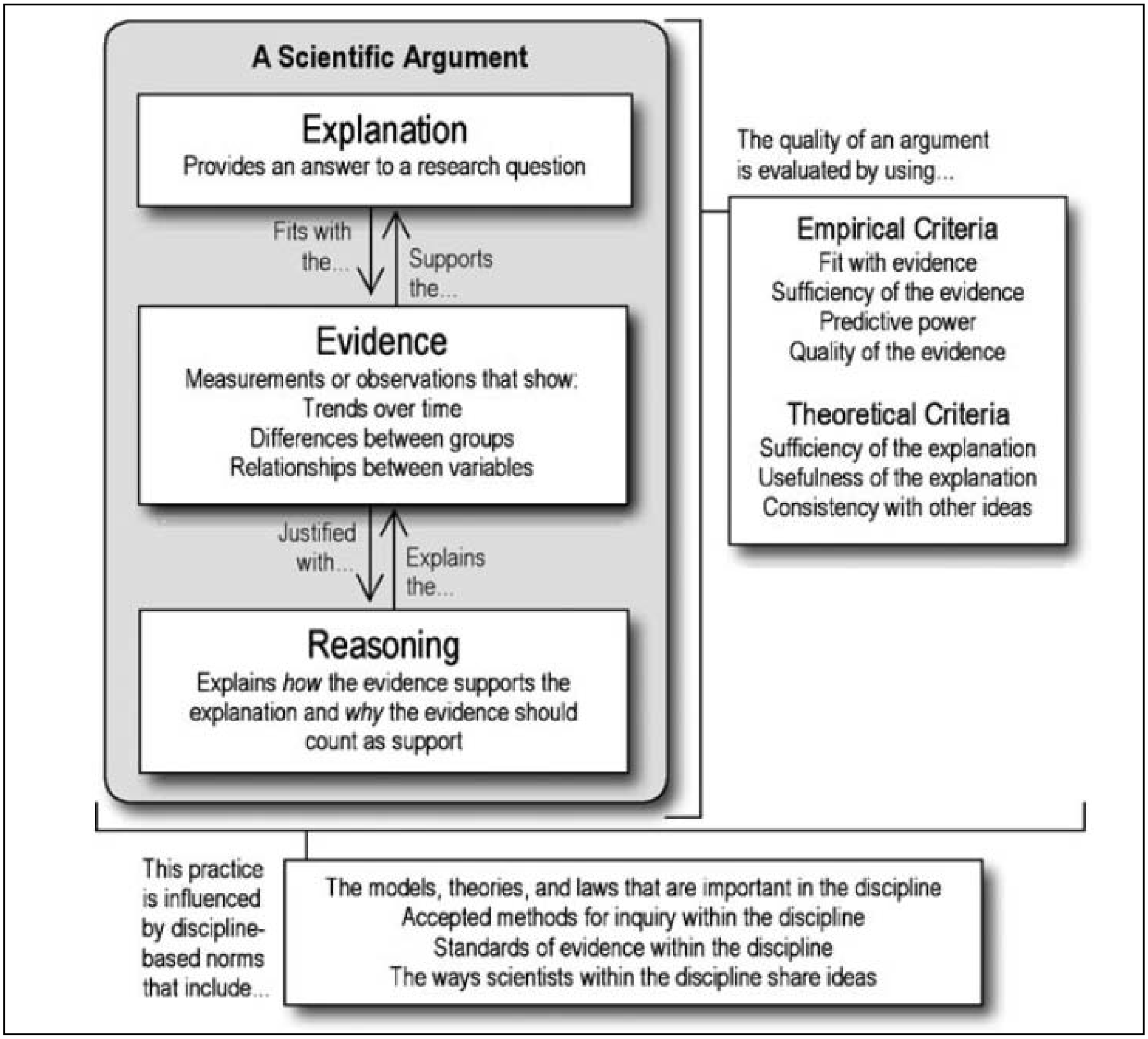

Figure 20: Argumentation-explanation framework (source: Sampson & Clark, 2008, p. 406)

According to this framework, the core scope of a scientific argument is to set a scientific explanation as valid. This is done by citing available evidence that confirms the hypothesis, but also explaining how the evidence supports the explanation and why the evidence should count as support. The *evidence* component of the framework refers to observations or experimental data that is used to support the validity or the legitimacy of the explanation, and it is distinguished from mere information as it needs to be used to either show a trend over time, a difference between groups, or a relationship between variables (Sampson & Clark, 2008, p.462).

Any criteria used for this model, the boxes outside the "argument", though, could create a new cycle and perhaps different kind of argumentation. For example the models, theories and laws are not always given, or accepted by all members of the community and counter-argumentation might spark on the light of different theories that might point to alternative explanations. The selection of the theory to be used, for example, could be an issue for further argumentation. Additionally, standards of evidence could be an issue of argumentation, as those do not hold as stable, given laws, but are also negotiated, revised and adapted to the specific situation within the scientific community.

Additionally we could broaden this framework by replacing "scientific explanation" with "scientific ideas": hypotheses, theories and predictions. Scientific endeavour does not deal only with scientific discovery and the evaluation of explanations, but also deals with the use of such explanations, once established, to theories and deduce predictions for future facts. Hypotheses, theories and predictions are essentially claims, while the data, warrants, backings, rebuttals and qualifiers are the components and conditions of "evidence" (Zeidler et al, 2003, p.111).

Latour and Woolgar (1979, as cited in Bricker and Bell, 2008, p.481) designed a classification system to account for the different types of such claims -statements found in scientific papers:

- *Type 5 statements*: They denote "a taken-for-granted fact" (p. 76) and contain no clarification verbiage because it is assumed that everyone understands these statements.
- *Type 4 statements*: They denote explicitly framed relationships between entities.

- *Type 3 statements*: They contain modalities (e.g., “generally assumed,”“possibly”), creating the impression that these statements are less certain (those are statements that scientific review of articles contain)
- *Type 2 statements*: Those contain more modal qualifiers and seem more claim-like than fact-like (Found more often in drafts explicating research that are being circulated in the laboratory).
- *Type 1 statements*: They contain actual speculations and these are used only in one-on-one discussions or at the very end of papers.

Accordingly, scientific endeavour is regarded as a means of changing statement types from one to the other through further research and argumentation practice. Furthermore, when statements are accepted, they are used to predict new facts or revise theories. According to Toulmin et al. (1984) scientific argumentation produces two types of arguments: regular and critical: in regular arguments, “the goal of reasoning is to establish a factual conclusion by appealing to currently accepted scientific ideas” (p. 333) whereas critical arguments on the other hand are those employed “when scientists challenge the credentials of current ideas” (Toulmin et al., 1984, p.332, as cited in Bricker & Bell, 2008 p.483). This is similar in pedagogical practice, according to Russell (1983) to the distinction between explaining a law or theory in the first instance and subsequently using a law in problem solving or laboratory activities: once a warrant has been established, its backing is implicit in the use of the warrant to reach conclusions (p.33).

Scientific endeavour aims therefore in the establishment of facts, theories, predictions and explanations for the natural world. This model in contrast with the goals of everyday argumentation has led to descriptions of scientific argumentation as non-dialectical in the sense that scientific argumentation is rather knowledge-building oriented than persuasive oriented

(Sampson & Clark, 2008). Duschl (2008) also refers to three forms of arguments: rhetorical which are “oratorical in nature and are represented by the discursive techniques employed to persuade an audience”, analytical, that are grounded in theory of logic and finally dialectical, that occur during discussion or debate and involve reasoning with premises that are not evidently true (p.162).

According to Duschl (2008) even if there is a general agreement that all three forms of argument are used in science, only dialectical and analytical that have their focus on evidence are more exacting and representative of high quality scientific argumentation (p.163). This is compatible with an ideal view of scientific argumentation which involves no real conflicts of interest; there are not any permanent winners or losers as a result of their resolution: having a personal stake in one’s work is not an issue because scientists argue solely to build sound theories for the collective good of the enterprise (Bricker & Bell, 2008, p.485). Of course, this is an ideal model; scientists do have personal goals and might include rhetoric in order to persuade for their arguments.

However, what has been described under this session as “scientific argumentation” refers more to this “high standard”, idealized model of scientific argumentation than to real scientific practice.

Appendix C: Scientific Explanations

Scientific knowledge in many domains, (explanations of the behaviour of electrical circuits, energy flow through ecosystems, or rates of chemical reactions), consists of formally specified entities and the relationships posited as existing between them (Driver et al, 1994, p.5). Information and events about those entities can be linked by different kinds of connections, including causal, contrastive, analogical and inductive links (Chinn & Brewer, 2001, p.31 as cited in Zimmerman, 2005). When the links are established and accepted by the scientific community, we do not talk about hypotheses anymore, but rather explanations. The types of links that explanations represent are classified through several systems. I will start this review of theories about scientific explanations from Hempel (1965), as latest theories have been established and base their criticism on this model.

iii. The deductive nomological model

Hempel (1965) has distinguished two major classes of explanation: A Deductive-Nomological (D-N) class, and a Probabilistic, or Inductive Statistical one (IS). As the names suggest, these are closely related to deductive and inductive forms of arguments respectively (Bell & Staines, 1981, p.40). According to the deductive-Nomological Model, a scientific explanation includes an explanandum, a sentence "describing the phenomenon to be explained" and the explanans, "the class of those sentences which are adduced to account for the phenomenon (Hempel, 1965, p. 247).

Hembel (1965) stated that for the question 'Why did event E occur?' event E is explained deductively from general laws and initial conditions (as cited in Park & Han, 2002, p.595). The model rests on two components: its deductive nature (D) and the nomological. (N): "the explanans must contain at least one "law of nature" and this must be an essential premise in the derivation in the sense that the derivation of the explanandum would not be valid if this premise was removed" (Woodward, 2009).

Hempel (1965) distinguishes between explanations of particular facts and explanations of general regularities (Hitchcock & Salmon, 2001, p.477).

a) The role of laws in d-n model

Scientific understanding of phenomena requires theories; scientists have to be able to use theories in order to generate predictions and explanations (Regt & Dieks, 2005, p.148). Theories therefore, provide general causal laws that are used deductively to explain an event as being a case with initial conditions related to the law, a practice very common to biological and behavioural sciences (Bell & Staines, 1983, p.40).

The process is also described by Toulmin (2003, p. 113) as "warrant-using" arguments: When a statement in physical theory is established by testing it in sample situations, both data and conclusion are independently known, are then rendered generally by induction, and are finally applied as a rule of deduction in fresh situations to derive novel conclusions from our data. In this model, or case of scientific explanation, an inference takes place that shows how observable phenomena can be deduced from basic premises which are the well-specified postulates of theory. Reasoning from those postulates is to be achieved by the inference rule of deductive logic (Reif & Larkin, 1991 as cited in Park & Han, 2002, p.596).

According to Hempel (1965), any scientific explanation should include, as one of the premises, a law of nature (as cited in Hitchcock & Salmon, 2001, p.470). The D-N model is based on established laws. However, causal explanations might come up also “accidentally” with no use of such laws. As Hempel (1965) cites we can distinguish between generalizations that are only "accidentally true"- (All members of the Greensbury School Board for 1964 are bald) and those that are "laws" - (All gases expand when heated under constant pressure) (as cited in Woodward, 2009). Accordingly, we might classify two types of explanations: every day explanations that are single-causal and scientific explanations that are law-based. However, as Woodward (2009) argues, the boundaries of the category "scientific explanation" are far from clear. Actually, Woodward believes that this model of explanation is not an attempt to reconstruct the structure of explanations but is rather only meant to apply to explanations that are properly regarded as "scientific".

b) Deductive nomological as argument -syllogism type: the deductive nature

Bell & Staines (1981) classify the deductive-nomological model in the "argument type" model of explanation (p.41). The argument model indicates the way by which statements in explanation can be evaluated: scientific explanations must meet the condition that "explanatory information adduced affords good grounds for believing that the phenomenon to be explained did, or does indeed occur" (Bell & Staines, 1981). The structure of explanation then, is similar to an argument: the explanans support the explanandum as the premises support the conclusion in an argument.

Long before Hempel (1965), Aristotle (Posterior Analytics) was another philosopher who has held that causal explanations are deductive inferences of a special kind. In the Posterior Analytics, Aristotle distinguishes a special sort of deductive inference - the demonstrative syllogism. This type of syllogism, according to Aristotle, has premises that are "true, primary, immediate, better known that and prior to the conclusion, which is further related to them as effect to cause" (Aristotle, Posterior Analytics). As Jeffrey (1971) cites, the affinities between the Hempelian and Aristoteleian accounts of explanation may be obscured by differences in terminology: Aristotle speaks of syllogism, Hempel of deductive inference; and Aristotle speaks of knowledge, Hempel explanation (p.104). However, as Jeffrey (1971) cites, the knowledge that Aristotle means is connected with cause, it is the sort of understanding that is conveyed by causal explanation.

c) Deductive statistical explanation (D-S)

The second type of explanation, within Hempel's nomological model is the deductive statistical explanation. Deductive nomological and deductive statistical explanations (D-S) share the same structure (as arguments): their premises contain statements of initial conditions and law-like generalizations. Their difference rests on the nature of the laws used in the premises, and to the truth of the conclusion given the truth of the premises. The laws in a deductive nomological explanation are universal generalizations, whereas the laws in IS explanations have the form of statistical generalizations (Mayes, 2005). Respectively, deductive statistical explanations involve a deduction of a "narrower statistical uniformity" and thus they provide conclusions of a high probability but not certainty. Hitchcock and Salmon (2001) give the following example for this kind of explanation:

> *"We can explain why atoms of carbon 14 have a ¼ probability of surviving for 11.460 years because the half-life of that species is 5.730 years. In this case we explained a statistical generalization about all*

C^{14} atoms by deducing it from the statistical law that any C14 atom has a probability of ½ of decaying within a period of 5.730 years (regardless of age)" (p.470-71).

In terms of inference, as Hitchcock and Salmon (2001) support, there is little need to distinguish deductive-statistical from deductive explanations, since there are no special difficulties for deductive explanation of statistical generalizations on the basis of statistical laws. As we can explain scientific phenomena deducing them from more fundamental general laws, we can also have deductive explanations of statistical laws on the basis of more basic statistical laws (p.472).

d) Inductive statistical explanation (I-S)

Hempel (1965 as cited in Woodward, 2009) recognizes a third type of explanation, which calls inductive-statistical or I-S explanation. According to him, those explanations involve the sumsumption of individual events (like the recovery of a particular person from streptococcus infection under (what he regards as) statistical laws (such as a law specifying the probability of recovery given that penicillin has been taken).

As another example, Hitchcock and Salmon (2001) cite the explanation of why a particular weed withered by citing the fact it received a dose of a herbicide, even though we know that the herbicide is not invariably effective: this means that the withering is related probabilistically to the herbicide treatment but it is not necessary by it (p.470). Those kinds of explanations as kinds of arguments show that given the particular circumstances and the laws in question, the occurrence of the phenomenon was to be expected; and it is in this sense that the explanation enables us to understand why the phenomenon occurred (Hempel, 1965, p. 337, as cited in Woodward, 2009).

So, when it comes to an explanation of a particular fact and not a law, deductive nomological and inductive explanations can be reconstructed as arguments to the effect; the fact to be explained was to be expected on the basis of the explanatory facts (Hitchcock & Salmon, 2001, p.472). However, the two types of explanations have important differences. The difference is that deductive explanations might be represented as deductive arguments whereas I-S explanations as inductive. But what does this distinction mean?

Firstly, inductive logic is non-monotonic as compared to deductive inference, where you can add any further premises to a valid argument with no change in its validity (Hempel as cited in Hitchcock & Salmon, 2001). With inductive arguments, new, further information might make the explanation collapse (Bell & Staines, 1983, p.47; Hitchcock & Salmon, 2001). As a result, two explanations belonging to the I-S model might come to a contradictory conclusion, a case that is not possible to be found in a deductive argument. As Hempel says “the concept of statistical explanation for particular events is essentially relative to a given knowledge situation” (Hempel, 1965, p.402 as cited in Ruben, 1992, p.151). Hempel (1965) introduced the concept of the “requirement of maximal specificity” for I-S explanations, as new information might point to a different, even contradictory explanation.

A second vital difference is that D-N model can be used to explain both specific phenomena and general state of affairs (as described by the laws), whereas the I-S model is only indented to explain certain events or phenomena (Bell & Staines, 1983, p.47). That’s why there are views that describe I-S explanations as incomplete D-N explanations. According to this view, I-S explanations cannot provide statistical generalizations that are invoked to them; this has to be done in the deductive way of D-N explanation (Bell & Staines, 1983). However, this view of I-S explanation as incomplete D-N is tantamount to determinism, the doctrine that events are completely determined by antecedent conditions, a view that, as Hitchcock and Salmon (2001) support, is highly questioned by modern physics - i.e. quantum mechanics- that suggest that there are events occurring by chance and their outcomes are not completely determined by previous conditions. As they cite:

> *"Our theory of statistical explanation should at least leave open the possibility that the world is actually intdeterministic. In that case, there might be statistical explanations that are complete- not merely explanations that, on account of our ignorance, fail to achieve full D-N status." (p. 473)*

Accordingly, (Ruben (1992) argues that the argument that I-S explanations are complete and not incomplete D-N ones, needs a metaphysical backing and some form of nondeterminism (Ruben, 1992, p.151).

In this sense, explanations belonging to the I-S model explaining a particular event, are regarded as complete and resemble what Peirce (1900 as cited in Flach and Kakas, 2000b) calls as abductive inference. Walton (2001) supports that Peirce's notion of abduction, even though presented as different from the notion of inference to the best explanation presented by Harman, it is actually not. The examples that he uses along with various definitions and characterizations, suggest that abductive inference and inference to the best explanation can be taken to be equivalent notions (p.147). Flach and Kakas (2000b) also support that Peirce's syllogistic view of abduction or hypothesis provides a special form of explanation as the result (taking the role of the observation) is explained by the case (is the explanation) in the light of the rule as a given theory (p.5,11).

This line of reasoning, distinguishes statistical explanations as described by the I-S model from mere correlations. Actually, views that do not interpret I-S explanation as abductive inference pointing to the best explanation for an event, actually do not find anything of importance in distinguishing two different models (D-S and I-S) of explanations. However, the discussion in the literature raises an important claim: inductive statistical "explanations", that are not interpreted as inference to the best explanation but are rather statistical generalizations, are not explanatory (Bell & Staines, 1983; Flach & Kakas, 2000a). Particular events, especially in psychological and social phenomena, are explained by means of probabilistic or statistical explanations. However the explanation does not explain why the event has occurred: it might only assert that the likelihood of an event is high, given some other occurrence (Bell & Staines, 1983).

As Flach and Kakas (2000a) argue, if induction provides explanation at all, these explanations are of a different kind and do not depend on a particular theory. They therefore, do not provide any insight to why things are so: the rule that every parent of John is a parent of John's brother does not explain parenthood (p.11). Jeffrey (1971) also supports that only in certain cases where statistical explanations act as "statistical mechanical" can be regarded as inferences (p.105-106). Inductive generalizations are therefore, not really explanatory; they are rather arguments that bring forward "good grounds for believing that the phenomenon to be explained did or does indeed occur" (Bell & Staines, 1983, p.45).

Another important difference between abductive inference and inductive generalizations is that they serve different purposes within the scientific discovery space. An application for example of abductive reasoning is used with problems such as diagnosis: abduction is used to produce a reason, according to some known theory of a system, for the observed phenomenon, whereas a typical inductive task would move from a collection of observations which are judged according to some background information to be similar or related to a hypothesis that aims at providing generalization of the observation (Flach & Kakas, 2000a, p.12).

e) Criticism for the D-N model

The strength of deductive explanations however, is limited as it rests on the application of laws and theories and does not point to new directions. A criticism therefore for deductive explanations is that they cannot discover anything new (Kantorovich, 1993, p.65; Flach & Kakas, 2000b, p.8). As Kantorovich (1993) explains: “Even if the laws of nature were theorems in a deductive system, deductive logic without the guide of a suitable heuristic would not hit upon an interesting, useful, theorem”. He also supports that deductive logic is not a method at all, since the discovery of a deductive proof is not a deductive process, as one has to find or even invent the steps in the proof. Accordingly, Flach and Kakas (2000b) support that deductive logic is rather “Logic of the Finished Research Report” rather than “Logic of Discovery” (p.8).

This criticism however, refers to the strength or capacity of D-N explanations and not to the D-N explanatory model. There are other criticisms though, which do question it. For example, the argument that not all causal connections might be provided by rules or laws, limits the scope of deductive explanations. According to this view, not all explanations apply laws, but they rather employ generalizations, that sometimes satisfy too few of the standard criteria to count as laws (Woodward, 2009). Woodward cites as examples explanations from sciences such as biology, psychology, and economics, which are full of generalizations that appear to play an explanatory role and yet fail to satisfy many of the standard criteria for lawfulness.

Additionally, there is another view which supports that the D-N model cannot explain causes, or mechanisms: deductive inference that relates laws and statements of the phenomena to be explained in D-N models, cannot capture, according to these views, the reasoning involved in understanding how a given mechanism produces the phenomenon (Bechtel & Abrahamsen, 2005, p.427).

Those two objections have created two different models of explanations: the model of counterfactual (Woodward, 2009) and mechanistic approach which are going to be briefly discussed below.

iv. Counterfactual approach - Woodward

The counterfactual approach takes it that causes make a difference to their effects. This difference-making is cashed out in terms of counterfactual dependence (Psillos, 2004 p.2916). This approach therefore is based on invariance that rests as a key idea in Woodward's account of explanation (Sober, 2006, p.45). Humphreys (2006) explains as follows the establishment of causation between two variables:

> *"Suppose that there is a relationship between two variables that is represented by a functional relationship Y=f(X). If the same functional relationship f holds under a range of interventions on X, then the relationship is invariant within that range. The intuition underlying this kind of dependence is that if we can exploit this invariance to control the effect, then we have a causal relation."(p.40)*

In particular, Woodward's interventionist counterfactual approach takes the relationship among some variables X and Y to be causal if, where an intervention changed the value of X appropriately, the relationship between X and Y would remain invariant and the value of Y would change (Psillos, 2004, p.2916). An important aspect of Woodward's position is that interventions are allowed to change not just values of variables that occur in regularities but can change the mechanisms that produce those regularities (Woodward. 2009 as cited in Humphreys, 2006, p.42).

a) Laws and mechanisms according to the counterfactual model

According to this model, the laws of nature are not to be taken as standard (Woodward, 2009 as cited Humphreys, 2006, p.43). Explanations generated by this model do not appeal to laws and thus, it has a greater capacity than the D-N model to capture explanations of the social sciences that do not use top-down rules but rather rule-governed individual based models (Humphreys, 2006).

As the D-N model distinguishes between laws and accidental generalizations, this model distinguishes between possible and actual causes. Woodward draws a distinction between causal generalizations that describe types of events and singular causal statements that describe token events, as shown in the following examples:

> *"Types of events: Short circuits cause electrical fires.*
> *Token event: This short circuit caused this electrical fire." (Sober, 2006, p.44)*

Woodward (2009), as Sober (2006) cites denies that these differences between the two statements show that there are two concepts of cause. He rather views the types of events as possible causes of fires whereas the token level claims as describing the actual causes of a fire.

This discussion brings us to the distinction of induction and abduction. Whereas the latter points to an unobserved event and acts as hypothesis generation (This short circuit caused this electrical fire), the first resembles to a statistical generalization, used as explanation (Short circuits cause electrical fires). Sober also defends the idea that type-level and token-level claims involve different concepts of cause (Sober, 2006), viewing the type-level claim from the point of view of a probabilistic theory of causation, whereas he takes token events as sometimes being related causally even though the probabilistic requirement is not satisfied.

An issue concerning this model is the invariance between two variables that depend on a third one. As Sober (2006) cites, until we discover the third cause we think of the two of them as cause to effect (Sober, 2006, p.46). Sober also disagrees with the claim that explanatory factors are necessary for their effects and finds a contradiction of this claim with other claims that coexist in the same theory that argue that generalizations provide deeper explanations the more invariant they are.

Third, the claim that explanatory factors are necessary for their effects can clash with Woodward's (2009) other thesis that generalisations provide deeper explanations the more invariant they are. As he cites:

> *"What should we say if the theory of ideal gases is less invariant than the theory about the individual molecules? Is the micro-story better because it is more invariant or worse because it cites factors that aren't necessary for the macro-effect?"(p.47)*

b) Mechanistic approach

The mechanistic approach takes it that causes produce their effects, in terms of mechanisms: two events are causally related if and only if there is a mechanism that connects those (Psillos, 2004). Literature advocating the use of mechanisms to explain phenomena, generally describes them as identifying the process between causes and effects (Russ, et al., 2008). In this sense mechanistic reasoning can be regarded as a “causal reasoning”, that acts as an explanation: it explains the process by which a cause brings out an effect (Koslowski, 1996 as cited in Russ, et al., 2008).

Bechtel and Abrahamsen (2005) give the following definition for mechanistic explanation: “A mechanism is a structure performing a function in virtue of its component parts, component operations, and their organization. The orchestrated functioning of the mechanism is responsible for one or more phenomena (p.423).

The counterfactual approach uses events and variables to be the basic entities that compose the explanation. In the mechanistic approach, on the other hand, processes rather than events are the basic entities in a theory of physical causation (Salmon, 1984 as cited in Psillos, 2004, p.296). Whereas Salmon restricts his theory only for physical causations, Glennan’s mechanistic theory is broad enough to include higher than physical mechanisms, such as social ones (Glennan, 1966, as cited in Psillos, 2004).

The mechanistic approach is very important in sciences like biology. In biology, identifying phenomena precedes and invites explaining them: biologists explain why by explaining how (Bechtel & Abrahamsen, 2005, p.442). However, as they cite, not all scientific explanations involve appeals to mechanisms or and not all explanations in biology could take the form of identifying the responsible mechanism. Additionally, according to Glennan’s view (1966, as cited in Psillos, 2004) mechanistic approach cannot explain all laws in physics. Actually, Glennan (1966, as cited in Psillos, 2004, p. 302) makes a distinction between the fundamental laws of physics and “mechanically explicable” laws: laws that are underpinned by a mechanism and characterize all the special sciences and “much of physics itself” (p.50).

c) The criticism for mechanistic approach

A shortcoming for the mechanistic approach is that mechanistic explanations are non-predictive constructs (Peters, 1991, p.168). As Peters argue, theories are only tools to describe, predict and manipulate nature. Mechanistic explanations fail to predict or manipulate nature and may not even describe it as if research breaks observed phenomena into separate mechanisms of cause-effect relations. It is unlikely that these can ever be reassembled into a functioning whole.

Additionally, the capacity of mechanistic reasoning to establish a causal link is also questioned. The issue is related to the way that the nature of causality is perceived. As Peters (1991) cites, causality has so many, easily confused interpretations that it is easier to avoid causal terminology.

Psillos (2004) describes the nature of "cause" adopting David Hume´s view of causation. According to Hume, "experience only teaches us how one event constantly follows another, without instructing us the secret connexion which binds them together, and renders them inseparable", and thus the alleged necessary tie between cause and effect is not observable (p.66). In that sense, causation is an intrinsic relation among events (the secret connexion) but that we can only get at some extrinsic marks of it. Therefore, according to Psillos, (2004) the mechanistic approach, but also the counterfactual approach fail to tell us what this relation is as for none of them renders causation an intrinsic relation (p.292). However, both of them are compatible, in the effort to provide a causal explanation.

Mechanistic considerations can help the counterfactual approach to deal with the endogenity problem (when effects are treated as causes), to help testing the stability assumptions (unit homogeneity, temporal stability) that are necessary for the counterfactual inference and finally, especially in qualitative research to help dealing with possible confounders, as in qualitative research it is possible that that the explanatory variable is correlated with a confounding variable. However, mechanistic approaches rest on a different level than counterfactual ones. As Psillos (2004) argues:

> *"There is an asymmetry between the two accounts we have been discussing: mechanisms need counterfactuals; but counterfactuals do not need mechanisms. In other words, mechanistic causation requires counterfactual dependence but not conversely. It is in this sense, that the counterfactual approach is more basic than the mechanistic."(p.306)*

Finally, the capacity of mechanistic approach is viewed as limited by the fact that not all explanations are causal. Even if many scientific explanations cite information about causes, there are views that do not take the notion of causation as primitive to the theory of explanation. Hempel (1965), for example was unwilling to simply say that X figures in an explanation of Y if and only if X causes Y (as cited in Woodward, 2009).

Appendix D: Glossary of abbreviations

Abbreviation	Meaning	Page
AAAS	American Association for the advancement of Science	27, 49, 70
CYBC	Cyprus Broadcasting Cooperation	26
D-N explanation	Deductive –Nomological Explanation (Hempel, 1965)	160, 163, 299, 460,464,465,467,468,469
D-S explanation	Deductive –Statistical Explanation (Hempel, 1965)	163, 299, 462, 466
GMF, GM	Genetically Modified Food	38, 41, 59
ICT tools	Information Communication Technology tools	23, 24, 28
IRF talk	Initiation-Response-Feedback type of teachers' guided talk in the classroom	256
NGOs	Non Governmental Organizations	45, 51, 52
SDDS	Scientific Discovery as Dual Search –Model for scientific inquiry (Klahr, 2000)	134, 148, 155,163, 164, 223, 224, 225, 298, 299, 336, 337, 339, 346, 382, 398, 399, 447, 449
SSI	Socioscientific Issues	12, 68, 73, 80, 81, 257, 261
STS	Science Technology and Society	27