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A case study in the teaching of immunology: written arguments and the counter-inductive method of Paul Feyerabend

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ABSTRACT

In this study, initiated during immunology classes in a graduate course, we analyzed argumentative texts written by students whose production was guided by the counter-inductive approach of knowledge proposed by Paul Feyerabend in his book 'Against method' (1975). It was applied a teaching practices activity about a topic on Immunology covering some aspects of the philosophy of science in higher education, particularly the philosophy of biology. The texts written by the students showed the presence of clearly identifiable argumentative structures and also the presence of contents related to scientific and philosophical contexts.

KEYWORDS: Argumentation. Counter-inductive method. Immunology. Paul Feyerabend. Science teaching.

INTRODUCTION

Modern science had as its predominant methodological basis the empirical-inductive approach. According to this orientation, the role of theories and hypotheses was conceived as temporally and logically dependent on the observation of a particular phenomena, usually described as "facts", that is, as a kind of value-neutral activity independent of presuppositions and theoretical commitments of any kind (GIL PÉREZ et al., 2001, EL-HANI; TAVARES; ROCHA, 2004). However, in the mid-twentieth century, this understanding of the production of scientific knowledge became to be accepted as largely naïve, due mainly to the critiques that philosopher Karl Popper directed to the neopositivist view of science. Some years later, the historical and sociological explanations of science dynamics proposed by Thomas Kuhn helped enormously to bury this more traditional, linear, and progressive, empirical-inductive philosophy of science.

In this context, and following the new path opened by his contemporaries, Paul Feyerabend can be seen as the one who breaks with the perspective of considering science the only valid form of knowledge about the world. For sure, he is one of the greatest philosophers of science of the twentieth century. His main contribution to the philosophy of science was the acid and very well informed criticism made to rationalism and the alleged superiority of the scientific method over other possible forms of knowledge. Differently from Popper and Kuhn, he defended that there are other forms of knowledge as reliable, good and useful as scientific knowledge and, consequently, that is possible to build genuine knowledge on other bases than the methodological limits accepted by traditional practices of science.

To present his epistemological proposal, Feyerabend borrows from political philosophy the concept of anarchism. Thus, he argues in his book "Against the Method" (1975) that the methodology of scientific research should be seen and pursued as an anarchical endeavor, that is, as a pluralistic enterprise that contemplates different ways of seeking knowledge beyond the fixed methods endorsed by the known sciences. Following the foundations of epistemological anarchism, the scientific methodology should adopt as its principle the motto: “anything goes”.

However, he does not fully embrace anarchism in his philosophy. Feyerabend makes a clear distinction between the proposal of the concept of anarchism in politics and its transposition to epistemology. He is not announcing the end of the State, so to speak; he is not saying that we should abandon or combat science as commonly practiced, but only that we have to see traditional science as “a" key to uncover the face of the world and not as "the" key. That is, what his main epistemological statement is that we should not be comfortable with a fixed, immutable and sovereign method for the search for truth; the search for knowledge has to allow fragmentation and the possibility of other methodological forms of insurgency, not against the rationalist proposal, but in addition to it. So Feyerabend does not endorse a kind of inconsequential multiplicity – as an anarchist, he is not an irrationalist. For him, epistemological anarchism is truly important in order to open science to new possibilities, to bring on theoretical flourishing, to promote a richer and diverse scientific dialogue and, finally, to attain the true progress of knowledge. Feyerabend’s epistemological anarchism could be summarized in the conjunctive claim that all common scientific methodologies

have limitations and the belief that only one should be privileged in its set of techniques and architecture is something that inhibits the real progress of science. Contrariwise, it is the multiplicity of methodological techniques that enables the real progress of knowledge. In his words, "Science is an essentially anarchic enterprise: theoretical anarchism is more humane and more apt to stimulate progress than its alternatives that proclaim law and order" (FEYERABEND 1975, p. 313). In this sense, favoring methodological multiplicity, Feyerabend proposes the counter-induction thesis as one of his theses. The word "induction" comes from the Greek word *ἐπαγογή* and was first used in a sense related to knowledge by Aristotle in the texts collected and organized under the title “Metaphysics”. We can say that what this term encompasses today is slightly different from what it used to refer in classical antiquity. Of course, this occurs because the scientific revolution and its experimental bias brought the notion of induction to the center of its practice, and so kept the idea of a knowledge based on generalizations informed by the observation of singular phenomena. At the same time, it added to science a quantitative, formal and meticulous care. Aristotle's interest in the concept of induction was not linked directly to questions concerning the observation of nature, but to the problem of the first premises of syllogistic reasoning, that is, to a question related to the achievement of rational knowledge, especially the quest for universal and necessary truths in the domain of metaphysics. For Aristotle then induction was just as a step to the attainment of universal truths essential to deductive knowledge and demonstration procedures. However, after Francis Bacon submit the idea of Aristotelian induction to a harsh critique and develop a more systematic and painstaking approach to it, the concept became a fundamental and invaluable element to the natural sciences method. Later on, David Hume (1711-1776) correctly pointed to the fact that the use of inductive reasoning in natural science was incompatible to the accepted status of science as a kind of universal and necessary knowledge, status largely seen as uncontroversial. This “humean problem” states that we can never know with necessary certainty if a whole series of past observations will repeat the same results in the future, and so, there is no logical necessity at the core of natural science, but only a fallible generalization. In the twentieth century, Popper (1902-1994) argued that the falseation of hypothesis, and not its confirmation by induction, that was the true feature of scientific knowledge and the demarcation criterion of its accomplishments in face of other forms of discourse.

It was at this point that Feyerabend re-read the question of induction. He does not question its importance to knowledge persecution, nor proposes a solution to the logical problem made explicit by Hume, but dismantles the idea that induction is a necessary condition to the scientific enterprise and its ongoing success. With the view to illustrate his thesis, he points to some historical examples where the employment of the inductive method was superfluous to the attainment of real scientific advances, but that a sort of counter-inductive reasoning was developed, for example, in the establishment of the astronomical theory based on the movement of Earth in the solar system. Thus, according to this perspective, instead of starting from known and accepted theories, instead of engaging in singular observations and then move on to universal propositions, what the inquirer should do is to formulate hypotheses inconsistent with the available theories and facts in order to promote a proliferation of new possibilities, of new theories. As said, Feyerabend proposes that scientific method should not be something absolute and rigid, but that it should have an anarchist spirit, and in constructing its hypothesis

it should integrate more pluralistic elements, such as metaphysical propositions or even magical beliefs. For him, the proliferation of counter-inductive hypotheses in all areas of knowledge is a very healthy methodological procedure for science since the confrontation of hypotheses and of methodological ideas sets a fruitful heuristic challenge to all the conflicting proposals. To pursue epistemic anarchism is the most consequent attitude if what is at stake is a kind of unchained scientific progress.

For Feyerabend, the progress of scientific knowledge is linked to the denial of traditional scientific methods by the scientist, that is, he proposes a new methodological form of production, communication, and evaluation of knowledge. Feyerabend further posits that the scientific progress of a theory can be obtained by inductive methodological action. The counter-induction thesis that he proposes, on the other hand, is just the practice of formulating hypotheses inconsistent with the theories and facts available:

> To see how this works, let us consider the rule that is “experience”, or “facts”, or “experimental” results that measure the success of our theories that agree between a theory and the “data” or leaves the situation unchanged, whereas disagreement compromises it and perhaps even forces us to eliminate it. This rule is an important part of all theories of confirmation and corroboration. It is the essence of empiricism. (FEYERABEND 1975, p. 433)

In short, Feyerabend’s counter-induction thesis presupposes a severe critique of the rigidity of positivist methodology. For the author, the evidence found in the history of science, as set out in chapters 2 to 11 of his work "Against Method", shows that the scientist works fundamentally in a kind of irrational activity supported solely by the acceptance of hypotheses that are adjusted, confirmed or corroborated, while the facts that are not well established or empirically confirmed are simply eliminated. For Feyerabend, these characteristics express the empiricist view of inductivism, a view of scientific activity that has to be overcome.

In line with this question, argumentative exposition is the predominant literary style of scientific language. Argumentation is developed in uncountable moments of the daily performance of scientists, especially when they have to present and defend a conclusion. To "convince" his peers, the arguments of a scientist must be persuasive; they need to present data and have justifications within its respective theoretical field. With this premise, Kuhn (1993) proposed that argumentation is one of the topics of science education that is based precisely on the way science works. It would be better to teach science by showing students how argumentation is actually constructed rather than trying to include all scientific innovations in the curricular content of the discipline – something that leads to decontextualized and disconnected explanations, especially when considering student scarce references. Thus, argumentative reasoning is a very relevant activity explore in the teaching of sciences.

Many researches on argumentation in the field of science education have been devoted to understand the main characteristics of the arguments formulated by students in subjects of this nature. The great majority of these researches seek to identify elements that characterize the structure of the arguments as described by Toulmin (2006) (JIMÉNEZ-ALEIXANDRE; DÍAZ DE BUSTAMANTE, 2003, JIMÉNEZ-ALEIXANDRE; AGRASO, 2006). This sort of analysis allows us to evaluate if students elaborate assertions constituted by the elements of the arguments layout, that is,

data, guarantees, support, and conclusion. However, to verify the presence of this layout does not show what are the characteristics of the knowledge mobilized by students in the formulation of their arguments. In a recent paper, our group showed that during the discussion of scientific and socio-scientific subjects the students involved constructed arguments following Toulmin's pattern (MANZONI-DE-ALMEIDA et al., [Manuscript submitted to publication]).

Immunology, since its consolidation as a science independent of bacteriology, has been going through important discussions about its main issue: how well are the mechanisms of recognition of entities (called antigens) that are specific to the individual (self) or are not self-self), such as microorganisms. In attempting to explain this phenomenon, various theories were proposed since the mid-twentieth century. The first, in the 1950s, was proposed by Burnet who coined the theory of clonal selection. This theory meant the synthesis coming from Darwinian natural selection theory, Ehrich's theory of autotoxicus horror and the theory of natural selection of antibodies. It was with this theory that Burnet proposed the explanation that the immune system functioned by recognizing and distinguishing what is "proper" to the organism from what is "not proper" to the organism, such as invading microorganisms. However, with the technological advances that increased experimental techniques in the field of immunology, this proposal was not sustained for long. The experimental results showed that the functioning of the immune system was not conditioned only by the discrimination of "own" and "not itself", because the immune system did not respond with aggression to a fetus during pregnancy, since half of the genetic material of the fetus was not of the mother's organism; or the breast milk proteins ingested by the individual; or coexist without developing an inflammatory response against microorganisms, such as bacteria, from the intestinal microbiota; or could they tolerate the transplantation of non-autologous organs? Based on these pieces of evidence, in the early 2000s, Polly Matzinger proposed an anti-Burnet model to explain how the immune system works. For Matzinger, what guides immune responses are not the discrimination of "self" and "not self", but the responding to danger signals emitted by the damaged tissue – the "danger model". Matzinger proposes an interesting analogy to explain her model. She asks us to associate the immune system with a city that has police (cells, immune system molecules) whose permanent function is to watch and protect the city against the entry of foreigners (antigens). In its model of danger signals, there are no "police officers", but "firemen". That is, these entities will only be recruited in case of danger. The proposal of Matzinger was well accepted by the immunology scientific community. However, it was not the only one to be configured in recent times in the field of immunology.

In view of what has been said here, we ask ourselves: can we identify the methodology of counter-induction proposed by Feyerabend in arguments written by students in immunology classes? How can philosophical and scientific knowledge be articulated in the production of hypotheses similar to counter-induction demands in argumentative scientific practice? What is the scientific and/or philosophical knowledge mobilized by the students in the elaboration of the hypothetical proposals in the contraindication on immunology? Thus, our objective is to analyze the written arguments and the knowledge mobilized by those students (and the scientific and philosophical context presupposed by them as well), in the presentation of hypotheses about a central theme of immunology.

METHODOLOGY

Our research is a case study (LÜDKE; ANDRÉ, 1988, YIN, 2005), with analysis of written material produced by groups of higher education students (graduate students) in an activity that involves the areas of biology and philosophy.

The idea of applying the didactic activity to a graduate group was guided by the objective of working the proposal of counter-inductive methodology with a group inserted in the daily doings of the scientific research in biology, including some students working already as teachers in universities.

The data collection took place during the accomplishment of teaching activities in the discipline of “special topic in teaching practices” in 2015. This discipline is offered annually, with a workload of 30 hours. The group was composed by 16 masters and doctoral degree students. All the information collected was previously authorized by the research participants, who read and signed the Informed Consent Term (TCLE). The present study was submitted, analyzed and authorized for accomplishment by the institutional ethics committee.

The activity application and data collection took five classes. In class 1 we had the presentation of the anarchist epistemological philosophy of Feyerabend. In class 2 we had the presentation and discussion of the proposal of the activity and formation of the groups of students. Classes 3 and 4 involved the student's research and preparation of the proposals of counter-induction approaching the theses of immunology, and class 5 aimed the discussion of the proposals developed by all the student groups.

ANALYSIS OF THE WRITTEN ARGUMENTS PRODUCED BY THE STUDENTS

The subject activity in "Philosophy of Immunology" was applied to students/researchers of masters and doctorates (n = 16 total students) of a postgraduate level discipline "Teaching practices" (40 h/2015), available in a postgraduate course in the major area of Biological and Medical Sciences (the subject studied is taught by a teacher with graduation level and graduate studies in Immunology). The course includes students with basic training in the areas of Biology and Health developing dissertations and theses on immunology, parasitology, pathology, and microbiology. The objective of the course is to provide students with methodological tools and resources for teaching science in higher education. Data collection was done through written texts produced by student groups (n = 6 total groups) in the "Philosophy of Immunology" activity.

The analysis of the material written by the students carried out in two stages. First stage: we thought the structures of the arguments as described by Toulmin (2006). This analysis allowed us to evaluate if the students elaborated assertions constituted by Toulmin’s elements of the layout of arguments, that is: data (part of the structure of the argument that holds the facts that are present in the argument and that together lead to the formulation of a conclusion); guarantee (part of the structure that is used to bridge the data and conclusion. It has the nature of rules and/or principles); support (part of the structure constituted by concepts or laws or theories that when used can support the guarantees given in the structure of the argument); conclusion (part of the structure that represents

the statement or proposition formulated, derived in the structure, containing data, guarantees and supports of the argument); and refutation (part of the structure that may appear in a specific situation that is used to make the conclusions formulated as invalid).

Second stage: we examined the characteristics of the kind of knowledge mobilized by the students in the formulation of the arguments. For this end, and based on the distinct nature of kinds of knowledge demonstrated and explicit in the texts produced, two main categories of analysis were used. First, considering the characteristics of the nature of knowledge about metaphysics, politics, epistemology, and aesthetics are the *knowledge of the world of philosophy*. Second, considering the sets of facts and empirical theories that explain physical, chemical and biological phenomena are the *knowledge of the world of sciences*. Other information unrelated to the worlds of knowledge quoted was labeled as "common sense". Thus, in the category of knowledge of the world of philosophy, some aspects were considered, such as the approach of philosophical theories, direct mention of thinkers, principles of philosophical concepts, and specific terms of philosophical debates. Concerning the knowledge of the world of sciences, other aspects were observed, such as the approach and mention of scientific results obtained empirically, mention of scientific theories of natural sciences, and the use of scientific terms and concepts too.

RESULTS AND DISCUSSION

The presentation of our analysis is divided into two parts. The first part exposes the presence of argumentative structures and its composition; and in the second, the results of the analysis of the proposed categories on the presence of contents of the scientific or philosophical world in the arguments.

THE STRUCTURE OF THE ARGUMENTS

The analysis of the texts produced by the students showed the presence of structured arguments in the Toulmin's pattern way (totaling 16 arguments in the texts produced by the six groups). Group 6 developed the larger number of arguments (5 arguments in the text), and Group 2 the lowest number (1 argument in the text). Groups 1, 3, 4 and 5 developed from 2 to 3 arguments per text. In the individual analysis of the structures that compose Toulmin's standard, we observed a greater total number of data in all groups (31 occurrences) and the lowest number of qualifiers (6 occurrences). For Guarantees, Support, Conclusion and Refutation sections, the total occurrences were 35, 27, 16 and 1, respectively (Table 1).

Table 1 - Analysis of the structure of the arguments constructed in the texts of the groups.

Groups	*Data*	*Warranties*	*Support*	*Conclusion*	*Qualifiers*	*Refutations*
G1	3	4	6	3	1	0
G2	9	2	2	1	1	0
G3	4	3	2	2	1	0
G4	3	5	5	3	1	0
G5	7	11	8	2	1	0

G6	5	10	4	5	1	1
Total	31	35	27	16	6	1

Interestingly, apart from the differences in the total number of arguments developed by Group 2 and Group 6, we also noticed a distinction in the presence of the number of structures that make up the argument between these two groups when compared to Groups 1, 3, 4 and 5. For example, Group 2 showed the construction of only 1 argument in the text. However, individual analysis of the argument structures has shown that this argument is built on 9 data presentations, 2 Warranties, 2 Supports, and 1 conclusion. Otherwise, Group 6, which showed the construction of a greater number of arguments, presented differences when compared to Group 2 in the use of the argumentation structures. The arguments of Group 6 are constituted by the occurrence of 5 Data presentations, 10 occurrences of Guarantees, 4 Supports, 5 Conclusions and 1 Qualifier (Table 1).

Group 2 chose the IV approach that agrees with all the theories presented. Group 6 has chosen the V approach, which agrees with just more than one theory. Despite this difference in the option chose to construct the hypothesis, both groups started from the same idea, which was the theory of clonal selection of Burnet (1959), to begin the construction of the counter-inductive hypotheses.

Group 2 has built a strong argument in the counter-inductive hypothesis, based on the decision that all theories of the immune system grounded on Burnet's clonal selection theory are true, and that they have only undergone changes and additions to the data along the historical, social and political course of the development of Immunology, as we can see in this section:

> We can verify that the various theories about the functioning of the immune system are compatible with the reality of the epoch in which they were developed, evidencing the social, scientific and historical context of each period. It is interesting to confirm that these theories are not mutually exclusive, but complement each other according to the technological and scientific advance, mainly political at the time (Group 2. Paragraph 13, line 61-65).

Following this path, Group 2 constructed its inductive hypothesis by explaining the functioning of the immune system based on empirical data obtained by immunology scientists to formulate other ideas about how the immune system works. Group 2 chose to write a text to explain and defend the functioning of the immune system guided by the whole set of theories formulated and available in the activity. For this group, explanations of the functioning of the immune system can be synthesized in the meeting of the various principles of the various theories formulated throughout the history of the field of immunology. In the development of its ideas, the group constructed a single great argument throughout the text.

Unlike Group 2, for Group 6 the functioning of the immune system is properly apprehended by the overarching ideas of Burnet's clonal selection theory, with some additions of other ideas, such as Jerner's recognition of "own", "no-self" and cellular interaction, as we can see in the following section:

> The authors of the present study agree on the primordial models for defining the functioning of the immune system, from the perspective of cellular interaction, the concept of own and non-self, clonal selection theory and the importance of cytokine production (Group 6. Paragraph 6, lines 66-69).

Both groups 2 and 6 started from the same idea and constructed hypotheses in their texts using different numbers of argumentative structures, but arriving at the same conclusion about the functioning of the immune system. However, what were the nature of the contents mobilized by the groups of students to construct different arguments with the same theoretical basis?

THE CONTENT OF THE ARGUMENTS

We analyzed the presence of specific contents mobilized in the arguments written by the groups of students according to two categories: (i) knowledge of the philosophical world, and (ii) knowledge of the scientific world. The analysis showed that these groups used the knowledge of the world of philosophy in writing, more often in the Guarantee and Qualifier parts of the argument when compared to the other parts of the argument structure (Table 2). Concerning the second category, the knowledge from the world of science, our analysis showed that the groups approached scientific knowledge, linked to experimental immunology, more in the Data part when compared to the other parts of the argument structure. We did not detect the presence of excerpts that could be classified as a common sense approach in the texts produced by the groups of students (Table 3).

Table 2 - Analysis of the presence of knowledge from the world of Philosophy in the arguments.

Groups	*Data*	*Warranties*	*Support*	*Conclusion*	*Qualifiers*	*Refutations*
G1	0	1	1	0	1	0
G2	2	2	2	3	1	0
G3	0	1	0	0	1	0
G4	0	0	0	0	1	0
G5	0	1	0	0	1	0
G6	2	1	1	1	1	0
Total	4	6	4	4	6	0

Table 3 - Analysis of the presence of scientific knowledge in the arguments.

Groups	*Data*	*Warranties*	*Support*	*Conclusion*	*Qualifiers*	*Refutations*
G1	4	2	0	0	0	0
G2	8	1	1	0	0	0
G3	2	3	0	0	0	0
G4	5	1	1	0	0	0
G5	2	1	0	0	0	0
G6	3	5	3	0	0	0
Total	24	13	5	0	0	0

In relation to counter-induction thesis and the criticism of science teaching, we noticed in our results that there were no instances of the refutation component in the structure of the arguments. However, we cannot conclude that the absence of refutation in the argumentative structures examined is a consequence of the epistemic operation of authority (JIMÉNEZ-ALEIXANDRE; BUGALLO RODRÍGUEZ; DUSCHL, 2000) accepted by the students or the researchers when encountering literature data in scientific articles well established. To resort to authority is a common and necessary practice in scientific activity, and that could lead to the uncritical acceptance of data thus nullifying the component of refutability in the

argumentative structure. In order to explain this question, one can take Feyerabend's own counter-induction thesis as a clear intention to compose a large block of refutation strategy. Thus, in proposing a counter-inductive hypothesis, the students are already constructing a refutation of the current theory and demonstrating a critical evaluation of the use of the argumentative structures different from what happens when argumentations are mechanized. The act of constructing a counter-inductive hypothesis enables the exercise of the critical refutation of a theory by itself.

CONCLUSION

The results showed that the groups of students that participated the teaching practice exercise proposed to construct arguments with hypotheses similar to Feyerabendian counter-induction, hypothesis filled with scientific knowledge (from the field of immunology for the most part) and intermingled with philosophical knowledge, and that these hypothetical proposals are dependent not only of the linguistic aspects and structures of logic argumentation. These arguments received support by knowledge obtained from the scientific world and of the philosophical world as well. However, the paths chosen by the student's groups to construct the arguments behind their formulation of hypotheses were significantly different. These differences appeared in the structure and constitution of both the scientific and philosophical knowledge mobilized in the texts.

Um estudo de caso no ensino de imunologia: argumentos escritos e o método contra-indutivo de Paul Feyerabend

RESUMO

Neste estudo, iniciado durante as aulas de imunologia em um curso de Pós-Graduação, analisamos textos argumentativos escritos por estudantes cuja produção foi guiada pela abordagem contra indutiva do conhecimento proposta por Paul Feyerabend em seu livro "Contra o método" (1975). Foi aplicada uma atividade didática sobre um tema de Imunologia abordando alguns aspectos da filosofia da ciência no ensino superior, em particular a filosofia da biologia. Os textos escritos pelos alunos evidenciaram a presença de estruturas argumentativas claramente identificáveis e também a presença de conteúdos relacionados aos contextos científico e filosófico.

PALAVRAS-CHAVE: Argumentação. Ensino de ciências. Imunologia. Método contra-indutivo. Paul Feyerabend.

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REFERENCES

BURNET M. Auto-immune disease: I. Modern immunological concepts. **British Medical Journal,** v. 2, n. 5153, Oct. 1959.

EL-HANI, C. N.; TAVARES, E. J. M.; ROCHA, P. L. B. Concepções epistemológicas de estudantes de Biologia e sua transformação por uma proposta explícita de ensino sobre História e Filosofia das Ciências**. Investigações em Ensino de Ciências**, v. 9, n.3, 2004.

FEYERABEND, P. Contra o método. Rio de Janeiro: **Livraria Francisco Alves Editora**, 1975.

GIL PÉREZ, D.; MONTORO, I. F.; ALÍS, J. C.; CACHAPUZ, A.; PRAIA, J. Para uma imagem não deformada do trabalho científico. **Ciência&Educação**, v. 7, n.2, 2001.

JIMÉNEZ-ALEIXANDRE, M. P.; BUGALLO RODRÍGUEZ, A.; DUSCHL, R. A. "Doing the Lesson" or "Doing Science": Argument in High School Genetics. **Science Education**, v. 84, n. 6, 2000.

JIMÉNEZ-ALEIXANDRE, M. P.; DÍAZ DE BUSTAMANTE, J.; Discurso de aula y argumentaciónenlaclase de ciencias: cuestiones teóricas y metodológicas. **Enseñanza de las ciências**, v. 21, n. 3, 2003.

JIMÉNEZ-ALEIXANDRE, M. P.; FREDERICO-AGRASO, M. A argumentação sobre questões sociocientíficas: processos de construção e justificação do conhecimento em sala de aula. **EducaçãoemRevista**, n. 43, 2006.

KUHN, D. Science Argumentation: implications for teaching and learning scientific thinking. **Science Education**, v. 7 n. 3, 1993.

LÜDKE, M.; ANDRÉ, M. E. D. Pesquisa em educação: abordagens qualitativas. São Paulo: **EPU**, 1988.

Yin, R.K. Estudo de caso: planejamento e métodos. 3. ed. Porto Alegre: **Bookman**, 2005.

MANZONI-DE-ALMEIDA, D.; PEREIRA, R. G.; TRIVELATO, S. L. F. Um estudo de caso sobre a formulação de argumentos por estudantes do ensino médio nas aulas de biologia envolvendo temas científicos e sócio científicos (Manuscrito submetido).

TOULMIN, S. E. Os usos do argumento. São Paulo: **Martins Fontes**, 2a ed, 2006.

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