Interanimation of voices and argumentative strategies in collaborative knowledge building of Physics teachers in an asynchronous discussion group

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Abstract: This study investigates social construction of professional knowledge among secondary school Physics teachers in a discussion forum in the context of an on-line course offered via the InterAge® constructivist virtual environment. The participants were asked to propose solutions to a problem related to the teaching of Heat and Temperature based on on-line discussion and the reading of research papers. An analysis of the discourse, based on Bakhtin's criteria for characterizing utterances, identified the movements of appropriation of meaning of the proposed solutions and of the readings. The analysis of the argumentative strategies involved the identification of the arguments according to Perelman and Olbrechts-Tyteca's theory and the comprehension of their roles in the discussion. An intense dynamic of appropriation of the problem and of collaborative construction of solution proposals was observed. The teachers' appropriation of ideas from the research papers was expressed through hybrid utterances mediated by their practice or expressed a radical change. Argumentative analysis helped to identify the use of real cases and of ideas extracted from the papers, generating arguments of illustration and of authority. Therefore, the argumentative strategies were used by them to reinforce the collective construction of knowledge more than to increase the adhesion of participants. Implications of using discourse and argumentative analysis are proposed aiming to improve the implementation of CSCL in the context of in-service teachers' training courses.

Keywords: social construction of knowledge, argumentation, on-line forum, Physics teaching, discourse analysis.

Introduction

This study investigates the social construction of professional knowledge of secondary school Physics teachers in a discussion forum in the context of a course offered via the InterAge constructivist virtual environment (Rezende et al., 2003). This environment was designed to disrupt the conventional model of knowledge transmission and to engage teachers in the discussion of realistic problems of instructional practice, as proposed in the Problem-based Learning methodology (Barrows and Tamblyn, 1980). Results of a research (Rezende et al., 2004) which investigated the practice of a sample of Physics teachers from publicly-funded schools of Rio de

Janeiro were used to give authenticity (Savery and Duffy, 1995; Jonassen, 1998) to the problems presented in InterAge. The narratives in which the problems are represented sought to reliably reproduce the context in which the teacher situated them. One of the main aspects emphasized in constructivist learning environments is the fact that knowledge construction is a social process. According to Vygotsky (1984), human psychology is characterized by the fact that cognitive development takes place through the "internalization of the socially rooted and historically built activities" (p. 64). Human learning presupposes a specific social nature, given that "every superior intellectual function originates from the relations between human individuals" (p. 64). Vygotsky's view of cognitive development as a process of transformation of an interpersonal process into an intra-personal one opens the way for the role of collaboration in the learning process.

Together with the notion of Collaborative Learning, the InterAge virtual environment is based on the model of professional knowledge development for science teachers (Porlán and Rivero, 1998) which describes it as a reflexive and critical process directed at professional action which occurs through the construction of alternatives to respond to the real problems of the school context. Professional knowledge development is based on the teacher's questioning of his/her own practice, which, via confrontation and integration with academic knowledge, allows the preparation of a curricular design that responds effectively to the problem and helps to consolidate the new theoretical-practical knowledge. The InterAge design allows the implementation of this model, as the teacher solves educational problems by proposing the planning of classes based on on-line discussion of the problem and of related research papers with tutors and other teachers. The discursive interactions between teachers, tutors and the texts and the possibility of a collaborative construction of knowledge in the discussion forums thus become fundamental and promote the development of teachers' professional knowledge.

Studies of the collaborative construction of knowledge have been conducted as part of a research field known as Computer Supported Collaborative Learning (CSCL), which emphasizes the use of technology as a mediation tool (Koschman, 1996) and brings social questions to the foreground as a phenomenon to be studied (Hutchins, apud Koschman, 1996). This dislocation stresses the social and cultural context as an object to be studied and represents a significant change in the theory and practice vis-à-vis previous paradigms of the use of technology in education. Some studies have tried to model the collaborative construction of knowledge (Stahl, 2000) and have analyzed the interactions within the micro and macro levels using both graphic and quantitative or qualitative instruments (Mckenzie and Murphy, 2000; Lally, 2001; Hmelo-Silver, 2003; Murphy, 2004; Schrire, 2006; Puntambekar, 2006). Research on CSCL in the context of science education has focused on primary and high school education (Veermans and Cesareni, 2005; Kapur et al., 2008; So et al., 2009; Lazakidou and Retalis, 2010) and on pre-service teachers training courses (Rezende and Ostermann, 2006; Rezende and Queiroz, 2009).

Argumentation has been largely explored in science education research. In the context of on-line education, researchers investigate the contribution of computer-supported collaborative argumentation software for the purposes

of scaffolding student's scientific arguments, improving argumentation skills and problems solving competencies or developing the social construction of knowledge (Cho and Jonassen, 2002; Bell and Linn, 2005; Veerman and Veldhuis-Diermanse, 2006; Clark and Sampson, 2007; Clark et al., 2008; and Sampson and Clark, 2009).

The present study aims to broaden our understanding of the process of the social construction of knowledge in discussion forums taking Bakhtin's philosophy of language as a framework that permits the analysis not only of the contents involved in the interactions but also of its dialogism and appropriation of voices and social languages. The analysis of the discourse will be used to examine how the voices of tutors, teachers and research papers interanimate in the discussion forum and how the enunciative strategies such as argumentative schemes are used. To integrate these aspects of the collaborative construction of knowledge the model proposed by Stahl (2000) is used as a background.

Collaborative knowledge building, discourse and argumentation

Collaborative knowledge building

The social construction of knowledge occurs, according to Stahl (2000), when an individual's personal beliefs are articulated into words, and when these statements are considered in a social context and discussed through the perspective of many participants. The original statements are, in this way, articulated inside an extensive and refined discussion subject to conflicting interpretations. The discussion consists of arguments that provide rational bases for different points of view. The exchange can converge into a shared comprehension that is a result of a clarification of differences in the interpretations and terminologies. If the negotiation of different perspectives in fact results in the acceptance of a common result, then this result is accepted as knowledge. What is new about Stahl's formulations is that this process is not considered as a merely cognitive process, but as a social process as well, in that the internal structures of these thinking processes originate in social interactions.

Interanimation of voices in collaborative knowledge building

By considering on-line interactions as social phenomena which fundamentally constitute language (Bakhtin, 2004) we can break down the separation between the social construction of knowledge and individual cognitive processes and understand them dialectically, as two sides of the same coin. This assumption reflects the complexity of the social construction of knowledge, assembling processes that Stahl's model took to be artificially separate.

For Bakhtin (2003), the use of language takes place "in the shape of oral and written, concrete and unique utterances made by the members of this or that field of human activity" (p. 261). As the utterance is the true unit of verbal communication, speech is always moulded in the shape of an utterance that belongs to a specific speaking subject, and cannot exist otherwise. The notion of voice, for Bakhtin, is applied to both oral and written communication and includes wider consideration of the speaker's perspective, his conceptual horizon, his intention and his world view

(Wertsch, 1993). Voices always exist in a social environment; there is no voice that is completely isolated from the others. The voice is inherently connected to the utterance, for it is the voice that produces the utterance. Therefore, there is no utterance without reflecting a point of view.

The interchange of utterances acquires different shapes in the different spheres and activities of social life, depending on the functions of the language and of the conditions and situations of communication. The choice of a discursive genre is determined by the specific nature of a certain sphere of verbal communication, by thematic considerations, by the concrete situation of verbal communication and by personal composition (Bakhtin, 2003). Thus, in the case of the speaker, every utterance produced inside a discursive genre is characterized, above all, by a semantic content of reference. The second element of the utterance is its expressive aspect, i.e., the speaker's subjective and emotional relationship with the content and the meaning of his utterance. Wertsch (1993) matches the expressive aspect of the utterance to the perspective of the speaker on its content. Regarding the other participants of the verbal communication, the dialogism of the utterance performs the main role. For Bakhtin (2003), "utterances are not indifferent between themselves, and they are not enough for themselves; they meet each other and are mutually reflected in each other" (p. 297).

This interanimation of voices can occur in many ways: through the repetition of the utterance of the other, through the reference to the utterance of the other, presupposition in silence, or the expression of some reaction. The notion of comprehension, for Bakhtin (2003), is intimately related to the relation between utterances: "the listener, when noticing and comprehending the (linguistic) utterance of the discourse, simultaneously occupies an active responsive position towards it: he either agrees or disagrees with it (total or partially), completes it, applies it, prepares himself to use it, etc." (p. 271), expressing, thus, his counter-word to the other's discourse.

The concept of social language permits us to relate the discursive genres which attend the specific discursive situations to the social horizons of the speakers. For Bakhtin, a social language is "a personal discourse of one specific layer of the society (according to profession, age, etc.) in one given social system and one specific moment" (Holquist and Ermerson, apud Wertsch, 1993, p. 77). A speaker always appeals to a social language to produce an utterance, being this, therefore, conformed by this language. In contrast to social languages, whose distinctive characteristic is the social layer of the speakers, discursive genres are typical forms of utterances used in specific social circumstances.

The process of elaborating utterances from social languages was termed "ventriloquism" by Bakhtin, in allusion to the act of talking through another voice. This suggests that we cannot choose our words in a neutral and impersonal language, but take them from concrete contexts lived by other people. When the speaker marks the other's word with his own intention and semantics, he makes it his own property, in a movement of appropriation.

When the speaker avoids conceiving one single discursive genre as more appropriate or effective than the others in a specific sociocultural scenario and builds a new language through the mixing of different voices, he creates a hybrid discourse, i.e., 'a mixture of two social languages inside the limits of a sole utterance, an encounter in the arena of one utterance, between two linguistic consciences that have been separated from the other at one time, by social differentiation or by any other factor" (Bakhtin 1981, p. 358).

Argumentative strategies in collaborative knowledge building

From the Bakhtinian perspective, arguments can be seen as enunciative strategies that take different forms depending on the demands of the context. Stahl's theoretical proposal of Collaborative Knowledge Building does not describe the argumentative process that is imbedded in the negotiation of perspectives, although it seems clear that argumentation is crucial to attain shared understanding. In the present study we assume that Perelman and Olbrechts-Tyteca's (2005) theory can be used to broaden our understanding of collaborative knowledge building as the authors conceive argumentation as a process which is always rational, verbal, and which emerges when an individual wants to persuade another (the audience) of some ideas or opinions presented either in his discourse or in a collaborative social process to solve problems.

The theoretical perspective of Perelman and Olbrechts-Tyteca (2005) considers both argumentation and rhetoric. Notions such as justifications, reasoning and argumentation (in the meaning of a discussion with confrontation) all come under argumentation. The idea is that the affirmations we make while arguing have to be judged as reasonable by those to whom the affirmations and their supports are presented. This characteristic is very important to our approach because we are working in a non-formal context, not one in which the participants will use formal logic arguments, but one in which the argumentation and reasoning are close to common argumentations and reasoning, such as the ones referred to in Perelman and Tyteca's theory.

Perelman and Olbrechts-Tyteca's (2005) theory recalls Bakhtin's notion of dialogism when the author states that "every discourse is directed to an auditorium" (p. 7). Although the authors recognize that there are argumentative structures that can be found in every discursive genre, they admit that the argumentation will present different characteristics in different auditoriums, just as it will reach different levels of engagement. For such, "if its aim is always effective action on the spirits, to judge its value we have to consider the quality of the spirits it will be able to convince" (p. 8). The authors also recognize that beliefs, internal and external experiences are more effective structures than arguments to act on the spirits, but when these proofs are disputed or when there is no agreement on their interpretation, then argumentation cannot be avoided.

Perelman and Olbrechts-Tyteca's theory consists mainly of three related essential aspects of argumentation and its impact on the audience: premises, argumentative structures, and theses. An argument consists of one or several premises, a thesis and an argumentative scheme. The theses

or conclusions are statements about which the speaker aims to convince the audience (himself/herself or others) by means of argumentations that these statements are valid. In our case, the statements result from the discussions and can become shared knowledge or public statements. The premises are the data and the agreements on which the argumentation is built. According to Perelman and Olbrechts-Tyteca (1969), the process of argumentation is always dynamic. Some premises are not accepted by others and therefore become theses that have to be argued. In addition, theses that are accepted in a part of the discourse will be premises in subsequent sections of this argumentative discourse.

The argumentative techniques include 'schemes' of isolated arguments, which are discursive structures that allow the transfer of agreement from premises to theses. Argumentative schemes are grouped into two main categories: schemes 'by association' or 'of liaison', which join elements in a new structure; and schemes 'by dissociation', or separation, which separate elements that are considered to be related or part of a whole, thus changing systems and notions. Many other subcategories can be identified inside these broad categories. There is always interaction between the arguments. Several kinds of interaction are possible. The order and kind of interactions are related to the persuasive force of the discourse.

Among the association argumentative schemes, Perelman and Olbrechts-Tyteca (2005) examine three types: the quasi-logical arguments, arguments that are based on the structure of reality and arguments that establish this structure. Quasi-logical arguments are those considered rational because they are assimilated to patterns of formal reasoning (in logics or mathematics). However, a quasilogical argument differs from formal deduction in that it always presupposes adherence to non-formal theses which alone allow the application of the argument.

Arguments that are based on claims concerning the structure of reality depend on liaisons which exist between the elements of reality. As soon as elements of reality are associated with each other in a recognized liaison, it is possible to use it as the basis for an argumentation which allows us to pass from what is accepted to what we wish to be accepted. Most arguments that are based on reality appeal to liaisons of succession, such as cause to effect, or liaisons of coexistence, such as the relation between the person and his acts. What is important is the existence of agreements which are not questioned and which the speaker uses to develop his argumentation.

Arguments which establish the structure of reality are those which, starting from specific known cases (a precedent, examples, illustration, and models) all of which imply and allegedly represent the operation of overriding rules or laws or principles. Inside the arguments which establish the structure of reality there are also types of arguments (by analogy or by metaphor), which serve to structure an unknown reality or clarification of an idea, and sometimes to take a position in regard to it.

Methods

Research questions

The present study investigates the social construction of professional knowledge of a group of Physics teachers through on-line interactions during an in-service training course. The research was guided by the following questions: (i) how are meanings related to the problem and to the research papers studied in the course socially built during the forum? (ii) how do the argumentation strategies participate in the process of construction of meanings?

The Context

The context of the present study is an on-line course for nineteen Physics teachers from different states in Brazil, offered via the InterAge constructivist virtual environment. During a ten week period, the participants were asked to propose a solution to a problem (Table 1) in which a Physics teacher, in a traditional lecture, did not succeed in helping his students to construct the concepts of heat and temperature.

Carlos is a Physics teacher from a publicly-funded school in a midland district from Rio de Janeiro. This school has a library, a video room, a computer laboratory and a Physics laboratory with experimental materials. Class 111 (second year of high school), which is heterogeneous and participative, is one of the four classes that Carlos teaches. Carlos has given three lectures on Heat and Temperature, using the board and the textbook as resources, following the book and doing exercises. During the classes, the subject was written on the board and traditional problems were solved as examples, while the students copied in silence. In the fourth class, he asked questions about the concepts involved in the problems, and the students were unable to answer. The bell rings, and Carlos leaves the classroom wondering about the traditional method he had been using and the fact that the students could not answer his questions. How could he help his students to learn the Physics concepts?

Table 1.- Problem presented in the discussion forum.

Our object of investigation is a corpus of 35 messages sent to the forum by nine teachers who discussed the problem proposed and research papers on Science Education [text 1 (Ricardo, 2003), text 2 (Ricardo and Zylbersztajn, 2002), text 3 (Aguiar, 2002), text 4 (Rezende, 2000), text 5 (Aguiar and Filocre, 2002) and text 6 (Alves and Bertolini, 2003] with the help of two tutors (Tutor 1 and Tutor 2). The participation of Tutor 1 was interrupted in the beginning of the course for reasons not related to the study.

Analysis procedures

The analysis of the social construction of professional knowledge includes the frequencies of the messages and utterances to give an overview of the forum, but it is founded, essentially, on the analysis of the participants' discourse in order to comprehend how the voices of the tutors, of the

teachers and of the research papers' authors come into contact with each other. To this end, inside every message sent to the forum, the utterances were identified according to Bakhtin's criteria, in particular the ones concerning the semantic content, the relation of the speaker with the utterance and the relation of the speaker with the utterances of the others (dialogism). The research papers were circumstantially consulted in order to determine how closely the contents of the utterances corresponded with the authors' voices. To make the analysis easier, the period in which the discussion forum was open was divided into three stages of three weeks.

The analysis of the argumentative process involved the identification of arguments used by the participants and the identification of theses, premises and argumentative schemes in accordance with Perelman and Olbrechts-Tyteca's (2005) argumentation theory. The argumentative schemes were analyzed based on categories which derived from this theory and which were already used in a previous study (Castells et al., 2007) of the argumentation within dialogues between students solving Physics problems.

Results: analysis of the collaborative construction of knowledge

The discursive movements of the construction of meanings and argumentative processes are understood as parts of the social construction of the professional knowledge of teachers within the forum, although they are analyzed and presented separately. Therefore, in each section, we present a discourse analysis of the three stages of the forum and the utterances that we have judged to be most relevant to discussing the questions of the study.

Movements of discursive appropriation

According to the criteria used to distinguish the utterances, the messages sent to the forum unfold in more than one utterance. The frequency of utterances increases as the forum develops, indicating that the interaction between participants also increases. The frequency of the utterances referring to the research papers increases along the forum showing that the interanimation of the participants' voices with the papers' authors increases as the forum develops.

The following sections describe the process of the teachers' appropriation of the research papers in the three stages, with regard to the meaning of the problem and the proposed solutions.

First stage: the invitation to participate

In the three first weeks of the course, just one teacher sent a message to the discussion forum. Except for teacher A, who asked Tutor 2 for guidance on the task to be put into practice at the end of the course, only Tutor 1 participated. His utterances contained some movements for appropriating meanings inside the problem. Trying to make it clear, Tutor 1 directs a question to all participants about the suitability of the macroscopic and microscopic approaches to Heat and Temperature at high school level, which reformulates the problem and makes it much more specific than the one reported in the initial narrative (See Table 1).

The interventions by Tutor 1 and the absence of teacher participation characterize this stage as an invitation to the discussion of the problem.

Second stage: the discursive interaction starts

In this stage, discursive interaction is established between Tutor 2 and nine teachers who share their reflections on professional practice, gradually introducing appropriations of the texts 1 and 2 in their comments. The search for a solution of the problem presented is also observed. Tutor 2 intervenes to clarify doubts and to help to solve the problem and the teachers then start to propose solutions; many different meanings are now being attributed to the initial problem.

(i) Appropriation of the problem and of the proposed solutions

Initially, teacher B expresses some doubts about the problem and shares her interpretation with the others.

Teacher B: "[...] I don't know if I got it right. I read the situation in which the teacher, by the use of 'the board and chalk' method, notices that his students have not learned the material".

Tutor 2 answers teacher B, agreeing with her interpretation and adding details about how the problem was elaborated. Next, with the intention of starting to solve the problem, teacher B describes and evaluates her own teaching practice, highlighting what she usually does and what she should do. The other teachers also begin to propose solutions, and initiate a sequence of reformulations of the problem, thus showing different appropriations of what they consider important within the situation and what should be solved. For instance, teacher C identifies with the problem and presents his experience of contextualization of the concepts of Heat and Temperature as a possible solution, which reverberates among the group.

Teacher C: [...] "This situation has already happened to me. This is what I did: in the following class, I took the students to the cafeteria and showed them what they have always observed at home concerning Heat and Temperature, showing a pot over the flame of a stove. That worked quite well, and aroused the students' interest".

Tutor 2 comments on teacher C's message, who had interpreted the problem in terms of a lack of contextualization of Physics and completes this point of view with a new reformulation of the problem concerning the relation between the context and the concepts of the laws of Physics themselves, combined with micro and macroscopic aspects.

Teacher D evaluates the situation forwarded by teacher C and widens his proposal, identifying it with the National Curricular Parameters, with the intention of continuing the discussion of the solution. Next, he proposes a way to solve the problem which was reformulated by Tutor 2.

Teacher E also reformulates the problem-situation according to his own practice and asks why students are usually passive during Physics classes and asks if this situation is also experienced by the others.

Teacher F also reformulates the problem by drawing the attention of the teachers to the difficulty of using computers for teaching. She identifies herself with this issue, and proposes a way of solving it that seems to be

based on her tacit knowledge of teaching Physics, shared with the teachers' community.

Teacher D discusses the problem stated by Teacher E through his political-ideological vision and also reformulates the problem, as he highlights not only the poor preparation of the teachers, but also the lack of teaching material and equipment in Brazilian schools, in a 'typical' language among the teachers community.

Teacher D: "So there is the dilemma: many have access to information and yet they do not want it; some want it and cannot have it. So, as we already stated: there is a lack of school material (computers, etc.) and the teachers do not receive adequate training".

Teacher G agrees with Teacher F on the need to bear in mind the micro and macroscopic aspects when teaching the concepts of Heat and Temperature and at the same time introduces his worries about the alternative conceptions of the students that make these two approaches confusing. This is the first reference to the students' difficulties due to their alternative conceptions, which adds a new meaning to the initial problem.

Teacher B agrees with Teachers F and G and endorses the solution proposed. She generalizes the solution suggested by Teacher C and proposes a solution for the teachers' lack of experience with computers.

Teacher H, agreeing with Teacher F's idea of initiating the classes by considering the macroscopic vision of Heat and Temperature, proposes conducting simple experiments inside the classroom (which he compares to Teacher C's idea of taking the students to the cafeteria), in order to discuss the concepts involved in the phenomena, and only then to present the microscopic vision.

Figure 1 summarizes the main discursive movements for appropriating the meaning of the problem in this stage of the forum. The interanimation of voices is noticeable as, most of the times, a later intervention enters into a dialogue with an earlier one. This discursive movement works as a basis for a collaborative construction of a solution to the problem that emerges in the last statements, by Teacher B and H, which are based on ideas from more than one teacher.

(ii) Appropriation of the research papers

At the beginning of this stage, the reading of the texts is mentioned, for example, when Teacher B intervenes to thank Tutor 2 for the help, or when Teacher H explains his delay in participating in the forum because he preferred to read some of the recommended texts before accessing it. By the end, Teacher H describes how he relates the contents of text 1 with his own practice by means of a hybrid utterance, in which he shows the appropriation of the text content by the use of the expression 'teaching contract', although he does not discuss the concept in more depth.

Teacher H: "Reading text 1, I was pleased to see some points that I have been thinking about, because it approaches the situation of being in a classroom and having to establish a teaching contract with your students".

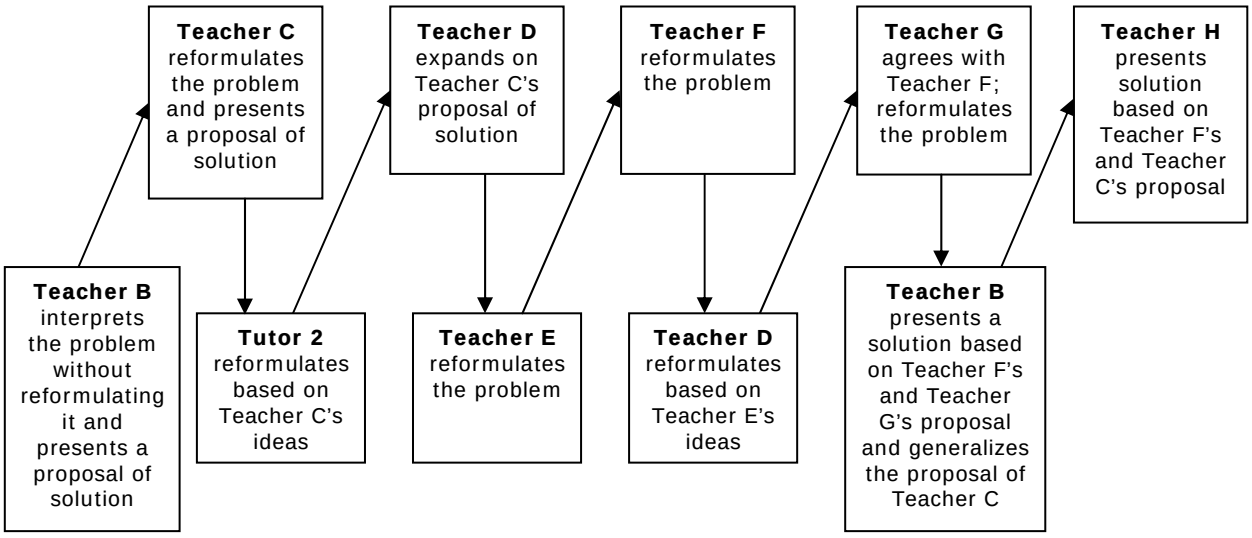

Figure 1.- Appropriation of the meaning of the problem and of the proposals.

The texts are again mentioned when Teacher E makes a comment directed at all the participants in which he relates the content of text 2 to his own practice, without demonstrating any specific appropriation of paragraphs or words, but showing how his professional experience between the years of 1998 and 1999, the period when the National Curricular Parameters were introduced, reflected the content of the text. He reports his feeling of alarm when he realized that his practice was no longer useful. By this reading, then, he re-evaluates the practice he applied at that time by considering it, now, as something to be overcome; thus, his statements demonstrate a change of view influenced by the text.

Teacher E: "[...] Reading the text has made me feel s if I was in front of a mirror, staring at my reflection in the years of 1998 and 1999. [...] Today I see that this is normal and positive. When you have a challenge, stimulation, you overcome that lack of variety and become able to surpass yourself. The effort is compensated by the results you are now able to achieve".

In a later message to all participants, Teacher H combines the fragment from text 1 on the relations of the students' knowledge and a reflection about his practice. This comment shows a general appropriation of text 1, although Teacher H does not agree with all of it.

Third stage: the deepening of the discussion

In this stage, the interactions are concentrated between four teachers and Tutor 2 and the discussion moves on to a deeper level. Though the meaning of the problem still suffers some transformations, the participants concentrate mainly on the reflection about the practice that comes from the reading of the research papers. The analysis of their utterances shows appropriations of fragments of the texts, a hybridism that mixes up the voices of the texts with the voices of the teachers and a degree of ventriloquism as well. The group preferred to discuss many solutions for the problem than developing a single solution in more depth.

(i) Appropriation of the problem and of the proposed solutions

In the first intervention in this stage, Tutor 2 starts by summarizing the comments and proposed solutions presented so far, and, in order to continue the discussion, Tutor 2 highlights other aspects that might be involved with the problem, which once again may lead to a reformulation of the initial problem.

Tutor 2: "In order to turn even more complex this class-planning activity that tries to solve this pedagogical problem, I will add more aspects that I consider important: the need to bear in mind qualitative Physics, conceptual Physics and also the epistemological aspect of the Physics that we are teaching! What do you think about that?"

The participants do not respond to Tutor 2's question, which seems to indicate that it has not motivated them to answer, either due to a lack of 'counter-words' involved in the comprehension or a lack of interest in reformulating the problem. Teacher B then raises another problem when questioning the applicability of the ideas from text 3 to real classes, especially when related to the time needed to develop the strategy proposed by the author.

Teacher B: "[...] When the student is part of the construction, doesn't the class become too long? This is my doubt. When there is a 'discussion', we have to be careful not to go off the subject. The classes are big and different shapes of 'understanding' of one subject may appear. Developing reflection on the part of the students takes a long time, even with careful pre-planning".

Teacher B's point is answered by Teacher D, who tries to solve the (new) problem about the difficulty of implementing discussions inside the classroom, arguing that there will have to be an agreement with the institution about the time to be dedicated to this activity. Also in answer to Teacher B, Tutor 2 directs a comment to all participants which highlights the dialogical attitude of a teacher inside the classroom and agrees with Teacher D's comment. This is followed by several interventions by the Tutor trying to guide the problem solution.

Despite Tutor 2's attempts to reformulate the problem at the beginning of this stage, the participants' silence has shown that the group has preferred not to appropriate her suggestion. Therefore, new meanings of the problem are generated only by Teacher B's statement, which is answered by Teacher D.

(ii) Appropriation of the research papers

The utterances of the teachers in this stage of the forum show that they incorporated the contents of research papers in their voices, increasing the development of a professional knowledge that involves the constructivist perspective on the teaching and learning of science.

Initially, Teacher B's utterance reflects the ideas from text 1 and expresses its positive concept of the student as a re-builder of knowledge within a very personal interpretation of the text. The continuation of her statement shows the appropriation of another aspect of text 1, related to learning and to contextualization. She extracts from the text whatever is

reflected in her practice, which seems to be the use of alternative material. When she talks about the process of building knowledge itself, she shows an appropriation of the concept of the construction of students' knowledge, mixing the contents of text 4 and her own words.

Teacher D's statement below tries to solve a difficulty that was brought up by Teacher B, adding a new idea extracted from text 5. The way he expresses it, without any justification or personal elaboration, characterizes ventriloquism.

Teacher D: "As mediators, I sense that we can control this discussion, despite the fact that we can only expect a result and not always determine it, as text 5 says: 'We understand the teaching model as a theoretic basis that supports the formulation of teaching propositions which are relevant to learning, that is, teaching interventions that favour learning for they are organized according to their premises'".

From the reading of text 4, Teacher G discusses the use of technology in practice that shows a comprehension of the text as he summarizes its fundamental meaning. For him, technology complements the pedagogical orientation of the practice. He mixes this fundamental meaning with his practice, using terms that are characteristic of the teachers' discursive genre.

Further, Teacher B's hybrid utterance shows an appropriation of a summary of text 6, when she extrapolates the idea that students would rather learn by experimenting to the generalization that practice therefore becomes an important method for learning.

In the last message sent to the forum, Teacher F gives evidence of the appropriation of ideas from the texts that were read throughout the course (without mentioning a particular text) and of the evolution that the teachers have experienced during the discussion.

Argumentative processes

There was hardly any argumentation in the first stage of the forum, but the argumentative process increased during the next stages. The following sections present the main arguments used by the teachers in each of the three stages of the forum, highlighting premises, their theses, and the types of argumentative schemes used.

First stage

In the first stage of the forum, already characterized as an invitation to the discussion, no arguments were found.

Second stage

In the second stage of the forum, the teachers start to express themselves by using arguments. Even when arguments are based on the authority of the research texts, they are mediated by practice and by personal conceptions or by the conceptions of the teachers' community.

Teacher B begins by affirming that she uses experiments and does not use the computer because she does not know how to use it very well. We can identify two theses in her argument: one says that experiments tend to

favour students' interest and learning and another which states that it is not valid for a teacher to use a computer when he/she does not know how to use it properly. We can identify two argumentative schemes: one 'argument by illustration' of a particular case (the use of experiments increases the students' interest) and another 'pragmatic argument', which can be classified within the causation arguments, which consists in accepting or rejecting a possible action due to its favourable or unfavourable consequences (it is not a good idea to use computers if you do not know how to use them properly).

Teacher B: "In my classes about Heat and Temperature, I try to differentiate these two definitions. I use accessible practice material I can, such as: thermometers, hot-cold situations, molecule agitations until the body becomes incandescent and so on. I do not use the computer because I am still learning how to use it myself [...]".

Next, Teacher C agrees with Teacher B, describing his successful experience when taking his students to the cafeteria in order to teach the concepts of Heat and Temperature. It is an 'argument of illustration' of one specific case (his own case), similar to the one presented by Teacher B. The intention of this argument is generalization; the thesis is that the students' interest depends on what is done in the classroom, so, in this particular case, the teacher has shown thermal phenomena that occurred in the cafeteria, and the students' interest increased. The conclusion is that when physical concepts are contextualized, students will 'always' be more interested in the content.

Other arguments are identified in this stage of the forum, as the one seen in the statement of Teacher I:

Teacher I: "Hello Tutor 1, regarding your question about Heat and Temperature being either macroscopic or microscopic, the GREF book contains a reasonable orientation for the microscopic explanation of the properties and of thermal processes".

In this case, we can understand her comment as a 'pragmatic argument' (if a proposal of a microscopic approach is found in a textbook, this kind of approach is possible).

Teacher D argues for introducing the model of 'clouds of uncertainty' in the classes, based on a directional argumentative scheme.

Teacher D: "[...] And then I think we should start to get used to giving the first step by thinking in terms of Modern Physics here too, in which the old 'planetarium' model is no longer valid. It's fine, it's a model. But why not mention the 'cloud' of uncertainty, even superficially?"

Teacher D's argument has a simple structure: the planetarium model is a model, and we agree to teach it; the 'cloud of uncertainty' is also a model. If we accept the first part, by a liaison of succession, we can also accept the second part, which means that we can also teach the 'cloud of uncertainty'.

Teacher B argues in favour of the use of computers in order to promote students' interest in Physics classes by means of an 'argument of authority', which is based on the trust it delegates to the educational material offered in the InterAge.

Teacher B: "[...] But I believe the use of information technology, as suggested in the course at [...] should be of greater help. If we master the computer, we can increase the students' interest".

Moreover, Teacher B, agreeing with Teacher F, defends the thesis of simple experiments carried out inside the classroom as a rather good strategy, by means of a 'pragmatic argument':

Teacher B: "[...] The (macroscopic) use of the laboratory is one of the solutions to the problem that we use sometimes. As in the example of Teacher C, who took his students to the cafeteria. Great, it is another alternative. With this, we can develop the interest of the students".

This thesis is replicated in the forum, for example, in Teacher H's intervention, who defends it based on previous proposals and on the reading of text 1.

Teacher H: "Well, by reading what has been discussed here, I agree with Teacher F, I think the macroscopic approach vision is more in tune with the relation of knowledge that the students initially have. Well, starting from this assumption, we can create situations with simple experiments, such as the case of taking the students to the cafeteria or even putting simple experiences into practice in the schools that have laboratories, so that after a discussion of the concepts, the microscopic vision of the concepts of Heat and Temperature can be presented".

In the first part of this contribution, we can identify the thesis: "an approach to the subject from a macroscopic vision of it is more in tune with the initial knowledge of the students". Teacher H defends this based on an argumentative scheme with implicit authority conferred by text 1, as it contains a phrase that is almost identical to the title of the text. In the second part, there are no explicit arguments, but we can suppose an 'argument by illustration', based on the case presented by Teacher C, who takes his students to the cafeteria, or Teacher B, who states that she develops practices with simple materials, and both of them affirm that these practices increase the students' interest.

In Teacher E's appropriation of text 2, when he considers a change in practices as something positive, we can identify a thesis that is not explicitly stated but defends the reformulation of one's own practices. This thesis is supported by the reading of the text and therefore, by an 'argument of authority'. In the following part we identify an 'argument of sacrifice', as he states his willingness to suffer in order to obtain a certain result. It could also be possible to understand it as a 'surpassing argument' which insists on continuing in a particular direction in order to achieve something that is more valuable. What is important is not to achieve one's objective, but to continue, to go forward, to surpass oneself. It seems that this argument is also present in Teacher H's response to Teacher E.

Teacher H: "Teacher E, I agree with you, I think we are always trying to do better, when we agree to do a good job as a teacher, we should not settle for always doing the same things, for this will create a passive approach to teaching that will not enable us to solve the difficulties presented by our students".

Teacher H shares the view of a part of the teachers' community that it is necessary to innovate in science classes in order to become a better teacher. The reason or argument is that, otherwise we will not be able to solve the students' difficulties.

Third stage

The third stage of the forum starts with an intervention made by Tutor 2, which summarizes the agreements that the group has made, which we can now consider as premises: 'the need to know the previous/alternative conceptions of the students', 'the need to increase the level of interaction between all the participants in the educational process', 'the need to contextualize' and 'the need to use new teaching materials'. These premises did not need to be argued as they were taken as accepted. The tutor then presents a new thesis: "the need to bear in mind qualitative Physics, conceptual Physics and also the epistemological aspect of the Physics that we are teaching". She does not present any arguments herself, but expects them to come from the teachers, as she ends with the question "What do you think about this?"

Teacher B then presents some appropriations of the reading of the texts and gives no continuity to the way proposed by Tutor 2. Without arguing, she presents a new thesis that seems to be based on an opinion that is shared by the teachers' community when she states that "developing reflection on the part of the students takes too much time, even with careful pre-planning".

Next come other interventions supported by the authority of the research papers, as in the case of Teacher D's comment that mentions text 5.

Teacher D: "Discussion may arise at any time and in any classroom activity. I believe that dedicating this classroom time to discussion should be in tune with the Institution's policy. As mediators I feel we should control this discussion, despite the fact that we cannot expect a certain result; we are not always able to determine it, as said in the text 5".

Teacher G intervenes, with affirmations that are at a higher level of generalization and could be interpreted as theses based on the authority of text 5.

At this stage of the forum, some 'cause-effect' arguments appear, but these arguments are too close to premises or beliefs which are already accepted within the science teachers' community. This type of scheme is identified within a statement made by Teacher B, in which she defends the thesis that in-service training course involving reading and discussion between colleagues and tutors would make professional practice better.

Teacher B: "[...] It is necessary to change the teacher's 'mindset', in order to change and improve his teaching methods. [...] Changing methods won't work if the teachings are still traditional. Expositive classes, audiovisuals, experiments, discussions, videos, those are ways of enriching the classes. And this seems to be something that is already done by everyone. But some people are still unsatisfied... Engaging in a course of this kind allows recycling and shows a desire to improve, which is already a step forward in my view. Discussing these changes makes us stronger".

Teacher D then argues in favour of his thesis: each way of teaching must be discussed and tested, based on an argument that could be 'of essence' (a type of liaison of coexistence), when he defends that each group has particular features that will distinguish it from among the others. The notion 'of essence' allows an approach to essential characteristics of stable structures.

Teacher D: "[...] This is a direct conclusion from other forums, that every way of teaching should be tested, because every class or space to teach is a different environment. None of them can be ruled out, just like the experiences that we are sharing here".

In the following interventions, the teachers continue expressing their points of view without arguing or based on the reading of the texts, presenting an 'arguments of authority', or based on their practice, expressing 'arguments of illustration'.

Conclusions and implications

The combination of the Bakhtinian perspective and the analysis of the arguments using Perelman and Olbrechts-Tyteca's theory has produced consistent and complementary results. Argumentation is a crucial part of the collaborative construction of knowledge, and the focus on the participants' argumentative strategies has helped to understand the collaboration process. The analysis of the interanimation of voices has permitted a microgenetic view of the discursive process experienced by the subjects which has given a more accurate idea of the shared construction of meanings.

Even though discourse analysis allowed an extremely detailed examination of the interanimation of voices in the forum, it does not permit generalization. Coherently with the sociocultural perspective, it is unlikely that the results of another analysis of this forum based on the same perspectives would lead exactly to the same results, although they would presumably be close. Also, the fact that the group of teachers studied was aleatory, does not allow us to imagine that the same discursive dynamic would be established by a similar group.

An intense discursive dynamic was observed in the appropriation of the meaning of the initial problem, which develops by taking different forms and by originating specific proposals for solutions. The collective (re)elaboration of the meaning of the pedagogical problem necessarily involved a reflection on practices, which, though it made the forum slightly erratic, defined a certain way of constructing syntheses.

The teachers' conceptions of Physics teaching evolved as a consequence of the appropriation of ideas from the research papers expressed through hybrid utterances in which comments on the theory were mediated by their practice. When using their professional experiences to think about the problem, the teachers moved on to a reflection on the texts as a way of finding elements to formulate the problem and propose solutions in new theoretical terms, which leads the forum to a certain degree of generalization. However, the influence of the authors' voices affected the teachers to different degrees. Their authority was not always passively

accepted, since teachers were also observed to question the authors' points of view in the light of their own experience of teaching in school. At other times, the influence of the text brought about radical changes in the teachers' perspective.

Even though ten out of the nineteen teachers did not send any messages to the forum, the discursive interactions that evolved among those who participated show that the forum was rather interactive. The non-participation of some teachers in the forum is an issue that lies beyond the scope of the present study and needs to be addressed in future research.

In spite of the absence of discursive patterns of the I-R-F type (Coulthard, quoted by Lemke, 1997), which are typical of the traditional discursive genre of the classroom, it is possible to say that the relation between the teachers and Tutor 2 has been established horizontally. This type of symmetrical relation between tutors and students' discourse in a discussion forum has already been observed (Rezende and Ostermann, 2006; Giordan, 2004) and its occurrence has been related to a non-hierarchical context of production.

The utterances of the participants commonly refer to earlier comments or are aimed at other participants, which characterizes the social construction of professional knowledge in the forum as highly dialogical. At the same time, especially during the second stage of the forum the discursive movement seems to indicate the collaborative construction of knowledge towards a proposal of solution to the problem. Differently from what was found by Puntambekar (2006), the systematic incorporation of ideas from other teachers indicated collaboration.

The argumentative analysis identified the types of premises on which the teachers based their arguments. These premises differed throughout the forum. At the beginning they were based on the initial experience of the teachers and as the forum advanced, ideas from the texts were introduced. In some point of the forum the tutor summarized the agreements which work as premises for the group: 'the need to know the previous/alternative conceptions of the students', 'the need to increase the level of interaction between all the participants in the educational process', 'the need to contextualize' and 'the need to use new teaching materials', in this way the built knowledge in collaboration has become public knowledge.

Among the argumentative strategies used by the teachers, the most characteristic was to bring real-life cases from their own experience and ideas extracted from the texts generating arguments by illustration and arguments of authority with the aim of increasing the engagement of participants. In the case of the argument by illustration, the practice is used as the basis for the argument. In the case of the argument of authority, text fragments are used as premises. The fact that the authority of the texts has had an important role within the teachers' argumentative scheme was not unfamiliar, considering that argumentative processes have been developed inside the context of an in-service training course based on the reading and discussion of research papers.

The lack of disagreement among the participants has shown that, despite coming from different parts of the country, their social languages, which

expressed their conceptions of Physics teaching, did not differ significantly. Therefore, the argumentative strategies were used by them to reinforce the collective construction of knowledge more than to increase the adhesion of participants.

The implications of this study corroborate the importance of the use of discourse and argumentative analysis aiming to improve the implementation of CSCL in the context of in-service training courses. Thus, a course management can use it to assess knowledge building processes in asynchronous online discussion and make the necessary adjustments by the identification of argumentative strategies, discursive genres and social languages. It can also be used to monitor the role of the instructors or to develop an instructor training course.

The analysis conducted in the present study indicates that the instructor has to face the challenge to create proper strategies to engage the participants in a discussion, solve presented problems and appropriate themselves of new concepts. In this sense, the instructor must be aware that the meaning of the studied concepts may differ among participants and that it is important to take these meanings into account to elaborate adequate strategies to develop the discussion. The instructor must also be prepared to recognize the most common discursive movements in on-line communication and must know how to promote the dialogic interaction when necessary.

Concerning the results related to participants' argumentation it is clear that some support is welcome to improve the quality of arguments in a forum in the context of in-service training courses. Although information technology can be used for this purpose, this support cannot prescind of pedagogical mediation. In this sense, it is important that the instructors are familiar to studies of argumentation in the context of science education to scaffold the present arguments and help participants to improve argumentation in on-line forum.

Among all the challenges to be faced by the instructor, maybe the biggest one is to use proper strategies to make people participate and compose the interanimation of voices. Future research studies focusing on the role of the instructor in distance education are considered necessary to investigate discursive strategies that make online students who usually do not manifest their voices want to participate and give their contribution to the social construction of knowledge.

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