Tutoring through the internet: how students and teachers interact to construct meaning[1].

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Abstract.

Two episodes of tutoring through the internet have been analysed in terms of situational, interactive and content perspectives. The episodes involved secondary students who submitted queries about chemistry issues to an on-line service provided by teachers. Studies of the asking of questions and of the dynamics of classroom interactions are employed to discuss the interactive and content factors of this approach to teaching-learning. The functions conveyed by students' and teachers' utterances are used to identify the structural patterns of the interactions. The occurrence of classical and inverted I-R-F exchanges, the questioner's role, the continuity of the dialogues, and other structural patterns, are used to classify the episodes as being Debate and Triadic Dialogue. The notions of mastering cultural tools and scaffolding are used to account for how meaning is constructed through the interactions.

Keywords.

Tutoring, internet, e-mail, dialogue, cultural tools, chemistry teaching.

Educational uses of the internet

Since the arrival of personal computers in the middle of 1970s, access to the main services provided by information and communication technologies has been radically changed. However, the combination of competitive costs and friendly interfaces did begin to attract a significant amount of people in the middle of 1990s. That was when the *internet*, became a common word and its associated lexicon began to form part in daily conversations. Nowadays, the three 'w' are intuitively linked to the 'dot', which makes people ready to recognise this sequence as some site in the internet, even if no other reference to the medium is provided. Therefore, the occurrence of the internet's lexicon in almost every mode of written and spoken communication can be considered a strong evidence of its dissemination over the entire world.

The internet had an impact on education as well, which has raised many challenging research questions. The design of virtual communities has attracted special attention (Johnson, 2001). Aspects like membership, social presence, written and asynchronous modes of communication, have been found to affect the organization of on-line learning communities (Wegerif, 1998). Due to its communicative dimension, the internet has been used to promote collaborative work, even when it was an embryonic project of the US Defence Department, and nowadays several collaborative environments have been developed for learning purposes (Sheremetov and Arenas, 2002; Ligorio, 2001). Particularly, collaborative environments have been observed to improve the quality of argumentation (Bell and Lin, 2000; Ravenscroft, 2000) when students were involved in science teaching activities.

On one hand, the non-hierarchical structure and its potential to encourage collaborative learning are two features that justify the development of teaching strategies based on discussion lists (Cronjé, 2001). On the other hand the diversity of communicational modes and teaching strategies might prevent the integration of the internet into classroom practice, specially if teachers do not have appropriate training (Dawes, 1999). The heterogeneous character of e-mail messages has been observed to be "affected by the numerous social structural and social situational factors which surround and define the communication taking place" (Yates, 1996, p. 46). Even being conveyed by written texts, the attempts to characterize e-mail utterances as inherently like writing or like speech have been observed to be complex (Baron, 1998).

While using the internet for learning purposes, students have been observed to ask questions as a major mode of interacting (Cronjé 2001; van der Meij and Boersma, 2002). That was the same behaviour we have observed among those students who spontaneously searched for information at the Brazilian Chemistry Society Web page. A large diversity of chemistry topics has been noted in the queries submitted by students of primary and secondary schools after they browsed the site. These queries, which were sorted into five main categories (Giordan and Mello, 2001), were also observed to emerge from classrooms activities, like problem-solving, short-piece research and projects.

The major impact of the internet on the schools is still to come. Broadband technology is already encouraging the development of new multimedia applications to visualize and simulate phenomena, what might challenge traditional practices of

teaching science. However, schools have yet to adopt the communicative innovations of the internet that could challenge teacher-centred activities.

Asking questions for teaching-learning purposes

After extensive studies on aspects of asking questions as the classroom's talking, curriculum, and research evaluation, Dillon has developed some techniques to encourage students' questioning in the classroom, based on a model for the process of questioning (Dillon, 1988a). The model resulted in some practical suggestions for classroom activities, essentially based on a Socratic teaching approach. Dillon (1988b) has also contributed to the debate about questioning and discussion in classroom settings, through organizing a multidisciplinary group to work on this theme. Five extracts from different classrooms were analysed by six disciplinary perspectives and by six pedagogical perspectives. From such a diversity of approaches, one of the general conclusions reached was that teachers tend to control discussions excessively using questions as a powerful instrument (Wilen, 1988, p. 314).

Durham (1997) has investigated the commonly teachers' responses to students' questions in secondary schools. Six classrooms of experienced science teachers were videotaped for 45 minutes when they were engaged in a variety of instructional activities. She found three main instructional activities that elicited the majority of pupils' questions: class discussions which introduced a new concept, lab activities, and teacher-stated directions. Although the instructional activities were structured to encourage student questioning, the author observed that the teachers as questioner prevailed in the classroom interactions.

Low question rates in classroom scenarios were also reported by Graesser and col., who investigated tutoring sessions and the questions asked on algebra involving 7th-graders as tutees and high school students as tutors. The results showed that tutees' questions were approximately 240 times as frequent in tutoring settings as classroom settings, whereas tutor questions were slightly more frequent than teacher's questions (Graesser et al., 1994). In previous work, the authors had identified a set of cognitive mechanisms that might generate questions. They were classified into four major groups, correction of knowledge deficits, monitoring common ground, social coordination of action and control of conversation and attention (Graesser et al., 1992). Following the same cognitive approach, Otero and Graesser (2001) developed a conceptual model of human question asking, which was based in a set of rules. The rules were obtained from reading text activities and they were set up on *if*<*condition*>*then*<*action*> formalism, which potentially enables them to be applied to computer simulations of asking question.

Comprehension-fostering and comprehension-monitoring activities have been designed in a reciprocal teaching approach that included asking questions by students, besides other practices (Palinscsar and Brown, 1984). In this study, not only was the quantity of questions observed to be enhanced, but it also showed that it was possible to get more detailed, clear and focused questions from the students when the reciprocal teaching approach was applied. Elements of elaboration and contextualization could be observed in the questions posed by the students after some weeks of reciprocal teaching.

These studies seemingly assumed that the way to raise the cognitive level of the students' understanding was encouraging them to ask 'better' questions. They presupposed that the question produced by the student was the same question perceived by the teacher and vice versa, but that is not what often happens in actual classrooms. Classroom settings are known to be complex and full of contradictions, specially when students are engaged in more interactive situations. As a sequence, I focus here on discussing the structure of dialogues performed by students and teachers and how questioning are related to these modalities of interaction.

Some aspects of classroom interactions.

A typical pattern of the classroom discourse, which was described by Sinclair and Coulthard (1975) as the I-R-F exchange and by Mehan (1979) as the I-R-E act, has accounted for how aspects as classroom control, low rates of students' question, and the central role of teachers in questioning are all involved in the dynamics of classroom interactions. I-R-F is conceived in terms of *initiation* of the exchange by the teacher, which elicits a *response* from the student, followed by a *feedback* of the teacher. In most cases, a question is used to initiate the exchange and the feedback consists of an evaluation of the student's response. The structure of I-R-F exchange is deeply related to the control that the teacher exercises over the classroom discourse in both a structural and thematic sense (Lemke 1990, p. 63). When teacher nominates a student to answer a question, he controls speaking rights in the classroom and he also controls the thematic pattern through the evaluative feedback, since dissonant answers are ignored and no room is left for the student to argue in favour of his answer. In a broad sense, I-R-F exchanges were observed to be responsible for the context and

continuity of the talk in the classroom (Edwards and Mercer 1987, p. 91). Therefore, if the student initiates an exchange with a question, there might be a rupture of the I-R-F structure, what might lead to changes in the overall dynamic of the classroom discourse, specially if symmetrical student-student interactions are taking place, as has been extensively reported (Lemke, 1990, Mercer, 1995; Mortimer, 1998; Hogan et al., 2000; van Zee and col. 2001).

Lemke considered dialogue as one of the main types of structure of activity that occur in high school classrooms. Students were observed to ask questions for clarification, "to fill a semantic link in the chain needed to make sense of what's been said" (Lemke 1990, p. 27). However sometimes, they find contradictions between what the teacher says and what they are looking for to fill in the chain. In these cases, the student challenges what the teacher says and he initiates a dispute for what Lemke called the 'thematic pattern' of the activity. This activity structure was classified as 'Student Questioning Dialogue' and it is characterized by the fact that students pose questions. Both types of questions, clarification and challenging, typically break the structure of I-R-F exchanges. Whereas in the first case, the student's question does not depend on his idea, in the second case it might contain some aspects of the student's reasoning.

After studying classroom interactions for several years, Mercer observed three main types of talk among students when working together on guided activities. Exploratory talk was recognized to be the most productive type of interaction for developing students' reasoning. Based on an analysis of the dialogues, he proposed a set of ground rules to foster exploratory talk, and the 'questions about reasons' rule was suggested to the students as part of a strategy to enhance the quality of the interactions

(Mercer, 1995). Selected extracts of classroom interactions showed a high incidence of questions asked by students that were used to elicit opinions and also to ask for reasons (Mercer et al, 1999).

While peers-based discussion tends to be more exploratory and generative, teacher's intervention in group activities was observed to reduce by three times the number of students' questions (Hogan et al., 2000, p. 401). This was an indication of the strong directive role of the teacher as a questioner, since the authors could relate teacher's presence in the group with low number of turns to achieve a high reasoning level. Groups that shared more questions also took more turns in the knowledge construction mode. The authors thus considered teacher-guided discussion a more efficient means of attaining higher levels of reasoning and higher quality explanations.

Van Zee and col. (2001) examined some factors that encouraged student questioning during dialogues. Since the planned science activities were structured to follow a guided discussion approach, the set-up of the discourse structures that explicitly elicited students' questions was found to be one of the most important factors to fostering questions. One of the employed structures was named KWHL chart in which the teacher asks students what they already 'Know' about a topic, what they 'Wonder' about a topic, 'How' they could find out, and eventually what they have 'Learnt'. Brainstorming and calling for student's questions were also recognized as the foremost structures. Besides the fact that student changed their ways of speaking, another particular relevant aspect was that they could engage in discourse practices that facilitated the learning of their colleagues.

In a comparative case study, the quality of the debate and the students' engagement were observed to be greatly improved when specific audience role assignments were provided to the students (Herrenkohl and Guerra, 1998). Students' reporting after practical science activities generally enhances the level of engagement, since they usually expose their own findings and explanations. However, they might not be involved in real active interaction if the audience is limited to the teacher, e.g. if the reporters only address their voices to the teacher. A model for enhancing students' engagement was designed and it included a question chart that was constructed by the students themselves to find ways for checking other groups' reports and to support the reporters in articulating their explanations. This chart, built up with around 40 different questions, provided a 'scaffold' for the students who used it less frequently as time progressed. Questioning has been used here as an 'artefact' to generate authentic classroom debates and promote students' engagement.

Herrenkohl and Wertsch revisited the same research scenario discussed above and concluded that sociocognitive roles, e.g. 'reporters' and 'audience', are effective in encouraging the further appropriation and mastery of cultural tools related to scientific reasoning (Herrenkohl and Wertsch 1999, p. 432). *Cultural tool* or *mediational means* are conceived of the perspective of an agent operating with it, a sort of irreducible tension that is characteristic of the mediated action (Wertsch 1998, p. 30). As a type of mediational means used by the agents, spoken language is strictly related to aspects of communication and reasoning in classroom activities. In this study, students in the audience were observed to ask questions for clarification, which elicited re-elaborations of the reporters upon their predictions, theories and collected

evidences. Questioning was also valuable in monitoring student's comprehension and in recognizing the diversity of alternatives for explaining their observations. The question was considered as a sort of cultural tool that mediated the communication and the reasoning of the students in structured activities. The mastery and appropriation of questions, besides other cultural tools, proved to be an important aim of science classrooms, since they were associated to enhancing the quality of the communication and of the scientific reasoning.

Another example of the process of mastering questions as a cultural tool has been provided by the dialogues among students while they were discussing aspects of the Theory of Matter (Mortimer, 1998). Assuming that the classroom is populated by different voices, the author used three excerpts of dialogues to show how students' understanding of the classic atomic model is constructed by building relations between energy, motion and arrangement of the particles in different states of aggregation (i.e., gas, liquid and solid). In a first instance the teacher's question "how energy is related to particle's motion" was rephrased by one student to initiate the sequence. While the students were negotiating the direct relation between energy and motion, they attempted to understand which characteristics distinguished gases from solids and liquids. By the middle of the same dialogue sequence, the student, who had rephrased the teacher's question in the beginning, posed a different one, 'why is its [gas] motion greater than that of solids and liquids'. In this case, the student attempted to guide the dialogue using the question as a typical cultural tool to elicit opinions. But, this second question can be considered authentic, since it was focused on causal and comparative relations, which have concerned the students through the episode.

These two forms of questioning evidence that the student *learned how to use* questions for different proposes, which characterizes the mastery of the cultural tool.

Summarizing the findings of these studies, we can say that teachers tend to excessively control discussions through asking questions while they occupy the role of questioner in classroom interactions. They employ a typical discoursive strategy, I-R-F, to take control over classroom interactions in both the structural and thematic sense. In attempting to break this discoursive pattern, students pose clarification and challenging questions, which might change the entire dynamics of the interaction in classroom. When working in groups, practical rules like questioning about reasons were found to improve dialogue skills among students. The process of mastering questions as a cultural tool has been observed to be particularly useful to account for the overall action performed in classroom settings.

In the next sections we describe and analyse how students ask questions to and interact with teachers in a tutoring setting that was initially arranged in the middle of 1990s. In a first instance, the Web based service is described and the methodology for collecting and analysing data is presented. Then, we analyse two episodes and discuss the findings in terms of the structure of the interactions and how meaning is constructed.

Methods.

Since the beginning of the 1990s, the Brazilian Chemistry Society (SBQ) Web site has been visited by students who were seeking assistance for their schools' tasks. As an attempt to match this spontaneous demand, the Tutoring through the Internet

Service (Orienta) of SBQ has been systematically offered since October 1996. The first step towards offering the service was the recruitment of a group of Chemistry teachers, who were providing stimulating dialogue with the students in an attempt to provide them a permanent channel of communication. The teacher acting as a tutor should identify the main purpose of the query and then suggest to the student a strategy to answer the question by their own. The students were advised to browse specific Web pages, read printed material, and carry out simple science experiments and observations of correlated phenomena. All strategies had the intention of stimulating dialogue and giving clues that could guide the student through elaborating his/her own answer.

The interaction between tutor and student started with the student replying to a survey that was hosted on a Web page. After that, all correspondences were exchanged by e-mail. The survey was composed of three blocks with a total of fifteen questions - seven about the student, four regarding the use of the internet, and four about student's opinion on school Chemistry. The objective of the survey was to gather a body of information about the student, along with his question. With the volume of information gathered by the Tutoring Service, we designed a users' profile, whose findings were reported elsewhere (Giordan and Mello, 2001).

The student's individual profile has been proved to be very useful in providing a rough initial context for the tutors. We use the approach that meaning should not be taken to adhere to an isolated utterance, but should be seen to arise from interaction and from previous knowledge as well. Thus we attempted to gather information from the survey in order to build up an approach to the situational context. Previous

knowledge was accessed in terms of the students' opinions on school chemistry, e.g., what they do and do not like, and what is easy and difficult. Information concerning students' identities, like name, age, sex, school year, home town, and the text genre as well were used by the tutors to engage in the dialogue, assuming that all these idiosyncratic characteristics should shape the interaction. In terms of situational contextualization to the student, the application provided a 'welcome' message telling about teachers' availability to assist him/her in finding the ways to answer the query. Therefore, the student initiated the interaction by applying to the survey, and the tutor engaged in reading the survey to elaborate a strategy that was announced in the first reply.

To achieve the purposes of analysing the structural patterns of the tutoring interactions and identifying the elements used in the process of constructing meaning, two episodes were chosen from over two hundred. In a first attempt, we have classified these episodes in five categories, according to the motives of the questions. For example, in the *problematization* category, the student was trying to solve some specific problem and at the same time he/she provided some idea of how doing it. The following query is an example of this category: *"*I'd like to know why the density of the ice is lower than the density of the water, my doubt is since both of them are water only one is liquid and the other is solid*"*. The second type of question which provided elements for continued dialogue between student and tutor were classified as *contextualization*. The daily chemical phenomena and the use of chemistry knowledge to understand complexes scientific phenomena were the motivation of the queries classified in this category. From the overall episodes, just 2% were classified as problematization, and 8% were classified as contextualization (Giordan and Mello,

2001). Among these categories, two episodes were selected which satisfied the criteria for the continuity of the interaction, for the visibility of the process of constructing meaning, and for the well-succeeded attempt to satisfy the student's initial aim. In these terms, the selected episodes are representative of the successful ones observed in those categories.

For analytical purposes, each e-mail message was considered as an utterance and they were analysed according to the types of function they performed. The analysis considered three major branches regarding situational, structural and content aspects of the exchanges. The texts were translated from Portuguese after deleting the message headings and changing the names of students, tutors and schools. The Web page was just referred to by number of appearance, without indicating the URL address. We preserved some of the linguistic forms of the texts, like abbreviation and greeting, in an attempt to provide the closest possible representation of the originals.

First episode: planning a task.

In the first dialogue, Raq is a female teacher who was beginning as a tutor in the tutoring service. Den is a female student attending to the second year in high school, who was looking for assistance with doing a school task, after she had already searched an encyclopaedia for information. Besides the encyclopaedia that was mentioned in the first utterance, other visible sources of reference were the Web pages and the tutor's e-mails. In quantitative terms, the average extension of the tutor's utterances were bigger than the student's, whose utterances mostly ranged between three to four lines, excepting the last one.

The interactive and content elements of this dialogue are spread over and included within all utterances. The simultaneously occurrence of I-R-F exchanges, which might be considered a consequence of the multifunctionality of the utterances, and also of the condensed nature of e-mail, leads us to unfold the episode into three extracts. This analytical procedure proved to be a useful strategy to characterize the structural and thematic patterns of the whole episode, since it clearly indicated the occurrence of eight complete I-R-Fs and three incomplete I-R-(F)s exchanges and also how they contributed to the construction of meaning. Table 1 shows how the moves are distributed through the utterances in each extract.

One distinctive feature of this episode is that most of the utterances begin and end with greetings, since every message was enclosed within a protocol sense of being acquainted with each other, as can be seen in Extract 1. In turn 19 and 20, student and tutor announced their intentions of joining the society and accepting a new associate, which can be seen as an attempt of sharing a common identity. This sense of commitment between student and tutor was also visible in utterances 5, 6, 7, 8 and 9 in which a Web page address was corrected. Besides greeting, informing, acknowledging and questioning, other typical functions performed by student's and tutor's utterances were replying and evaluating. The first I-R-F exchange was visible in utterances 2, 3 and 4 - turns 15, 19 and 20 - and its function was to support engagement. Two other I-R-F exchanges can also be seen in this extract - utterances 5, 6, 7, 8 and 9 - and they were performed to correct a URL address. In this case, the student initiated both the exchanges.

Extract 1: Getting commitment.

Tutor (2):

15. Any query, get in touch, ok ?

Student (3):

19. Love from the new ‘associate’, Den.

Tutor (4):

20. Hello Den, welcome to our Brazilian Chemistry Society ! Nice to see u enjoyed the texts about
21. pheromones. Were they useful to you ?

Student (5):

29. Hello Raq. Thanks for sending me the texts ! I couldn’t access the first one, I think the address
30. should be wrong. The texts about pheromones were very useful.
31. Love, Den.

Tutor (6):

32. Hi Den, you’re right, the correct address is
33. URL3-correct
34. Don’t miss me, ok ?
35. Love.

Student (7):

36. Hi Raq. How are u? I couldn’t access the site again, I don’t know what is going on.

Tutor (8):

47. Note: keep trying, the address I sent you was correct, probably the server was down when
48. you tried to access.

Student (9):

59. Ps.: I’ve got that page which I was not able to access, but the texts are very hard!

In total, five of the eight complete I-R-F exchanges were initiated by the student, which is not a typical pattern of communication in student-teacher relationships. The reasons for this ‘subversion’ might either be associated to the non-hierarchical nature of the medium, to the aim of the tutoring service or also to the student’s purpose. However, at this stage, it is important to consider how these exchanges sustain the continuity of the whole interaction and how they foster the construction of meaning.

In Extract 2, the student initiated the first I-R-F exchange soliciting information in turns 1 to 2. The tutor’s reply was provided in turns 13 to 14, in which she suggested

the strategy of searching on the Web. It is worth noting that in the previous turns the tutor was attempting to find a focus on a specific issue, which was her first contribution towards the construction of meaning of chemistry in animals, since she referred to 'a very interesting issue' specifically about insects. The student then provided feedback in turns 17 and 18 in the form of a positive evaluation, which was followed-up by a tutor's elicitation between turns 20 and 21. At this point, the tutor took the control over the interaction, since she asked an open question to be answered by the student. However, the student's reply in turn 30 was not followed-up by any evaluative or general feedback from the tutor, what constitutes an incomplete I-R-(F). Instead of the feedback, the tutor provided the correction of a URL address in utterance 6, as indicated in Extract 1. In this case, the continuity of the whole interaction was sustained by the I-R-F exchange performed to correct the URL address through utterances 5, 6 and 7.

If one considers the student's purpose at the beginning of this exchange, that is getting information about the chemistry of animals, it is acceptable that she intended to accomplish it at the end of turn 36 and turn 37, which was done by soliciting a second focused information (the first one is visible in Extract 3). The student 'regained the floor' asking a question and thus initiated another I-R-F exchange. However, she focused on the effects of a well-known substance on the organism. In the reply, turns 40 to 42, the tutor used her favourite strategy, i.e. to provide information on Web pages addresses. Indeed, she chose one specific topic discussed in the Web page and posed a question to the student, in an attempt to elicit her opinion about benefits of alcohol to health. Thus, this tutor's reply was a combination of an answer and a question, what signalizes her intention to take the control over the interaction. No

explicit evidence of student's feedback was found in the sequence. In fact, the student initiated another exchange complaining about the difficulty to understand some texts found in the Web. In her reply through turns 61 to 63, the tutor acknowledged the difficulty of the student in comprehending the information. Offering assistance and suggesting the student to ask questions was the strategy employed by the tutor to sustain the continuity of the interaction.

Extract 2: Disputing the control.

Student (1).

1. Hi. I've got a school task to do about chemistry in animals, I found something in Barsa, and I'd
2. like to know if u've got some texts, information, pictures, after all, anything regarding it to send me.

Tutor (2).

10. There's a very interesting issue that
11. involves chemistry knowledge and animals, specifically insects. It's about pheromones, volatile
12. substances produced by insects that have important functions in the life of these little beings.
13. I suggest you browse two texts in the Web:
14. URL1 and URL2.

Student (3):

17. I considered very interesting the text about
18. sexual pheromones.

Tutor (4):

20. Nice to see u enjoyed the texts about
21. pheromones. Were they useful to you ?

Student (5):

30. The texts about pheromones were very useful.

Student (7):

36. I'd like to
37. know if you have information about the changes caused by alcohol, for example, in the organism.

Tutor (8):

40. Regarding alcohol, I can suggest some
41. sites:
42. URL5, URL6, URL7, URL8
43. You'll note that the majority relates the effects of alcohols to driving. Does alcohol provide any
44. benefit for health ? Think about that to discuss, ok ?

Student (9):

51. I am looking for information about biochemistry almost daily in the
52. Internet, and issues related to this, but it is so difficulty. Some texts that I find are much
53. complex and hard, I don't understand anything that is written.
Tutor (10):
61. You said that the texts are complex and hard.
62. What if I could help you to understand some of them ? Tell me which ones and ask questions that
63. I could better assist you. PUT YOUR QUERIES ON.
Student (11):
72. When I told about a hard text I was referring to the PUC's address. I
73. didn't understand almost anything because the information were in the form of schema, which
74. raise much difficulty. If it were written in text, properly saying, the comprehension would be
75. easier.

As shown in Extract 3, the dispute for the control over the interaction is also related to the dispute for the thematic pattern. When the tutor said she was not sure what the student was referring to, she was actually inviting the student to state her query, and thus initiated another exchange. Since the information provided by the tutor– turns 13 and 14 in Extract 2 – did not fulfil her initial purpose, the student replied by asking for information about breathing, digestion, and reproduction, after considering the extensiveness of the issue announced by the tutor through turns 6 to 9. In this reply, the student made her first attempt at focusing on aspects of her interest, i.e. biological processes. In the feedback, the tutor denied help and suggested to the student the strategy of looking for a biochemist to assist her. As the tutor offered alternative thematic patterns, pheromones and molecules of life, the thematic pattern focused on biological processes submerged and came out to surface when the student initiated another exchange informing her intention to visit the Biochemistry Department at the university, which was announced in utterance 9 turns 55 to 57. In her reply, the tutor advised the student to 'take questions' when she visited the university. The student then confirmed the arrangement to the visit in turns 68 and 69. Therefore, this conflict

of interests between student and tutor regarding the focus of the issue constituted another movement towards the construction of meaning.

The last sequence of I-R-F exchanges was initiated by the teacher in utterance 8, as an attempt to bring back the student's initial purposes. The student's reply considered aspects of her strategies to find information and also the subject 'chemistry in animals'. In the move through turns 53 to 55, the student stated her understanding about chemistry in animals, which was acknowledged by the tutor in her feedback, while the tutor followed-up eliciting information and proposing a task. The reply for this elicitation was spread through utterance 11. First, the student described her school task, in turns 62 to 72, what was quite generic. And finally in turns 75 to 80, she announced a schedule for her task, which contained some issues that had been discussed through the episode and can be considered the expression of the meaning of chemistry in animals.

Extract 3: Chemistry in animals.

Tutor (2):

6. Chemistry in animals is a very extensive issue. We've got a branch of chemistry, the
7. biochemistry, which is concerned with the chemistry processes of living beings. We could talk
8. about the essential elements of our nutrition and in the consequences of their lacks or excess, or
9. even discuss chemical reactions that occur in the animals' breathing, just as examples. I'm not sure
10. about what you refer when you say chemistry in animals.

Student (3):

18. I'd like to know if u've got articles about breathing, digestion, reproduction etc.

Tutor (4):

21. There're two interesting sites about the chemistry of
22. "life's molecules". (…)
24. URL3 and URL4.
25. About digestion, … reproduction, they are out of our field. If u wish to know more about the
26. chemistry of these processes I suggest you look for a biochemist, which is the best professional for
27. these issues.

Tutor (8):

39. Hello Den, nice to see that our meetings are getting frequent. Are your queries personal or are
40. you doing some school task ? Which is the discipline ?

Student (9):

49. Hello Raq. My queries come from to a school task. It is for Chemistry lessons. The subject is
50. 'chemistry in animals'. I found some issues in magazines about a variety of subject that link
51. chemistry and animals, (…)
53. Some subjects which I'm looking for
54. are caffeine (how does it act in the human body), alcohol, drugs, because all of them involve
55. chemistry. Next week I'm planing to go to the University, in the Biochemistry area and try to find
56. something that I could use. It is almost sure that I'll find, because the teacher recommended to go
57. there!
58. Love, Den.

Tutor (10):

64. When you visit the Chemistry Department at the University, I suggest you to take questions and
65. queries in order to have a better profit of your research, ok ? I noted you're interested in
66. biochemical processes of specific substances (alcohol, caffeine, drugs) and their consequences to
67. our health. Is it the schedule of the school task ? If not, what about we plan one ?

Student (11):

68. Hi Raq. This week I arranged to go to the University, in the Biochemistry Department. Later
69. on, I write telling what I find. My task does not have a schedule, say, rigid, I can talk about
70. everything that involves chemistry in animals, from processes like digestion, breathing, to
71. alcohol, caffeine, etc, acting in our organism. I can't forget the irrational animals, which take part
72. in the work as well.
75. Back to the schedule you told, I did something like that:
76. - 1st some history, the origin of studies in this field;
77. -2nd I'll put the processes, like digestion …;
78. -3rd I'll comment information related to human beings;
79. -4th I'll tell about irrational animals, including the texts about pheromones;
80. -5th Conclusions.
81. I'm not sure if it is exactly what you referred to, but just in case!

The analysis of this episode reveals the multiplicity of functions that every utterance might convey when tutored interactions take place on the internet. These functions are responsible for the overall structure of the dialogue, which is basically shaped by I-R-F exchanges. In turn, these exchanges are responsible for maintaining the continuity of the dialogue from the interactive viewpoint, and also for the movements towards

the construction of meaning. Indeed, tutor and student alternatively substitute for each other in the roles of eliciting and replying, which is a characteristic of a less rigid structural pattern of interaction. From the perspective of content analysis, the dispute between student and tutor over what Lemke (1990) called 'thematic pattern' pervades the entire episode. Besides the information gathered during the exchanges, the student eventually produced a schedule for her school task, which contained some issues discussed through the episode and might be considered the expression of her meaning of 'chemistry in animals'.

Second episode: modelling chemical bonds.

The second episode involved one male student who lived in a small city and was attending the first year of high school, and one tutor who was an experienced male teacher that has been advising since the beginning of the Tutorial Service. Only five long utterances were used to reach the original purpose of the student. One important aspect of the situational context regards to the fact that the query has been raised from a classroom situation, which was announced in turns 3 and 4. The student went to the Tutoring Service because he was not pleased with a teacher's answer to his question. This information was used by the tutor to design his strategy, since no direct answer was provided, but an unusual 'thought experiment' was proposed, as is observed in Extract 4.

Extract 4: *Let's think about an experiment …*

Student (1):

3. At moment I'm studying chemical bonds. When the teacher spoke about bond between molecules,

4. referring to the hydrogen bond,I asked a question that he could not answer in a way that satisfied me.

Tutor (2):

12. About your question, let's attempt to think about an experiment that could prove your hypotheses
13. about the interchange of hydrogen atoms between molecules of water forming hydrogen bonds.

In his last utterance, the student used paper and pencil to draw a schema, which was scanned and sent through e-mail (Extract 8). Drawing was not a common type of representation employed by students in their communications with tutors, but the most peculiar feature of this episode was the interval of time between the second and third utterances. Even such a large delay of one year and a half was not sufficient to break the continuity of the interaction, since the student was capable of using written records to transcribe the first two utterances, and also because the teacher accepted the student's excuse, as seen in Extract 5.

Extract 5: Retaking the sequence.

Student (3):

25. Hello Teacher, I'm responding only now the answer for a request I did in 1998. The request and
26. your answer are transcribed bellow. I lost the sheet of paper in which I printed the request and last
27. week I found it and so I'm writing the answer:

Tutor (4):

34. Hello Car! Gosh, it's got a long time since we don't talk, hasn't it ?

In the first move towards addressing his query - turns 3 and 4, Extract 4 - the student announced the issue that he had learned in his classroom, chemical bond, while he specified hydrogen bond as his foremost concern. Before asking the questions, the student let the tutor know about the classroom's example, which the teacher had probably used to discuss the hydrogen bond. Since water is a classical example for this issue, employing it to produce his own question was the student's first successful move to construct meaning. The second one was made visible in his second question,

in which he re-elaborated the first question, suggesting the simultaneity of breaking and forming chemical bonds.

Extract 6: The query.

Student (1):

5. In the case of water, when hydrogen bonds are formed and broken, do the atoms that belong to a
6. molecule remain the same? Or for example, when a hydrogen bond is broken, can the hydrogen of a
7. molecule go to another molecule and the hydrogen of this one go to another one and so on?

In terms of structural pattern, this episode was observed to be shaped by only one I-R-F exchange. The very aspect of this exchange is the fact that the tutor took control over it in utterance 2, where he acknowledged the initial query of the student in turns 5 to 7, transformed the student's questions into hypotheses in turns 14 and 16, and asked three questions related to the hypotheses in turns 18 to 20. In the sequence, the student replied with an answer during turns 27 to 31 and explicitly asked for evaluation at the end of utterance 3. The tutor positively evaluated student's questions in turns 34 and 35, and extended the interaction using a second strategy, when he proposed that the student drew a schematic model. Despite the fact that the student had posed the initial query through asking two questions, he provided an answer and an explicative model with the assistance of the tutor. In this case, the movement throughout the construction of meaning was structured in terms of a classical tutor-initiated I-R-F exchange.

Extract 7: The imaginary experiment.

Tutor (2):

14. Let's suppose we have an equipment that could recognise the presence of hydrogen, according to
15. the type of chemical bond that is forming and at the same time could distinguish between
16. isotopes of hydrogen (deuterium 2H and hydrogen 1H). You should know that there is a variety

17. of water molecules formed by atoms of oxygen and deuterium, known as D2O. It's called heavy
18. water. If you don't know, take it as a data. How would our equipment react to the presence of
19. H2O? And in a situation where both H2O and D2O were there ? Could we isolate just the
20. 'signals' of H2O and D2O or there's the possibility to isolate another 'signal' ? Try to think about
21. this imaginary experiment and tell how it could be used to prove your hypotheses. We are
22. waiting for your answer,

Student (3):

27. If there were a mixture of D2O and H2O if the
28. molecules remained ever intact the equipment would just detect the signals of H2O and D2O.
29. But if there were an interchange of hydrogen atoms between the molecules, there could arise HDO
30. molecules and thus a new signal would be noted in the equipment. If this equipment does exist,
31. then we could detect the interchange of hydrogen atoms between the molecules. Is that right ? I
32. thank you for confirming my ideas, and about the interchange if the hydrogen atoms between
33. water molecules. Car

Tutor (4):

34. Well, your purpose about the
35. imaginary experiment is very sensible. According to the characteristic of this equipment (…)
37. you could follow the interchange between hydrogen and deuterium atoms. These data would be
38. indicative that it is actually occurring the interchange of atoms and therefore the water molecules
39. would not be totally stable (they were subjected to break and form bonds) at the experimental
40. conditions. What should we do now to sustain our hypotheses (which is well proposed and
41. subsided by the data)? The scientists usually draw schematic models to support them to posing
42. other questions/hypothesis. Science does not go ahead without new questions and to pose them the
43. scientists propose models. What about schematizing what you've described in your answer in
44. terms of chemical symbols, in which the bonds among atoms could be represented? How would
45. you represent the transition process between the atoms of D and H? If you could use any drawing
46. software, that's fine. Otherwise, use the e-mail software to schematizing your model, or else, if
47. you have a scanner available, scan your schema and sent it to us.

We now turn to particular aspects of two strategies employed by the tutor. In his first strategy, announced in utterance 2, he associated student's proposition on the hydrogen bond to a hypothesis and nominated it as an 'interchange', as seen in Extract 4. He then transferred the student's proposition to an imaginary situation, in which the differences between types of hydrogen bonds could be measured and compared by some equipment in two different scenarios. These scenarios were announced in the form of three questions during turns 18 to 20, i.e., just 'light' water,

and the mixture of 'light' and 'heavy' water. For this second scenario, two possibilities were suggested: only two 'signals' or a possible third 'signal'. Additional information was provided regarding the existence of a different type of water molecule. This molecule is composed of deuterium, whose bonds could be detected differently by the fictitious equipment. Eventually, he motivated the student to think about the imaginary experiment and to answer the questions and prove the hypotheses. The moves of transferring student's proposition, designing the scenarios and motivating the student are very similar to what Wood, Bruner and Ross (1976, p. 98) called *recruitment, reduction in degrees of freedom* and *direction maintenance*, respectively. This similarities observed between the moves in the tutoring through the internet and face-to-face tutoring suggest that the process of *scaffolding* was the first strategy employed to foster the construction of meaning in this episode.

The second strategy was announced in utterance 4. In spite of giving much attention to the molecular system, the tutor decided to emphasize the sustainability of the hypotheses, asking a rhetorical question in turns 40 and 41. This question was an indication of the second tutoring strategy, which was preceded by considering aspects of science and the scientists' work. In this digression, the tutor wove relationships among questions, hypotheses and models that directed student's attention to represent the interchange of hydrogens in a schema employing chemical symbols. The new task was then suggested during turns 43 to 45.

Chemical symbols are a sort of cultural tool largely employed by chemists to mediate their understandings on the structure of matter. In this episode they were first used by

the tutor and then by the student, to nominate atoms and molecules[2]. Chemical symbols were used by the student to make conjectures on the proposed scenarios, who used them together with another cultural tool in utterance 3, logical statements. Employing an *if-then* structure, the student evaluated the two major conditions of the modified hypotheses, i.e., the mixture of H_2O and D_2O, and the interchange of hydrogens. The student considered the mixture of light and heavy water as a necessary condition and therefore he dismissed the first scenario suggested by the tutor. He split the second scenario and associated the possibility of detecting the 'new signal' to the arising of a new variety of water molecule, HDO, which was suggested in utterance 3 and was represented in his drawing in Extract 8. In this sense, chemical and logical statements, two cultural tools, were used by the student with the assistance of the tutor, the agents, to construct meaning on hydrogen bond.

An extensive analysis of the drawing could be done. However, it is particularly noteworthy that his concern was with nominating the types of bonds involved in the process and the 'new' molecules, which were referred in a type of legend of the schema. Nominations performed the function of indexing to specific concepts discussed during the episode and a description stated the features of conditional and consecutiveness to the model. Therefore, the drawing showed what was described in the hydrogen interchange process during the previous utterances.

Extract 8: Drawing hydrogen bonds.

Student (U5):

50. Hello Teacher. Follow enclosed the schema for breaking hydrogen bonds that I drew and
51. scanned. Car

[2] Subscripts are not properly set due to limitations of the word-processor used in the e-mail software.

Differently from Episode 1, in this case the thematic pattern was not under dispute, since the tutor guided the interaction eliciting, evaluating and following-up within a typical asymmetrical I-R-F structure. Nevertheless, the tutor offered well-structured scenarios whose constraints were recognized by the student to belong to his initial proposition. The attention of both tutor and student remained focused on constructing meaning of hydrogen bond, which was based on the use of cultural tools, as chemical symbols and logical statements, and on scaffolded process.

Discussion.

As had been observed in both episodes, the utterances produced by student and tutor performed several functions. Some types of function were related to the continuity of the interactions, such as greetings, acknowledgment, elicitation of opinion and replying, since they contributed to the establishment of connections between what came early and what followed each utterance. In Episode 1, student and tutor alternated the roles of questioner, which did not happen in Episode 2. In this case, the student initiated the interaction asking a question, but in his reply the tutor took control over the exchanges through elaborations, elicitations and assessments. The asymmetrical pattern observed in Episode 2 is a structural characteristic of Triadic Dialogue (Lemke 1990, p. 8). On the other hand, the alternation of roles in Episode 1 is a structural characteristic of Debate, in which student and tutor "share control of the direction of the dialogue, and they compete for thematic control" (Lemke 1990, p. 29).

Another distinctive characteristic of the episodes was related to the voices that populated each one. The openness to new information made Episode 1 populated by a large number of Web pages, besides student's, tutor's, and teacher's voices which were also announced in Episode 2. Some of the Web pages suggested by the tutor in Episode 1 acted as counterexamples of the student's thematic pattern, as shown in Extract 3, utterance 4. On the other hand, when the tutor evoked scientists' proposition of models, in utterance 4 of Episode 2, he did so to guide the dialogue towards the direction of the shared thematic pattern. In this sense, the voices evoked in both episodes performed different functions depending on the structure of the interactions: contradiction in the Debate and reinforcement in the Triadic Dialogue. Therefore, based on the functions conveyed by the utterances and on the dynamics of their exchanges, it was possible to account for the differences in the structural pattern of these episodes, which were observed to own a high degree of interaction, despite of not being performed through a face-to-face modality.

Interaction and content analysis combined with the theory of mediated action can also provide evidence to account for the construction of meaning. In this approach, construction of meaning is conceived as a type of mediated action which involves an irreducible tension between agents and cultural tools (Wertsch, 1998, p. 25-30). Meaning itself is constructed by the *agent-acting-with-cultural-tools* and cannot be reduced to an isolated utterance.

In Episode 1, the alternation of questioner positions - student in turns 1-2, tutor in turns 21, student in turns 36-37, tutor in turns 43-44 - subverted the classical I-R-F structure of the exchanges, as reported by Sinclair and Coulthard (1975), Mehan

(1979) and Lemke (1990), since the student could provide evaluative feedback while eliciting for information. In this sense, the student used question as a cultural tool - which has also been observed in the studies of Herrenkhol and Wertsch (1999), and Mortimer (1998) - within structured exchanges to construct her meaning of chemistry in animals through the whole interaction. Suggesting the student to produce a schedule for her task, the tutor provoked the announcement of a new meaning of chemistry in animals. In this sense, the schedule of the task is not the meaning itself, but it is the cultural tool with which the student acted to produce meaning and to make it visible. The construction of meaning of chemistry in animals is thus a process in which student and tutor, the agents, act with cultural tools, such as questions and schedule to accomplish a school task. Within this approach, we can say that the student *learned how to use* schedule to plan a school task and *learned how to use* questions to obtain information, which indicates that he *mastered* two essential cultural tools for the construction of meaning.

On the other hand, in Episode 2, student-tutor interaction was structured in terms of classical asymmetrical exchange. The tutor's strategy of scaffolding was readily accepted by the student, and hence their attention remained focused on a common object. In this case, construction of meaning was a matter of mastering cultural tools such as logical statements and chemical symbols, which were arranged by the tutor and were employed by the student to model the process of hydrogen interchange. Therefore, modelling can be characterized as a mediate action, since the student mastered at least two typical cultural tools of Chemistry knowledge to execute the proposed tasks, which were suggested by the tutor as part of his strategies to foster the construction of meaning. Summing up, modelling of hydrogen bond was observed to

be intrinsically shaped by the use of cultural tools, which were mastered by the student with the support of scaffolded strategies provided by the tutor.

Implications.

The analysis of two episodes in terms of structural patterns and in terms of construction of meaning have provided evidence in support that tutoring through the internet is a feasible approach to teaching-learning that can be employed as a guided strategy to assist secondary students in their school tasks. In terms of research questions, the theory of mediated action and the concept of cultural tool have proved to be a profitable approach to understand the processes of construction of meaning, when these processes are conceived on the basis of situated events. The combination of situational, structural and content aspects of the utterances with the notions of mastering and appropriation of cultural tools might be considered a powerful analytical schema to understand the interaction between students and teachers in situations of tutoring through the internet. In these asynchronous computer-mediated episodes, the interactions were observed to have similar structural patterns to interactions of face-to-face science classroom (Lemke, 1990) which also reinforces my proposition of analysing this novel approach to teaching-learning using a situated perspective to understand the process of construction of meaning.

This emergent approach to communication has just started to be investigated in linguistic terms, as the works edited by Herring (1996) and Crystal (2001) have shown. In science education, much research has to be done and in this paper we just intended to explore some aspects of teacher and student interaction that could bring

about a desired programmatic investigation. In this sense, some questions that have particular consequences to schools and research in science education still remain.

Specific features of this continuous evolving medium regarding patterns of communication have brought to the debate important aspects of e-mail interactions. In this branch of research, remaining questions point to: how might structural and situational factors in schools account for the communication patterns of teaching-learning approaches such as tutoring through the internet? How could this approach be arranged in school settings to enhance communicational skills and the overall outcomes of the teaching-learning process?

A desired outcome of enhancing students' communicational skills is the improvement in the quality of their arguments. ICT might give a key contribution to this field, as some of the Web-based environments designed to foster argumentation in science education have shown (Bell and Lin, 2000; Ravenscroft, 2000). The multimedia nature of the internet provides in fact a unique opportunity to engage students in particular aspects of science knowledge, like simulation and visualization, which might be useful to foster argumentation. However, human-human interaction is also being affected by the non-hierarchical feature of this media, so that symmetrical peer-peer interactions are a common-place nowadays. If the designing of virtual environments and activities based on ICT takes into account computer mediated and face-to-face peer-to-peer interactions, how would argumentation construction be affected by the quality of these interactions? How would dialogue practices be influenced by simulation and visualization of scientific phenomena?

For me, fostering dialogue among students and teachers seems to be the most reliable approach to start answering these questions and also to propose educational practices using this new type of communicational means.

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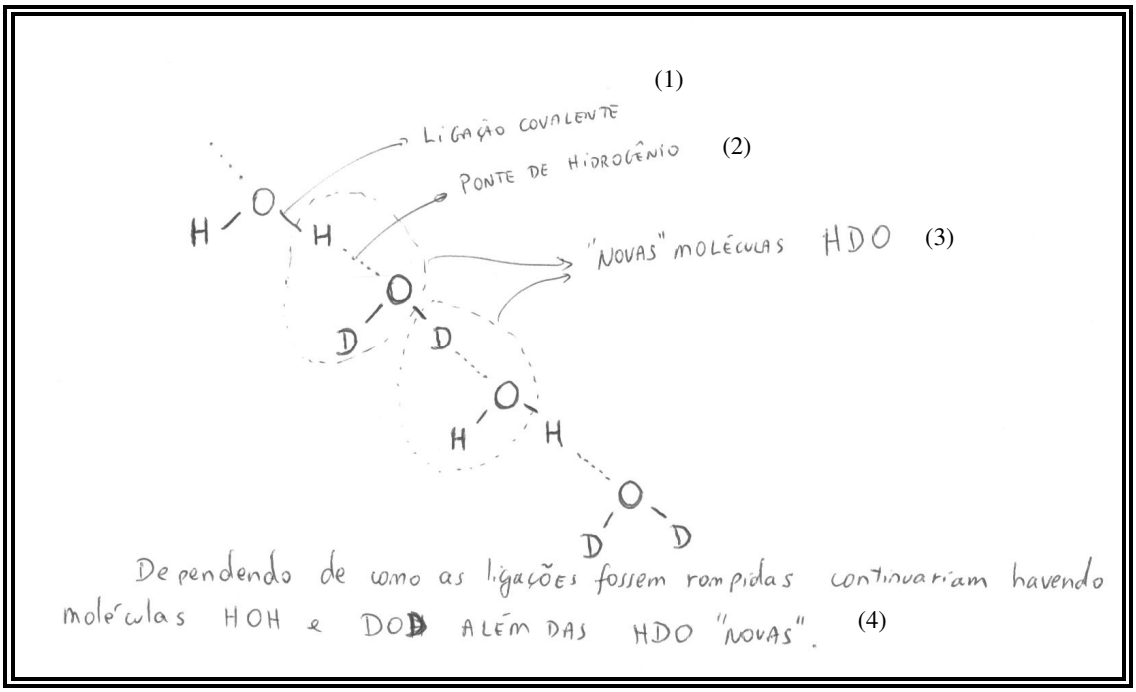
Table 1: Distribution of I-R-F exchanges through the utterances.

Utterance/ Extract	S1	T2	S3	T4	S5	T6	S7	T8	S9	T10	S11
E1		I_c	R_c	F_c	I_i	R_i	F_i/I_i	R_i	F_i		
E2	I_i	R_i	F_i	I_c	R_c		I_i	R_i	I_i	R_i	F_i
E3		I_c	R_c	F_c					I_i	R_i	F_i
								I_c	R_c	F_c/I_c	R_c

S and T refer to student and turor; sub-indexes *i* and *c* refer to *inverted* (student-initiated) and *classical* (tutor-initiated), respectively.

52. Drawing sent by the student



(1) Covalent bond

(2) Hydrogen bond

(3) 'New' molecules HDO

(4) Depending on how bonds were broken, there would keep existing HOH and DOD molecules, besides the "new" HDO