HOW TEACHERS DETERMINE WHAT STUDENTS KNOW :
COLLABORATIVE INTERPRETATION OF STUDENTS' COMPUTER-MEDIATED COLLABORATIVE PROBLEM-SOLVING INTERACTIONS*

Kristine Lund, Michael Baker

GRIC Laboratory, COAST Research Team, CNRS & Université Lumière Lyon 2, 5 Avenue Pierre Mendès France, 69676 BRON Cedex 11, FRANCE
tel. 04 78 77 31 17 — fax. 04 78 77 31 15
Kristine.Lund@univ-lyon2.fr, Michael.Baker@univ-lyon2.fr

ABSTRACT

Although teachers need to draw on knowledge of students' knowledge in order to engage in a wide range of educational activities — such as curriculum planning, explanation and even some types of adaptive tutoring — relatively little research has been carried out on what types of student knowledge teachers attempt to acquire, and how they acquire it. We propose a theoretical model of teachers' cognitive-interactional activities within an experimental reflective teaching situation. This situation employs a new research method that we call "collaborative interpretation", during which teachers study and discuss a computer generated interaction trace of a dyad's computer-mediated problem-solving with a view to engaging the dyad in a pedagogical interaction. Our model of the teacher's activity is based on viewing it as a complex explanation process, involving reconstruction of the students' activity, identification and evaluation of what is to be explained, and collaborative elaboration of aspects of the explanation process itself. This research is a first step towards achieving our long-term research goal, of designing innovative computer supported collaborative training techniques for physics teachers that provide different dynamic presentations of students' collaborative problem-solving in order to facilitate teachers' understanding.

KEYWORDS : AI ED and teacher education, modeling pedagogical interactions, collaboration and collaborative tools

1. Introduction

In order to carry out educational activities successfully, teachers need to draw on a wide variety of knowledge, such as knowledge of students' knowledge, the curriculum, teaching methods, classroom organisation, educational goals, and subject matter (Calderhead, 1991). Here we focus on the nature of *teachers' knowledge of students' knowledge* and on understanding how they acquire it in a form that is appropriate to the specific activity in which they are engaged. As De Corte, Verschaffel, & Schrooten (1991) have pointed out, there is a lack of research concerning teachers' knowledge of what students know. Research that sheds light on such a question could be useful for facilitating educational activities such as error diagnosis (e.g. Reimann, 1990), explanation (e.g. Beveridge & Rimmershaw, 1991), lesson planning (Brecht, 1990 ; Wilson, Schulman & Richert, 1987), as well as some forms of adaptive tutoring (e.g. Cox, 1991). Our main research goal is to understand the activities in which teachers engage when they attempt to interpret students' problem-solving activity, with a view to engaging the students in a pedagogical interaction.

We describe an exploratory study in the context of use of a specific CSCL[1] environment ("CHENE" — Baker & Lund, 1997). Three physics teachers were asked to study three computer generated interaction traces of dyadic problem-solving with a view to subsequently helping the dyads review their problem-solving. The design of this situation was inspired by a two-tiered version of the constructive interaction method (Miyake, 1986; O'Malley, Draper & Riley, 1984). Firstly, student dyads discuss together to solve a problem and secondly, teachers discuss these dyads' problem-solving and discussion. In the first case, the *students'* discussion should provide teachers with information on the students' conceptual understanding and problem-solving processes ; in the second, the *teachers'* discussion provides the researcher (and the teachers themselves) with information on the teachers' understanding of the students. This situation permits us to construct a virtual world in which the pace of students' problem-solving action is slowed down thus allowing teachers time to reflect (Schön, 1991) and thus *learn* about the way that students think. Our research is thus analogous to work carried out within the "vicarious learning project" (McKendree *et al.*, 1998) which aims to study how students (rather than teachers) can learn from studying or observing educational dialogues.

We propose that the teacher's activity can be modeled as a complex explanation process, involving reconstruction of the students' activity, identification and evaluation of what is to be explained, and collaborative elaboration of all aspects of the explanation process itself. This study constitutes a first stage of a longer-term research project directed towards the design of innovative computer supported collaborative training techniques for physics teachers based on providing different dynamic presentations of students' collaborative problem-solving in order to facilitate teachers' understanding.

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1 Computer-Supported Collaborative Learning.

2. Research background

Our main research questions concern the nature of the knowledge that teachers possess and acquire of students in specific educational situations, and the processes by which they obtain such knowledge. As it turns out, few precise answers to our research question are forthcoming from the available literature. Existing research has naturally concentrated on understanding teachers' *practice* (in the sense of "praxis", action) in conventional classroom situations. For example, Leinhardt & Greeno (1986) describe the cognitive skill of expert teaching as an interrelated set of organised actions (schemata). Schoenfeld (1998) proposes a model of teachers' interrelating beliefs, goals and knowledge that describes, explains and can predict in general terms teachers' classroom activity in different concrete situations. The two models differ in their account of teachers' knowledge of students' knowledge. Such knowledge is given more of a chance to appear in Schoenfeld's model. For example, a teacher's envisioning of his lesson includes how students may react to parts of it and what they may be confused about, teachers' knowledge includes students' pre-conceptions or alternative conceptions, and teachers' goals include helping students to employ specific learning strategies. Although some schemata in Leinhardt and Greeno's model provide for assessment of students' difficulty levels and teachers are seen to be seeking information about the progress of students throughout the lesson, a description of what that information specifically consists of is lacking. For example, do the teachers simply concentrate on checking students' answers with respect to their own knowledge, or do they also pay attention to specific procedures and concepts ? If so, which ones ?

Fredericksen and White (1977) helped apprentice science teachers focus on their practice by giving them a framework for collaboratively evaluating videos of their inquiry-oriented science teaching. The framework included the identification of situations that developed thinking skills in the classroom (e.g. those that made participants' thinking explicit or encouraged multiple perspectives) and in such a way gave apprentice teachers a way of recognizing their knowledge of students' knowledge. In a similar way, although more focussed on students' problem-solving and not teachers' practice, teachers in the MIT Teacher Project (Schön, 1991) were able to discover the meanings behind a students' puzzling behaviour by viewing a video of two students' collaborative problem-solving. The study showed that details of a problem-solving interaction between students, as opposed to the students' erroneous solution taken alone can inform teachers and even make them *change their minds* about students' knowledge.

The experimental situation within which our research questions arise shares similarities with the "video-clubs" that focus on teachers' practice or students' problem-solving but differs in several important respects from the normal classroom situation in which teachers' practice has previously been studied.

- Firstly, our situation is unusual for teachers in that they have access to *the students' problem-solving processes*, including especially their dialogue, in the form of a computer generated interaction trace. In most conventional classrooms (at least those in most European countries), teachers have little time to pay attention to the essentially private discussions of students working in pairs : their access to student thinking is usually restricted to marking their work. The access we provide them (analysis of an interaction trace) is a new activity for teachers.
- Secondly, teachers *have time to reflect* on the students' activity, offline, which would not normally be the case in a classroom, even if they could pay attention to a small group — they would normally have to understand and react in real-time. Nevertheless, teachers do enter subsequently into a pedagogical interaction in real-rime with the students whose activity they reflected on, contrary to the video-clubs.
- Thirdly, the situation we are studying is integrated into a situation involving *computer-mediated communication* — for the students' own work and the teachers' pedagogical interactions with dyads —, this being a situation which is completely new to most teachers.
- Fourthly, contrary to their classroom practice of explaining domain notions or procedures to students, teachers are explaining students' problem-solving to other teachers. This provides them with an opportunity to discuss students' knowledge with their peers. In addition, contrary to the video-clubs, this discussion is geared towards going online with their students.

In spite of the differences with the classroom, teachers are nevertheless participating in a cognitive activity in preparation for a form of teaching (reviewing a dyad's problem-solving) that is specifically designed for gaining knowledge about students' knowledge. We aim to understand the way that teachers bring to bear their professional practice on this new situation, and the extent to which they are able and willing to adapt it to new needs. The following are examples of general questions to which we sought initial answers in this exploratory study :

- Given that teachers, in their everyday practice, obtain their understanding of students from classroom discourse and marking students' copies, would they only concentrate on correcting the solution produced at the end of the problem-solving session, or would they be able to extract useful information from the study of the problem-solving process itself?
- Would the teachers only be concerned with correcting errors, or would they also be able to recognise potential for conceptual understanding that could be taken up in the subsequent interaction?
- To what extent would they pay attention to problem-solving processes as well as solutions?
- Would they be concerned with only the students' understanding of the teaching domain, or would they also be concerned with the extent to which the students "worked together", i.e. collaborated?

In the rest of the paper we describe an empirical study designed to answer these general questions, as well as our specific questions concerning teachers' knowledge of students.

3. Empirical Study

3.1. Students' problem-solving task

The students' task was to draw an energy chain for an experimental situation they could manipulate : a battery connected by two wires to a lighted bulb. Each student had a handout describing elements of the energy model. (See Tiberghien, 1996 for a description of the teaching sequence in which this task takes place). The task was a *modelling* problem and involved establishing relations between objects and events (e.g. battery, bulb, electricity), to concepts of the energy model and theory (reservoirs, transformers and transfers of energy). Figure 1 shows a correct energy chain for the battery-bulb problem.

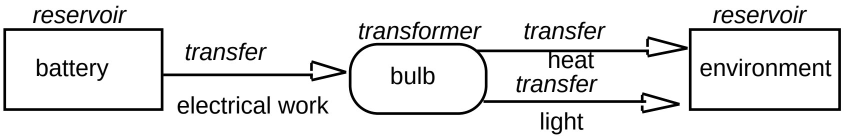

Figure 1. Correct energy chain for the battery-bulb problem

3.2. Phases of the study

Our study took place in our laboratory. Three physics teachers and six students (16-17 years old) following a scientific curriculum participated. Our three-phase experiment (see Figure 2) was designed around a teaching sequence on modelling energy in physics elaborated by Tiberghien (1996) that has become part of the official French curriculum. In phase 1, two students worked together with C-CHENE (cf. Baker & Lund, 1997 for a description) to exchange typewritten messages at a distance across the Internet and to construct their energy chain. Students worked for 30 minutes.

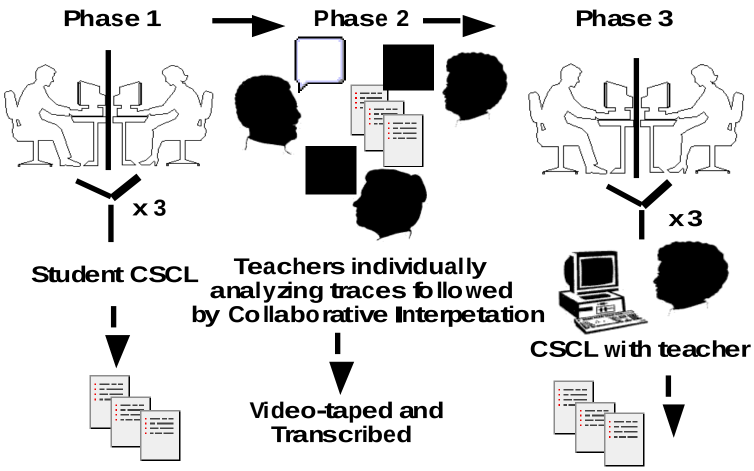

Figure 2. The three successive phases of the experimental situation : three dyads problem-solving in phase 1, three teachers each analyzing a dyad and then discussing in phase 2 and each teacher going on line with the dyad she analyzed in phase 3.

In phase 2, all the steps leading up to the three energy chains that the three pairs of students collaboratively produced on the computer and the messages they exchanged during this activity were printed out and given to the physics teachers. They were also given a screen copy of the students' final energy chain. Previously, the three teachers had practiced analyzing an example of what we will henceforth call an *interaction trace*, a chronological listing of the students' problem-solving activity involving C-CHENE and the messages they exchanged during this time (see Figure 3. for an example). The teachers were asked to perform three analysis activities on paper with a view to going on-line with Prof-CHENE (a version of C-CHENE with a communication space for the teacher) to help their student dyad in phase 3 :

1. Note the elements (both dialogical and graphical) in the interaction trace you believe are pertinent in the energy chain your dyad created ;
2. For the elements that you marked as pertinent, in your opinion, what are the reasons the students did or said what they did? and
3. Think about how you could use the information gained in 1) and 2) to help your dyad in phase 3.

The teachers analyzed their interaction traces individually for about 20 minutes. In the second part of phase 2, each teacher was asked to present the analysis of her dyad to her colleagues. This discussion lasted 45 minutes and was video-taped. The data presented in this paper is this transcribed discussion, approximately 25 analyzed pages. In the final phase, each of teachers went on-line with their dyad, everyone on his/her own computer. Each of the three student-student-teacher triads had the student dyad's final energy chain on the screen.

Each teacher and student dyad exchanged messages concerning the students' work on the energy chain. This phase lasted approximately 40 minutes. Teachers discussed for approximately twenty minutes following phase three. This discussion was also video-taped and transcribed. At a later date, the three teachers participated in a debriefing session with two researchers where they viewed part of the video-taped discussion in phase 3. Notes on the teachers' comments were taken by a researcher during this session.

[2] [DIALOGUE] [173 s] [Charlie : we can represent the battery by three reservoirs]
[3] [CONTROL] [191 s] [communication interrupted in order to communicate accepted]
[4] [DIALOGUE] [238 s] [Jon : I going to create a reservoir named battery, ok, you do it, ok?]
[5] [CONTROL] [253 s] [communication interrupted in order to construct accepted]
[6] [GRAPHIC] [267 s] [reservoir created reservoir 1]
[7] [CONTROL] [276 s] [construction interrupted in order to communicate accepted]
[8] [DIALOGUE] [377 s] [Jon : how do you want to name the transfers between the different reservoirs of the battery? I think it might be better to just do one reservoir]

Figure 3. A partial interaction trace student problem-solving and communication using C-CHENE, exactly as presented to teachers (translated from French)

3.3. Corpus collected and analysis approach

A systematic analysis of the teachers' utterances was carried out, the goal of which was to elaborate a model of the teachers' cognitive activity (cf. Figure 4). The trilogue was divided into utterances according to the smallest meaningful segment for the given context. For example, a single speaking turn might contain 3 different utterances. Turn 314 (cf. Table 4) contains an explanation followed by a reconstruction and an explanation.

Teachers' main cognitive activities during their discussion of their analysis can be described by the following categories : *reconstruction*, *identification*, *explanation*, *evaluation* and *projected remediation*. An utterance can sometimes be multi-functional, both evaluation and identification for example.

- Reconstruction is the process of rebuilding the students' problem solving with the help of the interaction trace, of reconstructing a mental model of the dynamics of the students' activity. This means recognising the evolution of the energy chain the students built as well as what they said about it and potentially what they thought about it.
- Identification is singling out a graphical or dialogue trace element for explanation. In fact when an interaction trace element is identified, this is because it satisfies one or more of a set of triggering conditions for explanation (see § 5).
- Explanation is the process of generating "something that explains" for "something to be explained" (see § 5) ; it crucially involves adjusting and matching representations of what is to be explained, and the explaining entity (in this case, a linguistic production), in order to achieve a coherent understanding (Baker, 1996)
- Evaluation refers to judgmental (either positive or negative) statements concerning student activity.
- Projected remediation is something the teachers mention they would like to either ask the students or have them do during the review of the dyad's problem-solving on line with the teacher (phase 3) ; some cases this can correspond to elaborating a partial tutorial plan.

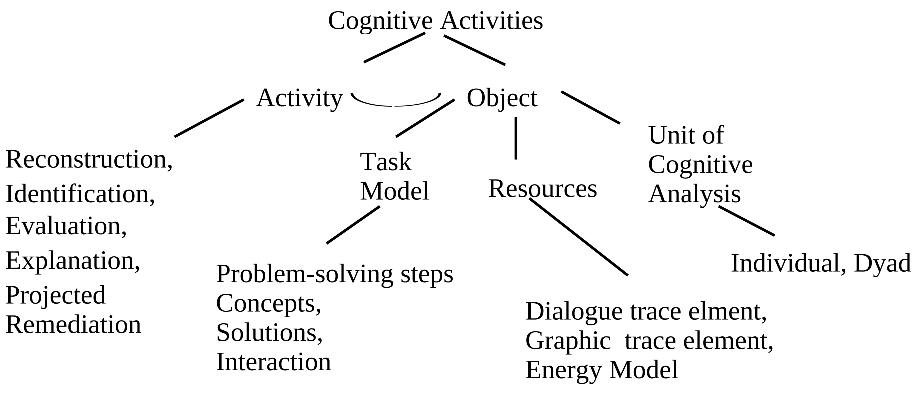

Figure 4. Analysis categories for teachers' cognitive-interactional activities

Each cognitive activity carried out by a teacher is applied to an « object ». An object has three components : a task model, a resource, and a unit of cognitive analysis. The task model is defined by the problem-solving steps, concepts, solutions and interactions between the students concerning the modeling of energy. Resources used by the teacher while performing a cognitive activity are what the students wrote to each other (dialogue trace element), the parts of the energy chain they drew (graphic trace element) or the energy model handout, given to the students at the beginning of their problem solving. Finally, an object has a unit of cognitive analysis : the cognitive process in question is instigated by the teacher either in relation to the individual or to the dyad treated as a single unit of analysis.

4. Results

4.1. Quantitative

We present quantitative results according to our analysis categories, taking the group of three teachers as a single cognitive unit of analysis. In fact there were no appreciable differences between the individual teachers' analysis styles, and most cognitive activities were carried out in collaboration between them. Although some of the utterances were multi-functional, a decision was made to assign each to a single category depending on contextual information.

The first aspect that we were interested in was the extent to which the teachers attempted to *reconstruct* the students' activity, in its temporal sequence, from the interaction traces (see Table 1) — to what extent would they exploit the trace elements to their full (pedagogical) potential ?

Table 1. Elements of interaction traces that the teachers attempted to reconstruct

	Trace elements		Graphic elements		Dialogue elements	
	Total N	N reconstructed	Total N	N reconstructed	Total N	N reconstructed
Totals (teacher group)	204	**109**	130	**75**	74	**34**

From Table 1 it can be seen that teachers only attempted to reconstruct approximately half of the interaction trace elements, whether they were dialogue or graphical actions. There was no noticeable difference between their focussing on graphical problem-solving steps and students' dialogue.

The second aspect concerns the cognitive activities teachers engaged in and what they were in relation to — e.g. explanation or evaluation of concepts or solutions. Table 2 shows that most of the teachers' utterances concerned reconstruction of the students' activity from the interaction trace that focused on specific steps of the students' problem-solving. Only 11% of reconstructions focussed on conceptions. However, 36% of identifications were in relation to problem-solving steps and 56 % in relation to conceptions. Evaluation was evenly divided between problem-solving and conceptions. Most strikingly, 20% of explanations were in relation to problem-solving steps while 76% were concerned with conceptions. There was not much projected remediation. However, 26% dealt with problem-solving and 70% with conceptions. There was no reconstruction or evaluation on the solution (final energy chain) and no projected remediation on the students' interaction.

Table 2. Repartition of cognitive activities to task model elements

	Reconstruction	*Identification*	*Evaluation*	*Explanation*	*Projected Remediation*
Problem-solving steps	94	16	18	13	6
Conceptions	12	25	18	50	16
Interaction	3	1	1	1	0
Solution	0	2	0	2	1

Finally, we were interested in the possible *patterns* in teachers' cognitive activities (e.g. is there a "script" of the type reconstruction—evaluation/identification—explanation—remediation ?) and what is the degree of (co-)elaboration of activities ? (see Table 3). For the present our results concern only consecutive pairs of activities.

Table 3. Table of relations between consecutive pairs of activities

1st ↓ 2nd →	***Reconstruction***	***Identification***	***Evaluation***	***Explanation***	***Projected Remediation***
Reconstruction	53	**12**	**15**	**16**	**1**
Identification	**9**	**5**	**3**	**12**	**2**
Evaluation	**12**	**3**	**4**	**3**	**3**
Explanation	**13**	**14**	**4**	**20**	**0**
Projected Remediation	**1**	**1**	**3**	**1**	**10**

Reconstruction appeared to be the most (co-)elaborated activity (53), for consecutive pairs, followed by explanation (20), then projected remediation (10). Reconstruction was mostly followed by explanation (16), evaluation (15) and identification (12), but very infrequently by projected remediation (1). Explanation itself was mostly followed by identification (14), then reconstruction (13). However, such transitions can also correspond to moving to analysis of a separate aspect of the students' problem-solving. Another possibility that was sometimes observed was where identification of something to be explained, followed by explanation generation, then led to a return to trying to clarify what should be explained. Explanation was never immediately followed by projected remediation.

4.2. Qualitative : an example from the teachers' discussion

Table 5 shows an extended extract from the teachers' discussion. The teachers are discussing the energy transfer arrow, labeled "electricity", in one dyad's energy chain (Figure 5) (see §3.1 for the correct solution).

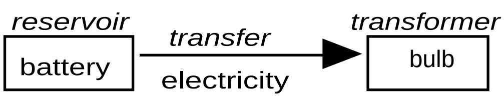

Figure 5. Students' energy chain discussed by teachers (Table 4).

The extract begins (312) with T3 reconstructing the students' problem-solving from the following graphic element in the interaction trace :

[29][GRAPHIC][link 1 from the battery to the bulb has been called : electricity]

Interestingly, the teachers' unit of cognitive analysis here is the *dyad* rather than the individual student (the teacher uses the word "they"). In 313 T1 identifies what is to be explained : why did the students name the transfer "electricity" ? The reason why explanation is 'triggered' is that, from the point of view of the teachers, the students' thinking behind the term "electricity" is unclear — although there is no *global* transfer of electrons from the left to the right, the electrons have traveled from the left wire and returned on the right. Do the students think that if there is a global displacement of energy, there is a global displacement of electrons (misconception)? Or do they realize that there is no global displacement, just local displacement that produces “electrical work”? The teachers’ discussion is not conclusive and one suggests that T3 evoke this potential confusion in phase 3, when each teacher reviews the problem-solving of her dyad with the dyad on-line. It is clear in this case, and throughout the rest of the extract, that the teachers are addressing the students' conceptions. We note the alternation of explanation and reconstruction activities in the middle of the extract, followed by an incomplete proposal for remediation.

Table 4. Analysis of teachers' collaborative interpretation : phase 2

N/ Teacher	*Discussion*	*Activity*	*Task Model*	*Resource*	*Cog. Analysis Unit*
312aT3	And then they do an arrow, uhh, a transfer	Reconstruction	Prob. Sol. steps	Graphic	Dyad
312bT3	and this arrow then that goes from the battery to the bulb				
312cT3	they call electricity, so in fact...				
313T1	Why is it electricity?	Identification	Conceptions		
314aT3	Yes, they have, yes, and then they haven't assimilated that it was by mode of transfer, by electrical work, I mean.	Explanation			
314bT3	So then, one of them says : - are you sure that there's a displacement of electrons?	Reconstruction		Dialogue	Individual
314cT3	So, here too there is a confusion.	Explanation			
315aT1	Yes, but in fact, you see, displacement of electrons...	Reconstruction			
315bT1	The idea of a transfer of work is present.	Explanation			
316T3	Yes, the idea is there				
317T2/T3	the mode is work				
318aT1	Because here, it says nja nja nja nja nja -			Energy model	
318bT1	there is displacement of an object, or a part of an object, there is displacement of a charge				
319aT3	There is the electrical work of the current			Dialogue	
319bT3	Yes, yes				
320T2	We could still evoke...	Proj Rem.			
321aT3	The idea is still underlying	Explanation			

5. Discussion : towards a model of the teachers' cognitive activity

Two main points arise from the results described above, in relation to our research questions stated previously.

Firstly, it appears that teachers *are* able, to some extent, to adapt their previous experience to an experimental situation designed to provide them with knowledge about students' knowledge. They do attempt to reconstruct students' problem-solving processes, and their degree of understanding of fundamental domain concepts, and do not solely focus on end-results, i.e. the students' solutions. However, the fact that they spend most time on reconstruction, rather than on, for example, the explanation process itself, indicates that our future work needs to be directed towards facilitating this reconstruction process, i.e. providing interaction traces that facilitate reconstruction of the dynamics of the students’ activity. The aim would be to facilitate this process without eliminating the perceived need on the part of teachers to seek for explanations.

Secondly, the teachers' activity, in the situation studied here, appears to be complex : no simple "script" can be readily identified — for example, the processes of evaluating problem-solving, identifying aspects to be explained, reconstructing what is to be explained, and elaborating an explanation for it, seem to be closely intertwined.

On the basis of these results, we propose that the teachers' activity can be modeled as a complex *explanation process* (see Figure 6).

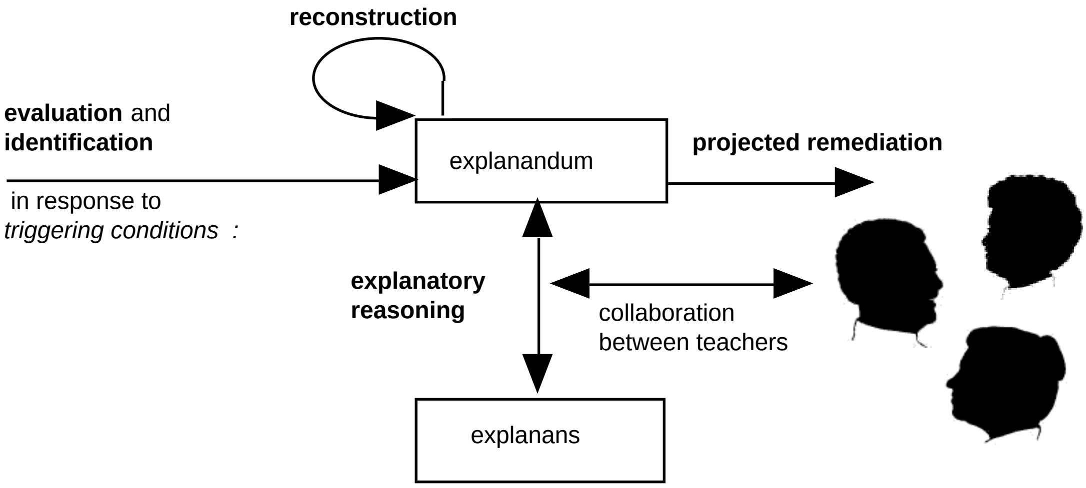

Figure 6. A proposed model for teachers' activity as an explanation process

Using Hempel's (1966) terminology, Baker (1996) describes explanation as a *process* of finding an "explanans" — the thing that explains — for an "explanandum" — the thing to be explained. In our case, the explanandum will correspond to aspects of the students' problem-solving, conceptual understanding, problem-solving steps, the solution and interactions ; the explanans corresponds to an utterance or a sequence of collaborative interaction between teachers. However, unlike the case of Hempel's epistemology of science, the explanandum and explanans are not necessarily absolute : the nature of the explanandum has to be reconstructed or elaborated ; its relation with the explanans will usually be negotiated. To that extent, the explanation process itself can be viewed as a specific type of *(student) modeling* that involves adjusting and matching *two* sets of representations (explanandum and the explanans). Consider an example from explaining the weather. Initially what is to be explained, the explanandum, might be described as "dark clouds" ; however, under this description it may be difficult to elaborate an explanans for it, in which case the description of the explanandum may have to be elaborated, for example to give a more technical description of the clouds, so that this description can match with the explanans. Similarly in the extract in Table 1, a teacher first identifies an explanandum (the transfer named electricity), a second teacher makes a first attempt at explanation by producing the explanans (the students have not understood the concept of electrical work). There is a refining of the explanandum (What *do* the students think about displacement of charge?) with the next reconstruction (So then, one of them says "are you sure that there's a displacement of electrons?"). This new explanandum produces conflicting explanans ("So, here too there is a confusion" vs. "The idea of a transfer of work is present.") that are not completely conciliated in the teachers' discussion.

Finally, one does not seek to explain anything and everything : the explanation process has specific *triggering conditions* (cf. Dessalles, 1993) such as surprise, contradiction within students' previous activities, mismatch with teachers' own previous knowledge, students' errors or correctness, ambiguity of students' activities, evidence of students' hesitation or differences between students, and so on. Usually these triggering conditions will be related to the overall *goal* of the activitiy within which explanations are generated — in this case the teachers are explaining students' activity in order to provide remedial teaching.

6. Conclusions and Further Work

On the basis of our exploratory study, we can conclude that our experimental situation, involving collaborative interpretation, is a potentially viable means for studying the knowledge that teachers possess and acquire of students' knowledge. Our situation can favour teachers' reflection, outside classroom management and/or time constraints, on students' problem-solving processes, as a means of knowledge acquisition. However, there appears to be potential for teachers putting more emphasis on understanding the nature of the collaboration between students, and not just their domain-related activity.

Teachers' knowledge of students' knowledge appears to essentially be locally determined by needs for explanation, in comparison with their prior knowledge. In future work we therefore require a more adequate understanding of teachers' background knowledge that could be brought to bear on this innovative task. Viewing the teachers' activity as a complex form of explanation appears promising ; similarities and differences between viewing teachers as trying to explain and with describing their activity as "student modelling" in AI and Education research, remain to be explored.

In the medium term, our analysis approach and model needs to be applied to a larger corpus of interactions between teachers. Our present work provides a promising basis for this.

Finally, the need for presenting interaction traces to teachers in a form that facilitates their understanding is readily apparent from our research ; our research also provides some indications as to what forms of understanding need to be facilitated. Teachers need both better access to the dynamics of student problem-solving and to its conceptual underpinnings. Obtaining such corpora requires both new presentation techniques that exploit the power of computational media, and proposing problem-solving tasks to students in the first place that encourage them to make their conceptual understanding explicit. Further research will focus on designing a situation using computer-mediated communication that facilitates teachers' acquisition of appropriate knowledge about students' knowledge. Our aim is to render teachers' models of students' more coherent and complete whilst emphasising modelling students' conceptual understanding.

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