# Individualistic appropriation as a primary mechanism of collaborative conceptual change: a case study

Michael Tscholl, University of Central Florida, 12461 Research Parkway, Orlando, FL 32826, USA, mtscholl@cs.ucl.ac.uk

John Dowell, University College London, Malet Place, WC1E 6BT London, UK. jdowell@cs.ucl.ac.uk

**Abstract:** Collaborative learning with cases and problems is characterized by the contribution of disparate knowledge and varying interpretations. The way in which this public knowledge is exploited individually to construct a conceptualization of the problem is examined here. The paper presents a microanalysis of a collaborative case-centered learning dialogue between three learners where a novel conceptualization is constructed re-using selected surface and structural elements contained in a prior conceptualization. How the novel conceptualization is constructed is shown by tracing surface and structural knowledge in the sequence of contributions and by identifying the point-of-view adopted by the learners. We argue that a mechanism of individualistic appropriation accounts for this construction, and this mechanism may be central in collaborative learning. This entails a revision of the notion of co-construction in collaborative learning.

## Introduction

In collaborative problem- or case-based learning, a divergence of views on how to conceptualize and frame the problem or case is a common occurrence. Groups' discussions are characterized by the effort to identify the right way to understand the problem, a process that may then produce the conceptual change we usually regard as learning. Through the sequence of discursive exchanges, different viewpoints on a problem will change and so also will the way in which problem aspects are conceptualized.

A fundamental research issue concerns how a change in conceptualization is achieved within a group and whether the change results from an individual developing it, or whether the group develops it jointly. An individual may put forward a view of the case or problem that may become the basis for the groups' conceptualization, or a different viewpoint may be proposed becoming the new basis. In other words, a conceptualization may *evolve* through transforming a prior conceptualization, or it may be created *de novo*, in part with selected elements of surface and structural knowledge contained in prior conceptualizations. By implication, effective collaborative problem-based learning may not depend on one person internalizing another's view; their own learning may develop through incorporating elements of the views put forward by others, possibly then resulting in the advancing of alternative conceptualizations, which may then be recognized as correct (given a specific task context) and adopted by others.

This paper is a case study of a discussion between three medical students working in a virtual learning system (featuring a chat tool and a means to navigate the learning material) to interpret a case of alleged medical negligence concerning a patient's consent. The students were tasked to interpret the case within given concepts of medical law, interpreting the facts of the case and relating them through consideration of those concepts. Individual viewpoints are central to our analysis and by identifying the viewpoints of learners' contributions, we describe how knowledge deployed within a conceptualization is taken up and re-used to support a different conceptualization. In this way, the development of conceptualizations as well as the change between them can be captured.

The analysis adopted the perspective of problem structuring and its corollaries of story abstraction and concept-fact bindings to interpret the interactive nature of the students' activities. This allows us to trace the introduction of facts and relational knowledge (in support of one or another viewpoint) and then, more importantly, to trace how facts and relational knowledge are taken up subsequently within a different viewpoint resulting in a different structure of the case. By adopting this perspective, we can show what a learner does with the knowledge being shared with them and how the reuse of knowledge relates to the development of the abstract representation of the case.

Through this analysis, we show that the development of an abstract representation of the case conforming to the set learning goals – namely the structuring of the case in relation to domain knowledge – results from an individual appropriating selected knowledge elements and the restructuring of knowledge conveyed in prior contributions.

## Iterative development of representations

Joint construction of knowledge is deemed to lie at the heart of collaborative learning and is a complex and multi-dimensional phenomenon (Hausmann, Chi & Roy, 2004). An influential model treats joint construction as the process of conceptualizing the problem within a shared problem space (Rochelle, 1992). Within this problem space a more or less virtual representation of the problem is produced and iteratively improved through successive contributions made by different people. The group converges on a set of shared meanings and shared view of the problem and problem solution by gradually aligning their views. Conceptual change, according to this model, results from the tendency of convergence: in the effort to be communicative and collaborative, peers' cognitive responses are gradually aligned resulting in a shared representation of the problem.

The prime attraction of the shared representation model is the explanation it affords of how conceptualization of the problem develops within the group with each group member contributing conceptually. The group produces a shared representation of the problem, albeit incomplete and flawed, and continues to refine it collectively. The conceptualization evolves as different meanings for concepts and different ways of structuring the problem converge on a common meaning and structure.

## Individual representations

However, the development of a shared problem representation is not intrinsic to collaborative knowledge construction, and learners' individual construction of representations is at least equally plausible. For example, Miyake & Shirouzu (2002) argue that whilst collaborative learning from problem solving may seemingly correspond with a 'one voice' interpretation, close inspection of a group dialogue reveals that each person is instead using the others as "stepping stones" to enable them to elaborate a distinctive, individualistic representation of the problem. Peers within a group provide a vital monitoring role for each other, allowing them to develop their own individual representations of the problem (Shirozou, Miyake & Masukawa, 2002). This individualistic approach allows that people can develop conceptualizations through integrating different considerations about the problem features and the relevant underlying concepts; however the conceptualizations remain essentially personal and re-interpretation occurs within the person.

The individualist model of collaborative problem-based learning supports a characteristically different explanation of how conceptual change occurs wherein each individual is seen to generate and modify their own conceptualization of the problem but influenced by others' conceptualizations. One way in which this influence may work is that a person internalizes and adapts the conceptualization offered by one of their peers in the group. Alternatively, the conceptualization is created wholly *de novo* by the individual but likely incorporating elements of the conceptualizations offered by the peers.

## Interaction

The individualist model sees interaction within the group as having a fundamentally different role of supporting the learners in developing their own perspectives, engendering, for example, more thorough checking and modifying of individual understandings (e.g. Miyake, 2007). In this view, individuals' construction of their own knowledge is a consequence of being challenged and critiqued (e.g. Glachan & Light, 1982) rather than a result of individuals building on each other's knowledge. In interactive situations learners are seen to readily produce explanations from which they themselves benefit most; this 'self-explanation effect', (Chi et al., 1994) is naturally consistent with the individualist model. More generally, for the individualist model the effect of learners being in a collaborative situation is primarily pragmatic: the situation engenders specific roles (the monitor, the task-doer; the explainer, the listener) that in turn result in re-elaboration of an individual's knowledge, and learners may change their understanding independently on the alternative understandings proposed by someone else (e.g. Schwarz, Biezuner & Neuman, 2000).

Central to research on interaction is the question of the mutual dependency of learners' activities and the level of the content, i.e. knowledge deployed in the groups' cognitive environment. In CSCL research, various concepts have been proposed to capture 'interactivity' in order to articulate claims about the role of interaction in learning (e.g. Fischer & Mandl, 2005). The concept of uptake (Suthers, 2006) is specifically intended to capture not only the pragmatic aspects of an interaction, but also the way in which the content of learners' contributions are related, and hence possibly dependent. Uptake describes how learners move within a shared problem space, each one adding, modifying, elaborating or combining knowledge and understanding of the problem at hand and influencing each other by the continuous refinement of that problem space. However, radical changes in conceptualization during a group learning session may be difficult to capture without also analyzing the point of view or perspective learners currently work within. These perspectives may not only be held and maintained by an individual, but may also be at the heart of changes in conceptualization that often represent the most advanced forms of collaborative learning. By identifying the point of view or perspectives of individual learners we can pinpoint the mechanisms through which such changes are engendered. Such perspectives are visible in the way in which a case or problem is structured, that is, in the way in which facts are

interpreted and related to each other, forming an often hierarchical multi-level abstract structure whose 'peak' is the 'point' or 'story' of the case. The notions of conceptualization and structure, and the processes of structuring and concept-fact binding are thus central in our analysis, and will be introduced now.

## Structures, structuring and conceptual change

In general, problems or cases (in this paper we use the terms interchangeably) consist of surface features and structural features. The surface features are the concrete aspects of the problem, both given and implied, and can include agents, objects, actions and events. For example, in the case of medical negligence used in the case study that follows, a surface feature is the low level of patient risk associated with the medical procedure. A problem also has a structure that represents its point or story. The structure is an abstraction that binds the surface aspects of the particular problem to the domain concepts. For example, in the medical case the structure is the causal relationship between the injury suffered by the patient in the operation and the failure to inform the patient of the risk associated with the medical procedure (i.e., if the patient had known about the risks, would they have consented to the operation). The question of the surgeon's liability turns on this point.

To conceptualize a problem is to develop a representation of the structure of a problem. It requires a person to have knowledge of the domain from which the appropriate concepts can be drawn to produce a correct structure. In the medical negligence case, to produce a correct structure the learners need to already know that the law requires one to show that harm to a patient was *caused* by the actions of a doctor, not simply that the doctor's actions were deficient.

## Method

The first analysis identified the argumentation structure of the dialogue. Utterances were categorized into claims, counter-claims, confirmations and elaborations. This gave us an overview of the overall dynamic of the discussion as well as insight into the individual perspectives adopted by the students.

A second and more important analysis we employed is verbal analysis (Chi, 1997) that focused on the content of the chat messages. This analysis assumes that specific terms represent a learner's view of the problem, and that the cognitive structural representation of a problem can be uncovered by analyzing the use of relational terms (such as 'because', 'but', etc.). To capture the relations between contributions, a further analysis, based the earlier verbal analysis, identified topical relationships between parts of or the complete contribution. So, for example, we checked whether a structural relation evident in a contribution was mentioned in a subsequent one; or whether contributions mentioned the same fact of the case. Based on this analysis, speculations about the relations of earlier utterances on subsequent ones were made, therefore giving us a picture of the interactivity between the learners.

## The study

### The learning setting

The setting for this study was a purpose built distributed and collaborative virtual learning environment. The students were remote from each other and all their communication was mediated by the system through a chat tool. The chat window can display 30 lines of text at one time, allowing the most recent exchanges to be reviewed. The user interface also contains a menu that allows users to select the content of a display window containing the case text and the background to the core notions of medical negligence. The system recorded all text-communication and the student's use of the hyperlinks. The study lasted about 20 minutes.

A group of three undergraduate medical students participated in the study. The students were given five minutes to read a short summary of the lecture on medical negligence they had attended. The students were then presented with the description of the case and were asked to explain the judge's verdict.

### The case

The students discussed the 'Chester case', a case of negligent liability. The text given to the students read:

> "Miss Chester suffered from chronic back pain and consented to neurological surgery. After the surgery, she had extensive motor and sensory impairment. The kind of surgery done, it was accepted, carried some unavoidable risks and a one to two per cent chance of serious complications. It was also accepted that a patient such as Miss Chester should be informed of those risks.
>
> The extent of this warning was disputed. The doctor claimed she had been warned adequately. Miss Chester countered that her fears about being 'crippled' were brushed aside and she had been told that the operation was merely a routine procedure. She went on to claim that if she had known about these risks she would not have agreed so easily to surgery without giving it more thought and/or seeking a second opinion.
>
> Additional information: There was evidence of her aversion to surgery – judged unlikely to be so reduced in three days, if she had been adequately informed of the risks."

## Analysis results

### Introduction

We will begin the analysis of the dialogue by describing the views taken by each of the three students – Erin, Claire and Susan (not their real names) – because the dynamic between the different views is central to our claim for the reuse of knowledge.

The essential dynamic is simply described as follows: Erin proposes a judgment of the case based on its conceptualization in terms of informed consent. Susan, while initially accepting and contributing to that conceptualization, changes, at the end of the first half of the discussion, radically her view of the case, and correctly applies the concepts and conceptual relations pertinent for negligent liability. Claire contributes more significantly than Susan to Erin's conceptualization, but analyses it critically, and by doing so, furnishes Susan with structural knowledge upon which Susan then builds her new conceptualization.

### Erin and Claire

Erin opens the discussion by introducing the concept of informed consent to conceptualize the case (figure 1, line 77). As described earlier, this conceptualization relies on ethical principles (primarily the principle of non-paternalism, i.e. the prohibition to limit a person's autonomy or liberty even if it is thought to be for their own good; the requirement of informed consent derives from this principle) and is complementary to the 'legal view' that the students *should* adopt. She concomitantly judges the surgeon's behavior by appeal to this view.

| | | |
|---|---|---|
| 77 | *Erin: I think the doctor has failed to achieve appropriate consent* | conceptualization (judgment) |
| 78 | *Claire: the risk was small 1-2%* | countering 77 |
| 79 | *Susan: he got consent, just not an informed one* | elaborating 77 |
| 80 | *Claire: he must have had the consent* | countering 77 |
| 81 | *Claire: informed but not well enough informed* | countering 79 |

Figure 1. Students' initial argumentations within the concept of 'informed consent'

Erin's view is therefore not incorrect, but rather misplaced. Claire attempts to counter the severity of that view arguing that that 'the risk was small' (figure 1, line 78), and that what has been told the patient suffices that the consent obtained is an informed one. It is important to point out that this argument is essentially incorrect because the requirement of informed consent stipulates that the patient needs to be informed independently of any other consideration.

| | | |
|---|---|---|
| 82 | *Susan: even risk of death from GA is small, but patients have to be told all the same* | countering 78, confirming 77 |
| 83 | *Erin: exactly he didn't fulfill the criteria of legal consent. i.e. the patient should understand the risks involved be able to weigh then in a balance and recall them.* | confirming 77 |
| 84 | *Claire: but if she had been told the risks and heard that there was only a 1-2% chance that it would go wrong, she might have dismissed it thinking that it probably wouldn't happen to her* | countering 82 |
| 85 | *Susan: do you think that the patient should be told of every possible risk?* | |
| 86 | *Erin: but there is evidence of her aversion to surgery* | countering 84 |

Figure 2. Claire's countering of the severity of the lack of information. It introduces the relation between the knowledge of the risk and the patient's decision, within the perspective of informed consent.

Erin continues to maintain that informed consent was not obtained (figure 2, line 83); while Susan confirms the absolute requirement to inform a patient (principle of non-paternalism; line 82, figure 2). Claire counters these absolute stances by reiterating that the risk was so small, that even a fully informed consent wouldn't have changed the patient's decision (figure 2, line 84). We view the introduction of this relationship as an essential stepping-stone towards the switch in perspective and the development of the correct conceptualization (see section on Susan, below). Through this argument, Claire introduces, for the first time in the dialogue, a relation between the knowledge about the risk and the patient's decision, albeit this relation is 'deployed' within the ethical perspective and in order to counter Erin's insistence on the principle of non-

paternalism. Claire's thinking in relation to the 'smallness' of the risk is evident in line 92 (figure 3), giving us proof of Claire's working within the ethical perspective.

The introduction of this relation (a structural knowledge) is crucial for the discussion, and indeed this relation is a core relation of the structure of the case within a conceptualization centered on negligent liability. Indeed, the plaintiff (Mrs. Chester) will have to convince the court or jury that if she had been fully aware of the risk, she would have not consented to the surgery. Through this, a relation of causality or co-causality between the surgeon's action and the harm is established.

## Susan

It is Susan who reuses the relation between the knowledge of the risk and the patient's behavior, to propose the novel (and correct) conceptualization of the case based on the concept of negligent liability (figure 3, line 90)

While not expressing the novel conceptualization as a question (the question to be answered in court), Susan's utterance displays the correct relations between the facts of the case in terms of negligent liability. Susan's reference to both aspects (knowledge of the risk and patient's decision) in utterance 90 is evidence that she had generated her new conceptualization on the basis of aspects that had become the main focus of the discussion. Susan's accomplishment is to isolate the aspects used earlier to support a different view, and insert them into a new structure.

| | | |
|---|---|---|
| 90 | *Susan: so had she known of the risks, she would have continued to suffer from chronic back pain* | (new) conceptualization |
| 91 | *Erin: that would be up to her* | |
| 92 | *Claire: patients should be told all the risks, but some risks are so small that there's no point emphasizing them too much otherwise you'll just end up worrying the patient (probably unnecessarily)* | countering 89 |

Figure 3. Susan's different (and correct) conceptualization (line 90): the correct relation between the 'knowledge about the risk' and the patients' decision.

## Claire

Claire switches between the views established by her peers. She initially embraces Erin's view, but remains critical of it. Claire's contributions are mostly counter-claims to Erin's conceptualization, but occur within the view of informed consent. They are shown here in context.

Claire's first contribution (line 78, figure 1) counters the judgment entailed by Erin's use of the concept of informed consent. Claire's use of the 'smallness of the risk' is unclear in 78, but is reiterated and becomes clear in 84 (figure 2). Claire's position on the case, reiterated and evident also in 92 (figure 3), is the following: she accepts that the surgeon has violated the patient's right to information, but proposes to include, in an eventual judgment, mitigating circumstances. Specifically, she argues that since the risk is so small, there was no need to acquire informed consent.

It is crucial for our interpretation to understand that Claire, despite her proposal to take into consideration the special and mitigating circumstances, views the case in terms of the concept of informed consent, not the concept of negligent liability. Claire, as Erin, views the case as representing an issue of patients' rights and professional obligations, not an issue of responsibility and compensation for damage caused.

Later however, Claire internalizes the new conceptualization put forward by Susan in utterance 90. Claire's contribution in 98 (figure 4) is clear evidence for this internalization: indeed this is the question that will be answered in court. This is in contrast to Erin who continues to maintain her point-of-view (figure 4, line 97) and still contributes to the conceptualization offered by Susan (and later Erin), thus remaining well interactive.

| | | |
|---|---|---|
| 93 | *Susan: she had a fear of being crippled, had an aversion to surgery, the risk of impairment from the surgery was small* | |
| 94 | *Erin: and then she wouldn't be complaining now as she would have fully consented to the surgery and understood the risks* | |
| 95 | *Susan: it seems to me that the doctor was trying his best to get her to have the operation* | |
| 96 | *Susan: true* | |
| 97 | *Erin: but at the end of the day it is not the doctors right to decide whether she should have surgery it is her decision* | countering 95 |
| 98 | *Claire: do you really think that she would have refused the operation even if she had known the risks?* | |

Figure 4. The last exchanges. Erin continues to view the case within the ethical perspective; while Erin changes to the perspective of negligent liability producing (in 98) the question that will be answered in court

### Reinterpretation of facts

Further evidence of the different perspectives and that a new (and correct) structure has been created by Susan, derives from the role and relevance given to an apparently negligible fact: that the surgeon was aware of the patient's aversion to surgery.

Erin had emphasized that fact to claim, 'it was even more important to fully inform the patient' (figure 2, line 86). The fact, therefore, acquires some relevance in her conceptualization. However, within the new 'negligent liability' conceptualization, this fact is differently explained. The surgeon's withholding of information is seen now as evidence for his caring attitude towards his patient (Susan, figure 4, line 95) rather than evidence for his professional deficiency. It can clearly be both, albeit in a civil court where only the question on the causal relation between an action and harm is discussed, it is not relevant. It is important to point out that it is Susan giving a new role and relevance to this fact: it is her who completes the binding of the facts within the new structure.

## Discussion

Two perspectives on the Chester case are evident in the dialogue: one based on ethical principles and one based on the legal concept of negligent liability. Each is a valid way of understanding the case, but the task the students were set demands to apply the legal perspective. Specifically, they need to consider whether the surgeon's withholding of a more extensive warning had a causal or 'causally contributing' effect to the damage sustained by the patient.

The two perspectives do overlap: both reference explicitly the failure to fully inform the patient about the risks of the surgery. It is correct, as Erin states in #77 and continues to maintain throughout the discussion, that the clinician failed to obtain informed consent from Ms Chester and therefore violated her right to be informed. However, the ethical perspective is not sufficient to identify the causal relation that is at the core of cases of negligent liability.

Our interest in the discussion lies in the conceptualizations that are constructed within the two perspectives, which enable us to show how knowledge constructed and made relevant within one perspective is taken up within a different perspective. We have identified these conceptualizations by analyzing the interpretations the students give to aspects, and, more specifically, the role and relevance they assign to the aspects. Erin proposes the first conceptualization of the case, embedded within the ethical perspective. Within it, the absence of adequate warning is uniquely sufficient to propose a 'judgment' on the surgeon's behavior because it violates the patient's right to information and, more generally, it violates the ethical principles of non-paternalism and autonomy. Most other aspects of the case have no relevance in this conceptualization. Later, Erin gives some relevance to the aspect 'aversion to surgery' by pointing out that, given Ms Chester's aversion, it is all the more important to inform her. Erin's interpretation of this fact is a further indication for her framing of the case within an ethical perspective; in a sense, she is clearly focused on providing a judgment of the surgeon's behavior in relation to ethical principles ("he failed (…)"). His knowledge about the patient's aversion is, for Erin, a further indication for a general ethical failure.

Claire accepts Erin's perspective on the case, but analyzes it critically by checking whether a specific concept – the concept of informed consent – of the ethical perspective is applicable to the case. She points out that since the risk was so small, informed consent was not needed. She mentions the 'smallness' of the risk, the aspect that according to her trumps Ms Chester's right to be informed, as a fact to counter Erin's quite severe indictment of the surgeon. The discussion revolves, as a consequence, on the significance of the 'size' of the risk, which is made relevant and becomes the focus for all students' contributions. In this way, they remain interactive and collaborative (Trognon, 1993; Barron, 2000), and indeed Claire, in #84, *works on* from this fact to propose a relationship between the size of the risk and the patient's decision. It is important to point out that the relation between the 'size of the risk' and the patient's decision is deployed into the group's cognitive environment to counter Erin's 'evidence' (the absence of adequate warning); it is an attempt to lessen the impact of Erin's 'evidence' on the judgment. The relation is hence deployed within the ethical perspective, which by itself is, at this stage of the discussion, not questioned.

But it is this relation between the 'size' of the risk and the patient's decision that provides the basis for Susan's re-conceptualization of the case. As we have shown, Susan constructs the different conceptualization within the perspective of negligent liability. She isolates the relation between the extent of the warning and the patient's decision from Claire's earlier relation between the smallness of the risk and the extent of the warning and the patient's decision, and so correctly identifies the core question of the case: whether being fully informed about the risk would have made the patient decide to not to undergo the surgery. She then also interprets the other aspects on the basis of this structure, as indeed the new conceptualization assigns different roles and relevance to the aspects. The 'smallness' of the risk is irrelevant within this structure, except in relation to the patients' decision (in the ethical perspective it was discussed as being central); another fact, the surgeon's knowledge about the patient's aversion to surgery, while not being crucial, is given an interpretation that is opposite to the one Erin gave it within the ethical view: rather than strengthening the view of the surgeon as

having failed, Susan points out that he may have withheld some information on the basis of his professional opinion that surgery was the best option available to the patient; he is, in this sense, a caring doctor.

Susan's novel conceptualization is only gradually taken up and developed. However, while Claire at the end accepts the new conceptualization, and indeed poses the question that will have to be answered in court (figure 4, line 98), Erin continues to persist on the ethical view.

By tracing the introduction and subsequent take-up of surface and structural knowledge (the causal relation) we show that the construction of a new (and, given the task demand, correct) conceptualization builds upon knowledge elements introduced previously (cf. Trognon, 1993). We argue that Susan's new conceptualization selectively exploits structural and surface elements of the earlier conceptualization, and that Susan remains interactive when creating the new conceptualization.

To what degree then is Susan's construction of the conceptualization a co-construction? Theberge-Rafal (1996) describes co-construction as the phenomenon where utterances by different speakers represent a complete idea or where a contribution extends a previous contribution. Co-construction is a mark for interactivity, and, in Barron's (2000) analysis, of successful coordination. Co-construction may however also indicate jointly produced novel ideas (e.g. McGregor & Chi (2002)); whether they are produced as a result of collaboration or are joint articulation of pre-existing ideas, is clearly difficult to establish. However, if co-construction were defined as the joint construction of a complete idea, then the dialogue between Susan, Claire and Erin would not count as an example of it. It is more the case that the learners take up one another's contributions, modifying the content and developing new ideas from them (Suthers, 2006).

Roschelle's (1992) notion of joint construction is also relevant for the interpretation of the students' discussion. He defines joint construction and, by extension, collaborative learning as the mechanism by which a new conceptualization is generated on the basis of a peers' partial conceptualization. The phenomenon described in this paper calls for a refinement of this definition. Roschelle's definition hinges on the notion of partial conceptualization. On the surface, Claire's conceptualization cannot be called a partial conceptualization of Susan's because it is embedded within a different perspective. However, we might only decide that Claire's conceptualization is indeed partial if we know what interpretation Susan gave it. Susan interpreted Claire's contribution in terms of negligent liability, and completed this partial structure. Moreover Claire's contribution becomes a partial conceptualization because Susan interpreted it in this way. Which is the mechanism within which collaborative learning occurs: a student gives meaning to information written in a text or knowledge introduced into the group's cognitive environment, which may then be taken up and given a different meaning by her peers.

It is important to discuss also the possible impact of the virtual environment of the discussion. It is likely that the availability of prior deliberations in the chat window (it displays about 8 messages from all learners) has made it possible to revisit those prior deliberations, and facilitated their reuse in the construction of the novel conceptualization. Face-to-face conversations are typically more strongly constrained by adjacency with the strict ordering of utterances organized – in addition to content relevance – by non-verbal cues and rules of turn-taking. Though 'far' references are not uncommon, they represent a significant effort on the part of the speaker to close a current thread, while needing to justify the opening of a new one. In a computer-supported learning environment many conversational rules do not apply and typed messages are more persistently present than spoken ones, allowing learners re-visits of prior contributions and interpretations less constrained by the currently agreed perspective.

## Conclusions

As recognized by many in CSCL, it is essential that the basic notion of interactivity – namely that an action is at least partially influenced by a prior action – remains the focus of collaborative learning research. More specifically, it is important to adopt frameworks that enable us to capture the determination of one peer's action in relation to another peer's action. Individualistic accounts allow, in this respect, quite under-determined actions: *what* knowledge is constructed when being, for example, criticized, is under-determined and indeed depends very strongly on an individual's own knowledge. The study of collaborative learning should therefore include a strong focus on what knowledge is constructed and how that new knowledge is specifically related to knowledge in the group's environment.

We have adopted a framework for studying collaboration that is focused on this analysis, as well as allowing an influence of individualistic processing. Our analysis illustrates how collaboration is sustained through a joint focus on shared information and knowledge (Barron, 2000, 2003) that provides opportunities for interaction, but may also, as a consequence, restrict what new knowledge is constructed. The group's achievement becomes, within this view, quite remarkable. Despite an early focus on a fact that is, at the end, not relevant within the sought conceptualization and the emphasis on the (ethical) perspective that all 3 students work within, a novel conceptualization is constructed interactively. Our analytical focus on knowledge elements and especially the introduction and uptake of structural knowledge, leads to the conclusion that this new

conceptualization results from an individualistic appropriation of elements (cf. Schwartz, 1995), rather than progressive shared construction (Rochelle, 1992).

In problem-based learning, where microanalyses are *de rigueur*, case studies have a special significance. However, a single case study cannot be the basis for a general claim – case studies are useful for illustrating particular processes or mechanisms that may then be the subject of further inquiry, both theoretical and experimental. This paper is not intended to provide evidence that individualistic appropriation is a key mechanism for collaborative learning; rather, it is intended to demonstrate the viable application of this concept to a collaborative learning situation; and also to demonstrate the difficulties of applying a notion of interaction to a real-world learning session where that notion does not take into account the positioning resulting for different viewpoints of the learners. But more importantly, the case study illustrates how individual viewpoints can be uncovered through a verbal analysis and by carefully constructing the alternative structures each viewpoint entails (fact interpretations and relations between facts). As such, our analysis may be seen as contributing to a much needed and increasingly sought framework for the analysis of conceptual change through collaboration.

## References

Barron, B. (2000). Achieving coordination in collaborative problem-solving groups, *Journal of the Learning Sciences*, 9(4), 403-436.

Barron, B. (2003). When smart groups fail. *Journal of the Learning Sciences*, 12 (3), 307 – 359.

Chi, M. T. H. (1997). Quantifying qualitative analyses of verbal data: A practical guide. *The Journal of the Learning Sciences*, 6(3), 271–315.

Chi, M. T. H., de Leeuw, N., Chiu, M., & LaVancher, C. (1994). Eliciting self-explanations improves understanding, *Cognitive Science*, 18, 439-477.

Doise, W., Mugny, G. & Perret-Clermont, A.-N. (1975). Social Interaction and the Development of Logical Operations, *European Journal of Social Psychology, 9*, 245-247.

Fischer, F., & Mandl, H. (2005). Knowledge Convergence in Computer-Supported Collaborative Learning: The Role of External Representation Tools *Journal of the Learning Sciences, 14*(3), 405-441.

Gick, M. and Holyoak K. (1980). "Analogical Problem Solving." *Cognitive Psychology* n. 12, pg. 306-55.

Glachan, M. & Light, P. (1992). Peer Interaction and Learning: can two Wrongs make a Right? In G. Butterworth & P. Light (Eds.), *Social Cognition: Studies in the Development of Understanding*, (pp. 238-262). Chicago: University of Chicago Press.

Hausmann, R. G. M., Chi M. T. H., and Roy M. (2004). Learning From Collaborative Problem Solving: An Analysis of Three Hypothesized Mechanisms. *Proceedings of the 2004 Cognitive Science Conference.* Mahweh: NJ: LEA.

Jeong, H. & Chi, M. (2007). Knowledge Convergence and Collaborative Learning, *Instructional Science*, 35:287–315

McGregor, M. U. and Chi, M. T. H. (2002). Collaborative Interactions: the Process of Joint Production and Individual Reuse of Novel Ideas, *Proceedings of the 2004 Cognitive Science Conference.* Mahweh: NJ: Lawrence Erlbaum Associates, 2004.

Miyake, N. (2007). Conceptual Change through Collaboration, in Vosniadou, S. (Ed.) International Handbook of Conceptual Change, pp. 453-478, Routledge.

Miyake, N. and Shirouzu H. (2002). Learning by Collaborating Revisited: Individualistic Vs. Convergent Understanding. Proceedings of the 2002 Cognitive Science Conference. Hillsdale: NJ: Lawrence Erlbaum Associates.

Roschelle, J. (1992). Learning by Collaborating: Convergent Conceptual Change, The Journal of the Learning Sciences, 2 (3), pp. 235-76.

Schwartz, D. L. (1995). "The Emergence of Abstract Representations in Dyad Problem Solving" The Journal of the Learning Sciences, vol. 4, no. 3, pg. 321-54.

Shirozou, H. (2010). Collaboration as constructive interaction and the jigsaw method as its enhancer, Workshop Proceedings of the 9th International Conference on the Design of Cooperative Systems, International Reports on Socio-Informatics, 7(1). International Institute for Socio-Informatics.

Shirouzu, H., N. Miyake, and H. Masukawa (2002) "Cognitively Active Externalisations for Situated Reflection." *Cognitive Science*, vol. 26, n. 4, pg. 469-501.

Suthers, D. D. (2006). Technology affordances for intersubjective meaning-making: A research agenda for CSCL. *International Journal of Computers Supported Collaborative Learning, 1*(3), 315-337.

Trognon, A. (1993). How does the process of interaction work when two interlocutors try to resolve a logical problem*? Cognition and Instruction, 11(3&4)*, 325-345.

## Acknowledgement

We acknowledge the support of the Economic and Social Research Council, award no. L328 25 3013.