

# **Mechanisms of Cognitive Change In Peer Interaction : Implications for the design of computer supported cooperative learning environments**

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## *Abstract*

In this paper it is argued that existing accounts of mechanisms of cognitive change in joint problem solving are inadequate for several reasons. In particular explanations based on sociocognitive conflict do not tell us how the resolution of inter individual conflicts leads to cognitive change. It is argued that a more effective approach is to analyse the dialogue processes involved. A model is presented which explains change in terms of the relation between dialogue focus and task focus moves. An experiment is reported which explores this relationship. The implications for designing computer supported cooperative learning environments are then reported.

## **1. Introduction**

There has recently been a lot of interest in designing computer systems that support learning in a cooperative context (1,6). One reason for this (and arguably the most important one) is that peer interaction is thought to promote cognitive change. One approach to the development of such systems is to design computer supported cooperative learning environments to support the processes in peer interaction which promote cognitive change. This is only possible if we have a detailed explanation of these processes.

This paper looks at one explanation (sociocognitive conflict) of why joint problem solving promotes cognitive change and argues that it has a number of limitations. It is proposed that these can be

overcome by analysing in detail the dialogue processes involved in cooperative problem solving. In particular this paper argues that analysing focus changes in joint problem solving can uncover some of the mechanisms involved in cognitive change.

A framework was developed to investigate the processes involved in focus change. An experiment is reported which investigated joint planning and the framework was used to analyse the dialogue processes involved. Several examples are shown which illustrate those processes. Finally the implications for computer supported cooperative learning environments are reported.

## **2. An Explanation of Cognitive Change in Peer Interaction**

Piaget (8) has proposed that peer interaction promotes cognitive development. Recently his ideas have been elaborated by Doise and Mugny (3) in their theory of Sociocognitive conflict. They propose that it is the resolution of inter individual conflicts that leads to cognitive change. Inter-individual conflicts, according to Doise and Mugny are at the very core of cognitive change. One reason for this is because the conflict is social as well as cognitive which means inter individual conflicts are less likely to be ignored than intra-individual conflicts. Another reason Doise and Mugny give for why Sociocognitive conflicts are likely to lead to cognitive change is because the one child can provide cues for the reorganization of the other child's cognitive system. They have tested their theory and have found evidence that under certain circumstances peer interaction does indeed promote cognitive change.

Recent work in cognitive science on constructive interaction (7) similarly suggests that inter individual conflicts in joint problem solving lead to cognitive change. Conflicts arise because of differences between the individuals initial knowledge and/or differences between their task foci.

The above account has a number of limitations. It does not explain how inter individual conflicts are perceived and also it does not explain how the resolution of inter individual conflicts leads to cognitive change. Joint problem solving is carried out through the medium of dialogue. It is suggested here that any explanation of cognitive change in joint problem solving has to include an understanding of the dialogue processes involved.

## **3. Framework for Analysing Focus Change in Dialogue**

A framework was developed to investigate the dialogue processes involved in the perception and resolution of conflicts. It is based on Grosz' (4) notion of dialogue focus. Dialogue focus is modelled by a set of focus spaces. A focus space can be either open or closed but only one is active or currently selected at a given time. Each has a purpose associated with it and contains a subset of knowledge relevant to that purpose.

The movement from one focus space to another is achieved by focussing, which is modelled by a set of transition rules. These specify the conditions for adding or deleting spaces. Focussing is determined by the plan or model of the task. It is used to order the subtasks needed to perform the main task. Without this model it would be impossible to know when the discourse has moved from one focus space to another.

To illustrate the above point here is an example used by Sidner (10)

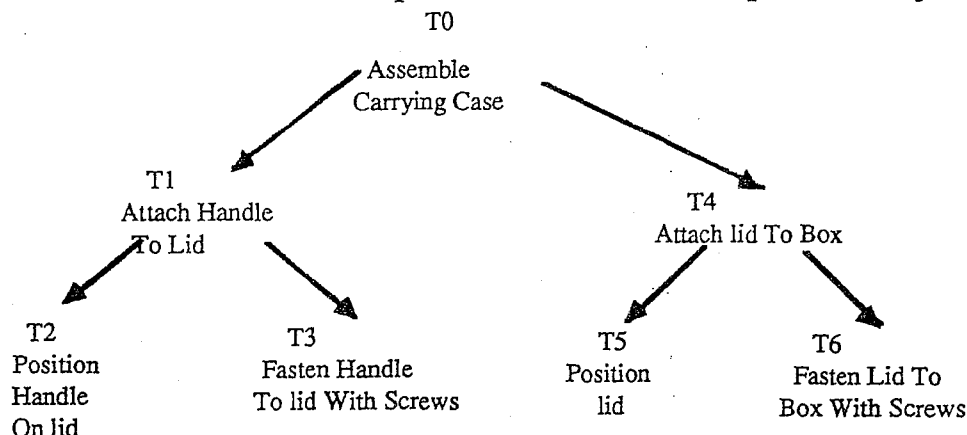


Fig 1: the Plan for constructing a box

If the discourse was at T2 then a reference to "the screws" indicates a move to T3. Once T3 is closed and T4 and T5 opened a reference to "the screws" indicates a move to T6.

Grosz assumes that each of the participants share the same task model. This is essential for successful understanding of the dialogue. However, one of the explanations for why peer interaction promotes cognitive change is that the participants have different task models. Therefore it is necessary to redefine Grosz' notion of dialogue focus and introduce the notion of task focus.

Task focus is similar to dialogue focus in that it represents the subset of knowledge relevant to the purpose of the focus space. However, unlike Grosz' dialogue focus which is assumed to be the same for both participants, the participants' task foci can be different. Dialogue focus will now be taken as the focus of the discourse (i.e. what is been talked about).

Another distinguishing feature of this framework compared with the work of Grosz, is that it proposes that an individual does not just have one task model but has several different task models accounting for different aspects of the task. There may also be several task models accounting for the same aspect of the task. More than one may be activated at any particular time. This aspect of the framework is based on Di Sessa (2) work on user's understanding of complex devices. From his observations of people using Logo he noticed that they don't have a single model of a task but had a patchwork of partial understandings.

Therefore in this framework the model of focus change is as follows:

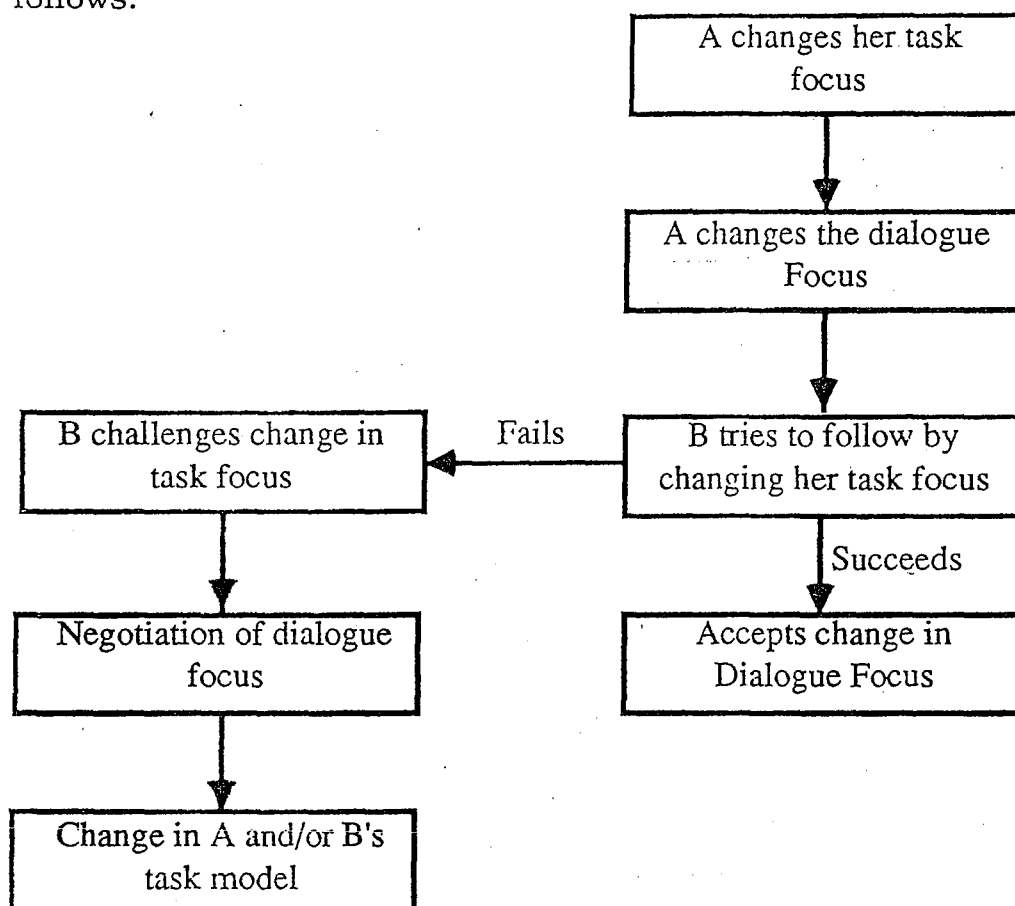


Fig 2: Model of Change of Focus

It is proposed in this model that the perception of conflicts occurs when B unsuccessfully tries to follow the change in dialogue focus. The model still leaves many issues unaddressed. First how conflicts are perceived and how the negotiation of dialogue focus leads to cognitive change. These issues were investigated in an analysis of the results of the experiment described in the next section.

#### 4. An Experiment to Investigate the Dialogue processes involved in Joint Problem Solving

An experiment was conducted which investigated the dialogue processes involved in joint problem solving. The subjects in the experiment were eleven year old children. The task they had to tackle was a complicated planning task which was in the form of a computer game called the Muksters. It was set in a imaginary world. (shown in fig 1)

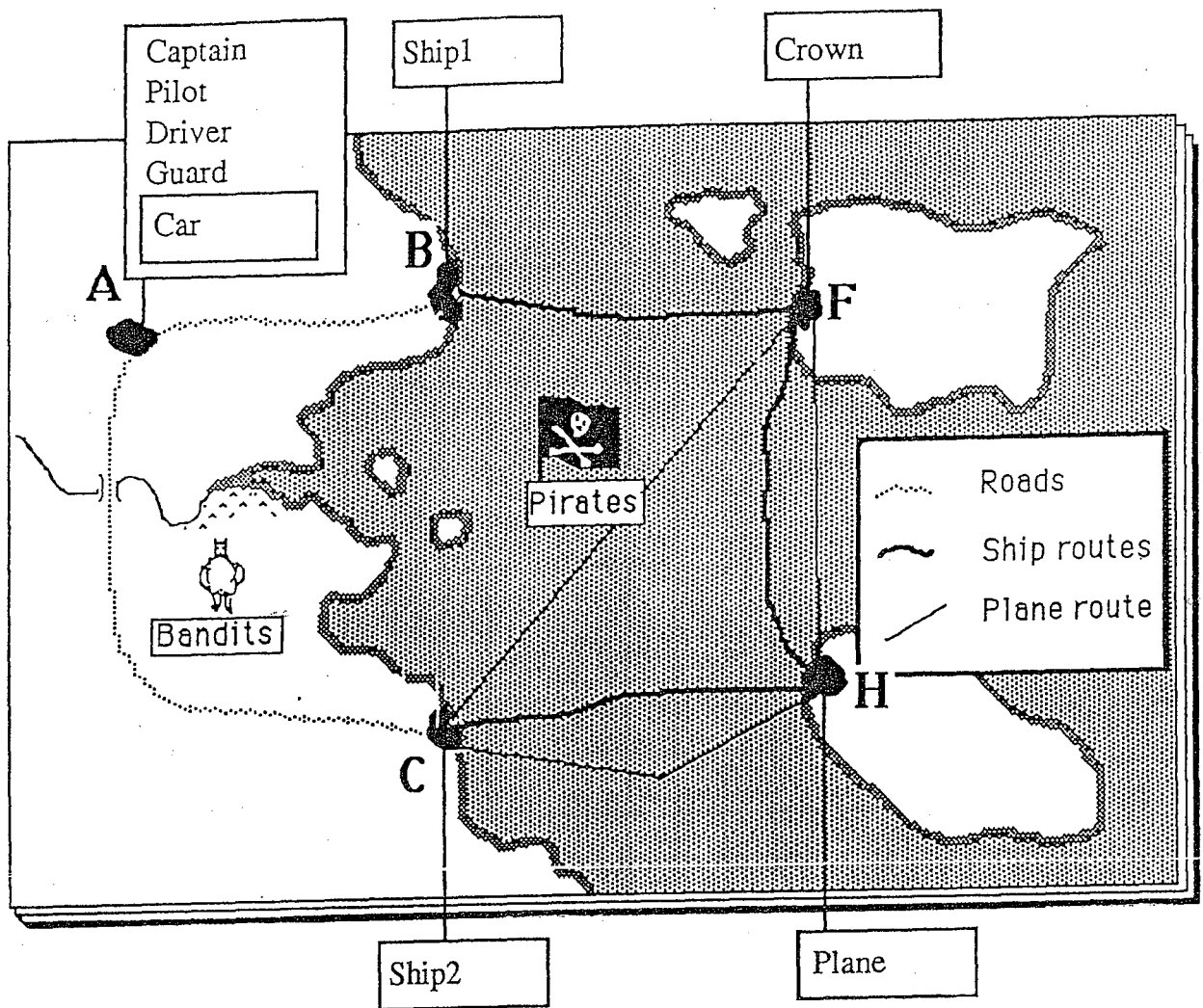


Fig 3: The Muksters World

The goal of the task was to transport the crown (at F) to A. The children had two ships, a car and a plane to accomplish this goal. They also had four people the driver, the captain, the pilot and the guard as the names suggests they all had distinctive functions in the world. The ships could only be sailed by the Captain and took any number of passengers. The car took three passengers and could only be driven by the Driver. The Pilot was the only one who could fly the plane and it only took one passenger. What made the task complicated was the presence of the pirates and the bandits. The pirates would steal the crown if it was on the ship. The implication being that you could only transport the crown across the sea by using the plane. The bandits would steal the crown if the guard was NOT present.

The experiment had two stages. In the first stage there were two conditions. The children either played the game alone or in pairs. All the time the children played they were being videotaped. The second stage of the experiment was a week later, when the children had a post test. This time all the children played the game

on their own. The result was that the children who had played the game in pairs in the first stage, performed significantly better than those who had worked individually.

## 5. Examples

The following examples each illustrate attempts by one participant to change the focus of the dialogue which is not accepted by the other and the resultant negotiation of the dialogue focus. This occurs when there is an inter individual difference between the participants. The first two examples are when the participants hold conflicting beliefs. The final two examples are examples of focus differences where the difference between the participant is caused by the particular aspect of the task they have focused on.

### Example I Check it

In this example the children are trying to get to Hushley from Fruggle in a ship. The disagreement was over which ship to use. The interesting part about how this example is how the pair resolves their belief difference by checking the information in the world to see who is correct.

- A) We have to get the ship to Hushley
- B) Ship 2 to Hushley
- A) Ship 1 ..... can't it
- B) I don't think it can  
Shall we look for some information

[ A reads this from the screen ]

A "ship 1 can go to Hushley" ..... Yeah

The analysis is as follows A's perception of the conflict occurs when B changes the dialogue focus to "Ship2 to Hushley" this directly conflicts with A's task focus which is "Ship1 to Hushley". A communicates this conflict by changing the dialogue focus to to "Ship1 to Hushley". Now B's task focus conflicts with the dialogue focus. She then follows the change in dialogue focus and changes her task focus to Ship1 to Hushley. This reveals a belief about ship1 which conflicts with the goal to go to Hushley in ship1. She communicates this to A and Proposes the goal to find out if ship1 can or cannot go to Hushley.

### Example II Test it

In this example the children are trying to get everyone back to Ashlan in the car. The disagreement is over whether all four of the people can get in the car. This is interesting because of the method of resolution which involves testing something to see if it works.

A Right then we want everybody on.

B We can't fit them all on

A Oh yes we can

[ A then puts them all on to the car].

A changes the dialogue focus to "get everyone on the car" B changes her Task focus to match the dialogue focus. In doing so this reveals the belief that the car can't fit four people on it. She then communicates this to B by changing the dialogue focus to the belief that "we can't fit them all on". A changes her task focus to match the change in dialogue focus but finds it conflicts with her belief that the car can take four people. She communicates this to B and resolves this difference by testing whether the car can take four people.

### Example III Resolve it

In the following example the participants are trying to decide whether to go Crowmarket or Brockley. It is interesting because this time the two apparently conflicting beliefs are resolved by one of the participants coordinating them into a single consistent belief.

A we can go to Brockley or Crowmarket

B Crowmarket

A We went to Crowmarket last time

B The car had to go to Brockley first I think

A yes because we went to Crowmarket first and then had to go back to Brockley.

B changes the dialogue focus to "go to Crowmarket". A changes her task focus to match the dialogue focus. In doing so this reveals a conflict with a belief she has about planning which is that it is not a good idea to do what you did last time if it was unsuccessful. She communicates this indirectly by changing the dialogue focus to "we went to Crowmarket last time". B tries to change her task focus to match the change in dialogue focus and fails because she believes they went to Brockley last time. She communicates this to A. Now A changes her task focus to correspond to the change in dialogue focus and succeeds. This leads to an internal conflict between her belief that they went to Crowmarket last time and her belief that they went to Brockley. She resolves it by finding the belief that they went to Crowmarket first and then had to go back to Brockley

#### Example IV

In this example there at the start and they are trying to work out who they need to load onto the car. Its a particular interesting example of a focus difference. In it B spots a bug in A's proposed Goal

- A We want a driver and a guard
- B We need a captain for the ship
- A Yeah

The analysis is as follows both participants are trying to work out who they need on the car. It is hypothesized that B has the goal "need to use the ship" activated and from this infers that they need the captain. Its also hypothesized that A has at least two goals in focus i) need to use the car

ii) need to protect crown

and from these she infers that they need the guard and the driver She communicates this to B by changing the dialogue focus to 'We want the driver and the guard". B now follows the change in the dialogue focus and accepts they need the captain and the guard but also because of the difference in initial task focus adds that they need the captain aswell.

#### 6 Implications

This framework is still in the early stages of development and further work needs to be done before it is complete. Even so, the examples just given have several implications for designing CSCLE They relate to two questions; firstly, how can a computer environment support the perception of conflicts or inter individual differences and second, how can it support the resolution of inter individual differences. On answering the latter question the first two examples are very pertinent.

In the first example the inter individual difference was resolved by finding the relevant piece of information. Therefore it is important that the participants can access from the computer all the relevant information. The Muksters failed on this count a number of times and this can be seen in the third example. In this case there was a disagreement over what they did first in their last attempt. One of the participants thought they went to Crowmarket the other thought they went to Brockley. There was no way the participants could resolve this by actually seeing what they did last time because that information was absent from the game environment. In this case they resolved it by another means. If they had wanted to resolve it by checking what they did last time, the Muksters would not support them.

In the second example the inter individual difference was resolved by one member testing out something to see if she was correct. There are two implications from this example for the design of CSCLE. The first is that the testing process should not be too costly. For instance in the above example, one member tried to put all the people in the car. If this had failed the pair would have incurred one penalty point. This time they took the risk other times pairs did not. Although this is an artificial cost there are genuine costs in the real world associated with testing. In a computer environment these could be lessened or removed. The second implication from the testing method of resolving inter individual differences is that in a computer environment it is possible to test things that in the real world you would not be able to. A prime example of this is SharedArk (reference)

The fourth example is an example of a focused difference. In this case the different foci of the participants enabled one of them to spot a bug in a goal proposed by the other. The question is how can a CSCLE support the perception of this type of interindividual difference. It was proposed in the dialogue framework that the task focus contains all the knowledge relevant to the goal of the task focus. The problem then is how to manipulate what each participant thinks is relevant. One method would be to give the participants different roles (eg in the Muksters example driver navigator) which would alter what each participant thought was relevant.

However role division has been thought (9) and has been shown to inhibit the facilitatory effects of peer interaction (5). The reason given is that the participants tackle different aspects of the problem and therefore only learn about that aspect. In other words participant A with role X tackled one part of the task while participant B with role Y tackled the other part with little or no shared involvement. What is needed is that both participants with different roles tackle both parts of the task together. Therefore a CSCLE should be designed to support the latter type of role division and inhibit the former type of role division.

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