SOCIOCOGNITIVE INTERACTIONS IN A COMPUTERISED INDUSTRIAL TASK:
ARE THEY PRODUCTIVE FOR LEARNING?

Danièle Golay Schilter, Jean-François Perret, Anne-Nelly Perret-Clermont
& Franco De Gugliemo [*]
University of Neuchâtel

In collaboration with Jean-Philippe Chavey [**]
Ecole Technique de Sainte-Croix

INTRODUCTION

Through the "in vivo" study of professional training, we intend to contribute to the understanding of complex learning procedures about which we have formulated the hypothesis that learning procedures of this sort incorporate factors not only of a cognitive and technical nature but also of an identity and relational one. This chapter is thus concerned with the socio-cognitive interactions observed in a real training situation in the workshops of a technical college where students, working in small groups, are familiarising themselves with computer aided production. The aim is to analyse which interactive dynamics are deployed and to examine when these interactions can be considered to be effective.

1

In approaching these interactions and attempting to grasp the dynamics involved, it is possible to base ourselves upon a number of pieces of work which come from very different theoretical and methodological directions, as pointed out by Dillenbourg et al. (1995). Nevertheless, they can be placed along two axes, distinguishing between, along the one, those works which describe the *interactions between learners*, and along the other, those which highlight the important task of *interpreting the meaning of the situation*, an interpretation which the participants must put into operation in order to manage their activity.

How do the learners interact?

Work on collaborative learning is most often concerned with primary school pupils who carry out different types of tasks in groups. With young adults undergoing professional training, do we find the principal processes accounting for cognitive interactions described up to the present? Amongst the different interaction patterns identified by Granott (1993) from the degree of collaboration manifested and the relative level of the partners' expertise, which of them are prone to placing themselves in the context of this activity? In the training situations studied can we observe in particular:

- *socio-cognitive conflicts* of the same nature as those observed in a psychosociogenetic perspective and about which a series of experimental research has shown that they could be at the origin of cognitive resttucturations (Perret-Clermont, 1980; Emler & Valiant, 1982; Doise & Mugny, 1984; Perret-Clermont & Nicolet 1988; Light & Blaye 1989; Bearison, 1991)? In what ways might young adults benefit from the confrontation of different points of view? Of what micro-geneses is it a question: do they relate to the cognitive reelaborations relative to the task and its aim, or do the restructurings implicate the knowledge that the task mobilises? Or do the conflict interactions produce instead, changes in solution strategies? (Gilly, Fraisse & Roux 1988; Blaye 1988).

- *the approaches to collaboration* to which the partners each bring complementary elements? Do the learners observed enter into a dialogue when engaged in joint action? Discussion and explanation are in effect often considered to be favourable to the solving of tasks and this for two main reasons: on the one hand, because they permit common goals to be established with regard to defining the problem and the interplay of meanings (which should facilitate an effective educational soft, according

2

to Healy, Stefano & Hoyles, 1995); on the other, discussions help to bring about an analysis of the problem to be solved (Pontecorvo 1990; Howe & al., 1995; Mercer 1996; Pléty, 1996), a sharing of ideas, and what is more an evaluation of those ideas in view of a communal decision. Will our observations present the characteristics of exploratory talk described by Mercer (in press: 138-140)? However, some research has also shown that at times, the negotiations and dialogues of a "resolution of conflict" type have little effect upon the immediate task performance of the groups studied (Perret-Clermont 1980; Jackson, Fletscher, & Messer, 1992; Hoyles, Healy & Pozzi, 1992 p255, etc.)? What will the outcome be here?

- *an explicit or implicit distribution of different roles and tasks to each participant*? The review of experimental research on group work presented by Moscovici & Paicheler (1973) as the research in an ergonomic perspective (Leplat, 1993) have clearly shown that in order to be carried out efficiently, different tasks necessitate different social organisations of the group. What happens when faced with a complex industrial computing task? Is there a distribution of roles and does it take place in a conscious or implicit manner? Does it evolve alongside familiarisation with the task? In a task of co-resolution of an arithmetical problem, Saint-Dizier, Trognon, & Grossen (1995) have shown that this distribution is reflected more particularly in turn- , decision- or power-taking, as well as in their evolution throughout the interaction. Is it also the case here? Are the respective places and status of the participants negotiated before or during the activity? Do we observe power taking _and are they effective or not in relation to the collaboration objectives? Are there any leaders and of what type? In effect, research has shown the sheer amount of attention subjects pay to place maintenance and face saving, indeed to their identity, in situations which one might believe to be essentially dedicated to the resolution of cognitive problems (Flahaut, 1978; Vion, 1992; Schubauer-Leoni 1986; Grossen, Liengme, Perret-Clermont, 1997; Muller & Perret-Clermont, in press).

- *asymmetric interactions*? When are interactions explicitly experienced as asymmetric, with certain participants in the position of expert and others, novice? When, on the contrary, are relationships horizontal? Following from Vygotsky and more widely, from a number of Russian researchers (notably Leontiev, Galperin and others), numerous studies have attempted to describe the relationships between novices and experts (McLane & Wertsch, 1986; Wynnikamen, 1990; Mercer & Fisher, 1992; Forman & McPhail, 1993; Rogoff, 1995; cited as an example). The 'a priori' theory adopted in this line of research is that knowledge is transmitted by the expert to the novice, the latter appropriating it in successive stages, deploying

3

behaviours scaffolded by his/her expert partner. Are these phenomena found within the framework of learning to master a complex computing device? And if interactions of this sort establish themselves, is it only with the teacher or also between the students in the Technical College which draws together learners form very different scholastic and professional backgrounds? Which events solicit modelling or scaffolding in an asymmetric relationship of this sort: breakdowns, the particular requirements of the teacher, the necessity to stand out on the part of young people seeking social acceptance, or is it simply a question of a common mode of interaction and thus normal and frequent?

This question is particularly important when one knows that certain authors advocate the model of cognitive apprenticeship as a pedagogical method (Collins et al. 1989), notably in the context of a technologically complex environment (Järvellä 1995). However, other studies, in particular those of Trognon (1993) regarding adults, have highlighted that in certain problem solving situations, the partners can be observed supporting each other not in an asymmetric but in a reciprocal manner, both and alternatively leaning on the reasoning of the other in order to progress towards an efficacious solution.

- *interactions influenced by the characteristics of the task and software*. The characteristics of the computer tool used are equally susceptible to influencing the modes of collaboration adopted. The distributed use or not of the keyboard and mouse is a major sensitive point, as observed by Blayes et al (1992). The nature of the software and in particular the visual feedback or the error messages that it can provide, are also worthy of attention. As revealed by Hoyles, Healy & Pozzi (1992), the fact that a piece of software allows for open exploration (as is the case with the Logo) favours reflection upon rules and dialogue as well as a means of resolving conflicts, whilst this is not the case if the software proposes a guided computer assisted learning type of approach.

How do the learners interpret the situation?

In our research, the task presented to the technician students seems clearly defined: referring back to teaching received some months beforehand, the students should use a piece of CAM (Computer Assisted Manufacturing) software to devise the machining of a part which has already been designed. During the first stage, that of devising the machining, they should work in groups of three around the same computer than, during the second stage, they should set up the machining cell which

4

will automatically manufacture the part. At all times they can refer to the teacher for assistance if they are stuck and for help if they should need it. At the end of the afternoon and after four hours of practical work, they have to provide a brief report on their work to be handed in to the teacher along with the machined part. The instructions are complete, the working conditions defined and the object of the exercise clearly designated. This apparent clarity does however merit closer examination.

Research alerts us to the fact that even apparently simple conversational situations (for example asking a question in a test situation) are prone to revealing themselves to be complex polysemic social situations (Rommetveit, 1979; Hundeide, 1985; Grossen, 1988; Säljo 1991). In effect, the students do not always endow the situation, the task and the instructions with the meaning anticipated by the teacher (Donaldson, 1978; Perret 1985; Schubauer-Leoni, 1986; Light & Perret Clermont, 1989; Bell, Grossen & Perret-Clermont, 1989; Perret-Clermont, Perret & Bell 1991). The observation of subjects in interaction reveals that they deploy a breadth of cognitive activity to enable them to grasp not only what has to be done, but also the meaning of the situation in order to place themselves in a position to undertake the role most favourable to them. In scholastic situations in particular, we know the extent to which the institutional framework plays a role in structuring the images that teachers and students have of their roles and expected performances (see Gilly 1980; Brossard & Wagnier 1993; Säljo 1993; Schubauer-Leoni, 1993; Iannaccone & Perret-Clermont, 1993). Is the industrial computing task with which we are concerned here also open, behind its apparent clarity, to diverse interpretations? This appears to us to be the case for two complementary reasons:

> - the procedure to be followed is open given that numerous options and decisions regarding the appropriate route are to be taken along the way; there is in effect no standard procedure which can simply be faithfully applied. To the complexity of the software, the fact that it presents some unexpected limitations has to be added, for example error messages are not given in a systematic manner. All this gives rise to an element of uncertainty amongst the students at different stages of the activity with regard to the type of knowledge and strategies to be put into action.

> - in order to manage this element of uncertainty, the students will spontaneously rely upon their previous experience and the similarity that they perceive as existing (or not) between what is required in the present situation

5

and what has been required in the past. From the point of view of the learners, the proposed task and their interpretation of it cannot therefore be isolated from the series of practical work being carried out as a whole, week after week throughout their training. The forms of scholastic work, and in particular the modes of collaboration which establish themselves do not reinvent themselves day by day; on the contrary, constants are observed in each activity, linked to the expectations and working rules which are generally established implicitly but which are components of the didactic contract (Brousseau, 1986; Schubauer-Leoni, 1986; Schubauer-Leoni & Grossen, 1993). This framework of interpretation that the students have forged out of their previous experiences cannot be ignored in our situation, that is to say, when we wish to understand their reactions when they are faced with a new task in their practical work.

We therefore expect to see reflected here, at this level of micro-analysis and through the meanings that the learners attribute to the task, a certain number of psychological and social factors at work in the wider reality of the lives of the students and of the school. Other authors have already shown such articulations of different orders of phenomena within the same observed pedagogical "micro-reality" (Woods, 1990; Benavente, 1993; Guarduno-Rubio, 1996).

LEARNING A TECHNICAL TRADE TODAY:
THE CASE OF COMPUTER ASSISTED MANUFACTURING

The opportunity to study socio-cognitive interactions in a Technical College is linked to our participation in the Swiss National Research Programme on "The efficiency of our training systems". The programme as a whole was set up to examine the possibility of improving training systems through a better understanding of the ways in which they evolved as well as their constancy. In this context we are interested in the impact of new production technology on the redefinition of knowledge and know-how to be taught to future technicians, this within a training establishment itself. Firstly this necessitated a knowledge of the institutional framework of the Technical College studied, in order to grasp the principal elements of its history and evolution linked most notably to technological developments (Golay Schilter 1995). It was also a matter of getting to grips with the professional and pedagogical motivations of those members of the college management and teaching staff who were affected by this evolution, as well as the financial conditions surrounding an undertaking of this sort

(Perret 1997). Interviews with and a questionnaire given to the students (aged between 16 and 25) again enabled us to grasp certain important elements of the scholastic, professional and existential problems encountered by them (Kaiser & al. 1996).

This approach to the reality of a professional training establishment has revealed the existence of pedagogical choices which are difficult to make and manage when having to take into consideration multiple factors, each pulling in a different direction: some of a material order (financial constraints, but also architectural ones linked to the fitting-out of training facilities); others professional, between on the one hand a *traditional view* of the trade, almost as a craft, all be it an industrial one (shown by for example, the importance given to experience and "hands-on skill"), and on the other, an *emerging view* based upon the development of automation, the future form of which we still know very little. Other tensions also appear amongst the trainers given that their experiences of the professional world are diverse and often very different from those of their colleagues; and amongst the students who, in their working environment or during periods of work experience, glean information and opinions which feed their own perceptions of the industrial world and its evolution. Other dimensions render the management and pedagogical choices even more difficult within a professional training establishment: at times anachronistic State regulations; competition between colleges; the pressures of the employment market and not least, the fear of unemployment.

In this context, introducing students to automated manufacturing is a mirror which provides a particularly clear reflection of these tensions, even in view of the fact that this teaching only occupies a relatively restricted place in the training curriculum as a whole (an initial approach is of course already proposed at the beginning of training at 16, but it is above all in the two years of preparation leading to the main qualification for technicians that systematic teaching in the subject is introduced). This is why we have chosen this learning area in particular, as a privileged observation point from which to identify the factors present in such training, the different modalities possible, as well as the respective roles of traditional know-how and more formal knowledge which requires the entirely mediated conception of a technical activity of this sort (Martin, 1995; Rabardel, 1995; Verillon & Rabardel, 1995).

The situation observed: a practical training session

7

The automation practicals take place one half day each week and cover different technical devices. The session at the centre of our observation required the students, working in small teams, to program the machining of a piece of synthetic resin, using Computer Assisted Manufacturing (CAM) software. As we have already indicated above, the aim of the practical work is to carry out the complete manufacturing of a part (shown in figure 1). This task must be performed in a short period of time and in order to carry it out, the students must refer back data and processes covered several months beforehand. It is thus an opportunity for them to revise and use a large body of knowledge in a practical context. In this, it differs from their typical practicals which are generally more directly linked to a textbook chapter in particular. This activity is also closer to an actual work situation than usual.

At the beginning of the practical, the teacher gives oral and written instructions to the students. He describes the three main stages of the procedure as well as some of the technical constraints. He also states the assessment criteria: the time taken to complete the machining should be as short as possible and during the practical session the students should work independently of the teacher as much as possible. All the members of a given group will receive the same mark. The teacher addresses them collectively.

At the first stage, activity is focused on the screen; a large number of variables have to be specified. The software interface shows a long series of running menus including sub-menus. Data is input by opening the running menus and clicking on the desired options. The program then provides a series of windows and dialogue boxes. Each time a window has been completed correctly (by clicking on the options chosen or by filling in values), the next one opens. Windows and dialogue boxes are complex and require a lot of data input. The program indicates the next general process at the bottom of the screen (e.g. "select outlines"). It also transmits error warnings and includes a thematic help menu. Finally, it enables users to visualise and monitor work already done on the part.

The subjects

The subjects observed were ten student technicians, all male, aged from 20 to 25 years and organised into four working groups. The groups observed have worked together during previous practical sessions. In the present chapter we will focus our attention on one of the groups in particular but without losing sight of the others (Golay Schilter & al. 1997). The students' knowledge of machining processes varies

8

according to their former training. Whereas the mechanics have had some practical experience in the use of traditional and/or Computer Numerical Control (CNC) machine tools, the others have only followed a thirty hour course in computerised machining.

Selection and transcription of the sequence to be presented

The activity as a whole, from its conception to the effective machining of the part, takes place over four hours. The session was recorded and filmed using two cameras, in order to obtain an image of each team and the computer screen they were using. These recordings allowed us to capture a series of difficulties encountered by the students during this activity. One such difficulty regards the relative definition of the values corresponding to different machining plans which have to be specified to the machine: the surface of the part called the "reference surface"; the depth of a hole; the depth of a hole in the interior of an already machined cavity; without forgetting the "security plan" and the "rapid approach plan" which regulates the approach of the reamer even before it starts machining. It is the reaction to this particular difficulty and the examination of the management of it that we have singled out for the present study, going into more depth in the case of one group in particular made up of Ted, Guy and Didier.

Basing ourselves on the video recordings, as well as notes taken by one of the researchers, the relevant passages were transcribed in their entirety following the normal conversation format ("turn taking" is indicated by a new paragraph. Data input activity as well as the reactions of the software (changes, messages) have been indicated, in order to report on the interaction between the students as well as between the students and the computer.

The sequence presented below is particularly interesting because it shows different aspects of the dynamics involved in collaboration at the following levels:
- task solving procedures; i.e. the way in which the students plan each stage, define aims, take and assess decisions, deal with the information provided by the program and proceed when faced with a problem.
- division of labour and roles; the way in which the students share the computer commands, take part in the conversation and make suggestions, the nature of their exchanges, and the roles they assume during the working and decision making processes, in terms of who initiates and concludes important decisions, who

9

contributes decisive arguments, who takes the final decision and which feelings and emotions are expressed.

- the meaning given to the task; this sequence in effect allows something of the meaning that the students attribute to the learning situation to show through.

The sequence in progress

The sequence presented here lasts roughly ten minutes, during which time a team of three is programming the drilling of five holes in the part to be machined. This sequence is divided in four stages: initial choices; reactions to an error warning; various attempts towards a (wrong) solution.

Stage 1: Initial choices.

The three students, Guy, Ted and Didier, have already been at work for roughly fifteen minutes. Since the start of the exercise, Guy has been monopolising the commands of the PC. Ted is sitting on his left, in front of the screen, while Didier has placed himself the outer edge of the group, furthest from the computer. The instructions and a sample of an already machined part are in front of Ted. Didier has offered to write the report to be handed in at the end of the training session. This division of roles was not preceded by any explicit negotiation.

The first stage of production lasts roughly 90 seconds, during which the students (Guy and Ted) input various data. Then, in the following excerpt, the students decide the values in millimetres for each working level of the drill. These values correspond to the distance between the surface of the part, taken as level zero, and each level reached by the drill from its initial position.

Security level (at tightening): level on which the machine positions the drill above the part.	Fast approach: level reached by the drill in its quick descent from the security level towards the part, still without touching it.
Reference surface: surface of the part, on which the tool makes contact with the raw material.	Depth of the hole: - at the diameter: depth reached by the part of the drill determining its diameter (above the tip) - at the tip: depth of drilling at the tip of the drill

[insert fig. 3 and 4 here]

The correct solution would require that the values for each level deeper follow a decreasing order. For instance: Security level: Z=10 mm. Fast approach Z=2 mm. Reference surface Z=0. Depth Z= -12, given at the diameter. In this case, the students use a drill, for which the program automatically integrates the length of the tip into its calculations. Therefore a depth indicated as -12 "at the diameter" becomes an actual depth of -17.5.

G1[1]   (He reads the screen, then speaks without turning towards the others) Security level. Pfff.   *Goes on to the next box without filling the first.*

G2   (He reads) Fast approach, (turning to T) Down to z 0, OK?

T3   No, less, I mean more! +2.

G4   Down to z 2. Yeap, that's right.   *He types +2.*

T5   Now, depth (looking at the screen).

G6   (reading, without paying attention to T.) Surface level, 0.

                                                       He leaves the 0.

T7   And now depth…

G8   (reading) depth of the hole… (both look at the instructions in front of T.)

T9   (reading the instructions) 12. (Turning to G.) It is -12. -12 or +12?

G10   (looking at the screen) z -12.   *He types -12.*

G11   (reading) Fast: at tightening

T12   (skipping to the next stage, looking at the screen) Careful, "depth of hole" is meant for the diameter, not for the tip.

G13   *Accept the default option "Fast: at tightening" and clicks on the "diameter" option for the depth.*

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[1] Guy=G; Ted=T; program=**P**.
  Data input activity stands on the right side of the page in italics
   and the other actions are in brackets in the text.

G14   (checks the values indicated for each level, going up with the pointer). Surface, OK. "Security level, at tightening", what's that?

T15   That, I don't think we have …

G16   (turning briefly towards T) I don't think we have used that..

T17   No, never.

G18   *Leaves 0 for "security level" and clicks on OK to indicate that the window has been completed.*

P19   Recalculates the depth from -12 to -17.5 and changes the option "depth at the diameter" for "depth at the tip". Beeps. Remains on the same window.

All the verbal exchanges take place between Guy and Ted. By his attitude and his glances, Didier shows that he is paying attention, but he does not intervene during this first stage.

As for the working procedure, we notice that Guy, almost always looking at the screen, reads the headings of the dialogue boxes aloud, following the order suggested by the program. Decision-making is partly based on what the students remember of the processes used in the exercises done during the school year preceding the practical work. Decisions are not justified through discussion (G4, G10, G13), this makes it difficult for an external observer to discern their motives. In the exchange from G14 to G18, it is clear that the point of reference is the curriculum, and not the computer program, nor the future drilling situation. The dialogue determining the choice of the value for the security level (from G14 to G18) is important, because the decision taken give rise to a serious mistake in the drilling of the part. What is happening here? Guy's question might have lead to a conceptualisation (G14 "security level, what's that?"), but the tone used rather indicates irritated surprise ("What is that thing I don't know about?") The decision is based on the idea shared by both, that having never used it (i.e. in their former schooling experience) they should not pay attention to it. G18 translates into action the conclusion that if something has never been used, the zero value should be left as it is.

Regarding status, Guy seems to occupy a high position. Sitting at the commands, he plays the role of an intermediary between the program and his team mates. He, alone, determines the reading rhythm of the program and the filling in of answers. Twice (in T5 and T7), Ted tries to introduce the concept of "depth", against the order indicated

12

both by the program and by Guy, but the latter ignores Ted's interventions until his own reading of the screen brings him to the same point. Guy passes judgement on Ted's proposal (G4: "Down to Z. Yeap, that's right"), and chooses what answer he will feed to the computer. In the transcribed passage as well as in the preceding exchanges, he seems to be able to recall the proceedings with greater confidence, a capacity he expresses in normative assertions: "That's how it' s done"; he has a greater influence on the decision taken. As for Didier, he follows what is going on with his eyes, but he does not express himself verbally, nor do either of his team mates address him directly in this excerpt.

Stage 2: reactions to an error warning.

The students have given 0; 2; 0; -12; and the "depth at the diameter" option. The program automatically recalculates the depth of the hole at the tip of the tool, beeps and does not move on to the next stage.

G20   (looking at the screen) What crap is it telling me!? Depth of the hole, what's that codswallop?

T21   (slightly irritated and looking at G) That's because you haven't defined the depth of the part, you can't make a hole in a sheet!

G22   (in a low voice, and looking at the screen) Well, perhaps it wasn' t like that.

In G20, Guy poses as the main interlocutor of the program, which addresses <u>him</u> ("…telling <u>me</u>"). He also seems to indicate the program to be the cause of the problem (the computer is talking crap). Is it an attempt at face saving? At the same time, he wants an explanation.

Ted answers, confirming that Guy is indeed the main interlocutor of the program and indicates <u>him</u> to be the cause of the problem ("<u>you</u> haven't defined…"). At this point in their collaboration, the mistake is not considered as having been made by the team, but by one of the protagonists. From a cognitive point of view, it is interesting to note that in his question, Guy already mentions an interpretation of the problem: the trouble is the depth of the hole; and Ted implicitly accepts this suggestion when he starts explaining (in T21) what is wrong with the depth.

How did they arrive at this idea? In P19, the program simultaneously gives several indications: it moves from the "depth at the diameter" to the "depth at the tip" option, then it recalculates the depth and it beeps. This signal reacts to the fact that the students have given a security level that is lower than the fast approach level. But the students do not interpret the beep in that way, because they think the problem is linked to the recalculation made by the computer, i.e. to the depth of the holes.

Apparently, they have not noticed that the "tip" option has replaced the "diameter" option and, like other teams observed, they do not seem to remember that the program makes this conversion automatically. They are also backed up in their opinion because the software, in this case, does not give them a written message specifying what mistake they have made, whereas it has done so on other occasions.

We shall see that Ted and Guy's (incorrect) understanding of the problem influences many of their attempts to solve it in the next six minutes.

Stage 3: various attempts

For six minutes Guy, Ted and, to a lesser degree, Didier, will thus embark upon an intense search for solutions. Besides the systematic exploration of the menus, twice repeated by Guy, they perform nine separate interventions on the program, in vain. Their procedures in this search [2] prove to be very varied: checks and changes in the computer image of the part, changes in the piercing options, consultation of the menus and "help" option. The main line of their research aims at making sure that the part, as defined for the program, is indeed 20 mm high. This height already worried them when they started, and has been the topic of a fruitless interaction with the teacher; now still unsatisfied, they focus on that point. Ted also suggests some modifications bearing on previous choices. Does this reveal the fragility of both the decisions taken and of the knowledge and agreement underlying them? Or is it a simple trial-and-error approach, often described in people accustomed to seizing the opportunity allowed to them to modify former choices, which is facilitated by computerised instruments?

In this part, Ted plays a more important role: most proposals come from him, and are followed by Guy. Moreover, Ted does not like Guy's silent dialogues with the program and he interrupts him twice, asking him what he is doing. As for Didier, he goes away for a brief moment!

The students show signs of stress and irritation: sighs, violent blows on the keyboard, and disparaging comments: "A real treat, this practical work, isn't it?" says Didier to Ted, sounding disabused. Further on, the latter comments: "We haven't touched this subject for a year, why do we have to do this all of a sudden?" Some of their remarks to each another are made harshly: "Why are you doing this?" "Anyway, it doesn't make any difference". At other times, they scold the program for not "agreeing".

Stage 4: Towards a (wrong) solution

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[2] The transcription of this long part is not reported here for lack of space.

After the various attempts described above, Ted makes a suggestion from which they will elaborate a means of solving the problem.

T101   Try to fill the field with the zeros[3], write some mock values, to see if it accepts them. If it does, it means that we have forgotten to indicate a depth [4]

G102-G111   *Following Ted's indications, Guy puts 3 for security level, for fast approach and for reference surface.*

P112   "Refuses" their parameters by keeping the same window on the screen. Beeps.

T113   (sounding exasperated) Ooooh! That's not it!

G114   *He feeds 0 s everywhere, even for the depth of the drilling.*

P115   Moves on to the next window, which means that the values offered have been accepted.

T116   (surprised, laughs ironically and speaks to D) We've put 0 s everywhere and it works! That thing' s stoned!

G117   (scratches his head and moves from one box to the next with the pointer. When he is on "bottom of the hole", Ted suggests:)

T118   Try it with -20 (stressing the word "minus"), well, - 12, then check the diameter as well.

G119   *Follows T's proposals.*

P120   Accepts and moves on to the next window.

T121   Well, we only have to check the fast approach, now; normally it's +2.

G122   Let's drop the fast approach!

T123   Come on! If we are above (gesture of one hand pointing down towards the other, level hand)…

G124   (grunts dismissively, with a gesture inviting T. to drop the issue)

T125   No, it won't work, we must try to approach fast.

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3 In the window concerning the drilling levels.
4 For one of the levels, the correct value is not 0.

G126   We won't approach fast, that's all.

T127   OK, go ahead.

As far as collaboration is concerned, we notice that up to G19, Ted takes the initiative. Indeed, the alternation of the speakers in T1-G2, T3-G4, T6-G7 and in T18-G19, shows that his suggestions or orders are followed by Guy. This passage confirms Ted's role as "proposer". Since he cannot, like Guy, search the menus for ideas, he seems freer to elaborate suggestions that are not directly linked to what appears on the screen. In G14 Guy, again, modifies the values without previous discussion but Ted, who watches him, comments on the program's feedback and directs the next action.

What solution do they come to? In T1, Ted finally takes into account the values given to the parameters and suggests a test that ought to show if they must replace one of the 0's with another value ("it means that we have forgotten to indicate a depth"). That he should suggest putting random values, and then be surprised by the program's refusal, reveals an important aspect in his visualisation of the problem: he considers each level as a discrete unit, as it appears on the screen, and not as a stage in the descending movement of the drill, where values must follow a decreasing order, as in the actual drilling situation. In this instance, the program, which does not offer error warnings concerning the security level, backs him up in his mistake.

After P12, which indicates the failure of the T1 proposal, Guy, in turn, seems to carry out a test by putting 0's everywhere, but his test concerns the program's feedback; thus they notice that it accepts solutions that are wrong for the actual machining (a drilling depth of zero). But the team does not grasp the full implications of this phenomenon (i.e., that an incorrect solution can be accepted) and afterwards they opt for the following procedure: starting from the solution accepted by the program (0 for all parameters), they add the value needed for drilling (the depth of -12), which is so evident that it does not give rise to any discussion. Here, apparently, their aim (and consequently their interpretation of the task) has momentarily changed: now they no longer refer to the machining process but want to give the program a solution it will accept. Nevertheless, Ted thinks they still have to give a value for the fast approach: "Normally, it is +2". When Guy, unimpressed by this appeal to respect a norm, refuses, Ted goes back to the previous interpretation and defends his idea by describing - verbally and with gestures - the machining situation, and then by defining more precisely the action concerned, i.e. to approach fast. He stresses his assertion with an impersonal directive ("we must" - in French "il faut", literally "one must") and eventually by mentioning the generic consequence of Guy's option: "it won't work". In G26 Guy insists: "We won't approach fast, that's all", as if for him not

approaching fast was not a mistake and besides, it was not important to approach fast. Furthermore, Ted gives in, abandoning for the moment the goal set by the teacher i.e. that the machining time should be as short as possible. In the end, the program accepts their solution and the students think they have got away with it. They will use the same procedure for all the operations programmed.

As a result, when their part is machined it will actually be scratched by one of the tools for lack of positive values for the security and for the fast approach level.

ANALYSIS OF THE OBSERVATIONS

The interactions between learners in this sequence

The interactions between learners are quasi permanent and throughout the length of the activity verbal exchanges, which are at times very lively, accompany their work. What is the nature of these verbal exchanges and how should they be characterised?

As we anticipated, socio-cognitive conflicts were observed at certain times between those individuals who had different points of view. However, the confrontation between learners seems neither valued as such, nor methodically thought through at any time. What stands out is that rather than really confronting each other with their points of view (as they do in, for example, excerpt T.121 to T.127), they tend to ask the computer to settle the argument by means of the immediate feedback that it provides (feedback which still needs to be interpreted correctly). The computer is expected to confirm or contradict the sound basis or not of each operation or course of action. Requiring this of the software risks, as can be seen at times, short circuiting the cognitive restructuring processes necessary for the integration of different points of view, processes which, in psychosociogenetic research, are precisely identified as being fruitful.

Nevertheless we observe, notably because of negative feedback from the software, certain cognitive reelaborations on the part of the subjects. Their understanding of the task can, in effect, evolve along the way; the aim of the activity is itself at times prone

17

to modification. This is for example the case when, following persistent blocks, the initial task aimed at *machining a part* is manifestly transformed into a task aimed at *satisfying the program*, that is circumventing it as the need arises by introducing incoherent data with the aim of progressing with the task despite everything.

In the sequence analysed, the distribution of roles is equally worthy of attention. In effect, it is striking to see the work being carried out by two students, leaving the third, that is to say Didier, outside the sphere of activity. However this marginalisation of Didier's role should be examined within the context of the work carried out as a whole during that afternoon. Effectively, in group work, it does happen that the person who appears to be 'left out' is in fact at a distance which facilitates a more reflective overview, a "meta-view' of the action taking place. It can happen that from this position, it is possible to give points of view and make proposals which are pertinent to the activity and useful in its development. This contribution, neglected by the duo in command does, at a later stage, play an essential role in the end solution, when the duo has become capable of integrating a third point of view and one which was not lacking in relevance.

Everything takes place as if, for this third partner, the fact of not having to act (through lack of power), allows him to develop a meta-cognitive space for reflecting upon what is happening. He may not have sufficient social weight to impose his point of view, but it is through the persistence of his observation that in the end he plays an essential role, at least in certain cases.

The tool which is at the centre of the activity has an important place in this distribution of roles. In effect, the computer only has one mouse and holding it is, de facto, a form of seizing power which, at least in the examples reported here, can only be countermanded by an imposing verbal control on the part of the partner. During the exercise however, we see a changing distribution of roles, most notably as particular difficulties are confronted.

The characteristics of the software also influence the nature of the interactions which develop between learners. In this practical work session, one can question whether or not the program used incites them (perhaps to excess) to resort to methods of trial and error. In effect, the rapid presentation of countless windows and the large number of choices cause the students to take risks, and this all the more because the time available to them is relatively limited. To orientate themselves they sometimes seem to click on options or data almost at random, counting on the feedback to readjust

their choice. It should also be noted that other aspects of this software, in particular the possibility of simulating and visualising the state of machining at any given time is little exploited by the students. It can be hypothesised that the use of the visualisation options could have given rise to other interpersonal relations orientated less towards forging ahead with the activity and more towards close examination of work that had already been carried out.

Without doubt, these observations as a whole reveal that the students do in fact collaborate, but the form that this collaboration takes is quite particular: it is essentially a pooling of resources, in which the partners do not appear to require justifications or explanations from each other. Given the perceived sense of urgency, proceeding in this manner is probably the most rapid strategy. The work is thus carried out in constant dialogue, (at least in the excerpts presented here), without argumentation or exploratory talk being observed. We see the students neither planning each stage nor establishing partial objectives. The activity is considered globally. Everything occurs as if responsibility for this is left to the machine, given the job of "testing" the worth of decisions taken. What is more, one of the participants is perceived as the computer's main interlocutor; having this responsibility does not encourage him to integrate the third partner into the collective dynamics. We never see them offering an opinion 'in turn' for example. Studies have already reported that work by trial and error does not encourage social grounding (Blaye et al. 1992; Hoyles, Healy & Sutherland, 1990).

To sum up, there is collaboration, practically continuous interaction, role distribution strongly dependent upon the nature of the software and tools being shared (a screen, a keyboard, a single mouse) and probably upon the students' perception of the limited time available, causing them to aim for efficacy. A preoccupation with confronting and deepening their comprehension of programming machining does not appear to be central to the learners, as we shall see now in the part which deals with their interpretation of the meaning of the proposed activity.

The students' interpretation of the meaning of the situation

The naive observer who arrives in a workshop could be under the impression that s/he is placed in a situation from which to observe interactions aimed mainly at broadening knowledge of a technical operation. This is not the case. The impression released from an attentive examination of the reality of the exchanges transcribed is of a scene which includes other factors even though learning does nevertheless take place. What

representation of the task do the students make for themselves? They seem to understand their role as being essentially one of correctly carrying out the machining of a part during the afternoon and respecting certain limitations, most notably that of finding an optimal machining time. In a way, this is what the teacher asked of them during the initial instructions. Nobody speaks of what else might be learned here, nor takes any action in that direction.

In keeping with an implicit didactic contract, and no doubt present in all their school experience, these students expect that essentially the task presented to them by the teacher require the application of knowledge learned and practised previously in class. They refer to this several times: either positively, to base themselves upon it, or negatively to complain about this task found by some of them to be lacking and for which they do not feel adequately prepared.

The students do not bring this up in the excerpts reported here, but we were informed of this elsewhere: the mastery of this Flexible Manufacturing System cell does not form part of the final examinations which certify their level of professional competence, thus this only had the status of a college exercise. This 'college' interpretation of the task, probably caused them sometimes to operate in the abstract, without basing themselves upon their knowledge of machining. However, this practical knowledge is essential for the correct use of the software and to give full meaning to the numerous parameters to be introduced (notably the specification of different plans of advance for the tools).

But the task that they set themselves that afternoon is not only a cognitive one: one senses at all times the need for one or the other of them to save face when confronted with a difficulty. They play power games. Thus, for example, when Ted attempts to win control of the situation by giving Guy orders one after the other, the tension mounts, an aggression towards the machine and between them both manifests itself, each blaming the other for the impasse.

A further interesting element concerns the students' perception of the software: the latter has imperfections, but it is a possibility that the students do not appear to envisage seriously. They implicitly expect the software to work perfectly, require it to test everything and when its reaction appears absurd, they think it has broken down (cf. T116:"We've put 0s everywhere and it works! That thing's stoned!"). This perhaps reflects only a partial understanding of the nature of the tool that they are using and of the logic behind its working. The software can allow solutions which lead to errors

20

and does not reject fruitless avenues of research; it is an open-ended instrument, conceived in the first place for use in a professional context and not for training beginners who still need to be led step by step much in the style of a tutorial. These characteristics of the machine and the consequences which arise from them for their way for working, do not really appear to be perceived or thought of as such by the students.

The slight apprehension of this strange partner the machine represents for them, probably also causes them to miss using certain symbolic resources, such as the possibility of simulating on the screen the machining that they have already programmed in and to visualise the successive stages of the part. What is striking is that throughout the length of these sequences they use the visualisation possibilities very little as a means of alleviating uncertainties or controlling the adequate nature of the work which has already been carried out.

The meaning which these technician students give to different events experienced during the task, that is to say the situation itself, thus appears very marked on the one hand by the college framework and on the other by their utilitarian rapport with the technical device which they are spending time getting to work, even if it means without understanding it. Where do the representations that the students manifest here come from?

Reflections upon wider psychological and social factors

The arrival of automated systems of production has not been without the creation of uncertainty and even worry for those directly concerned. To what extent will the machine replace human labour? Where do we stand in relation to this? Is there a risk of human activities becoming subservient to the machine or, on the contrary, will these machines enrich them? Who will really benefit form the changes taking place? What level of skill will the worker, the technician or the engineer have to achieve in order to take part in this change and not pay the price? These questions may seem philosophical, they are however very everyday and concrete, in that everyone is familiar with firms that have restructured with the introduction of computerised tools, putting people, perhaps even family members, out of work. But there is some awareness of other firms which are growing because of their know-how in computing and automation.

21

In this sequences observed as well as in the opinions that certain students expressed elsewhere regarding automated manufacturing we find traces of this same problem, but at another level. At their stage of training seemingly the student technicians do not allow themselves to take mental control of the device to which they are beeing introduced. They become attached to mastering the workings, to the level of competence which is expected of them, but the rapport that they have with the latter gives rise to, are clearly not thought through and thematised as such.

The introduction of new computer assisted manufacturing techniques and the perception of it that those concerned have, has repeatedly called into question the status of traditional industrial know-how that can be described as a craft: is it still necessary? To what extent is the mastery of machine tools an indispensable prerequisite to a technical training? Can automated manufacturing be learned without passing through this stage? These questions are not specific to the Sainte-Croix Technical College but have been posed since the introduction of the first generation of computer numerical controlled machines (Martin, 1991). In the excerpt reported here, we see the students wawer between threating the problem in a concrete way (thus at certain times, they have recourse to a language of gesture in order to make themselves understood, cf. T123), but at other times (for example just after the use of gesture mentioned above), we see them formally trying to manage data which does not appear grounded in reality. In fact, this second type of data management predominated in the group. This admittedly allowed them to "fill in" all the windows provided by the software, and in doing so, to advance in their work, however, the end product was scratched due to a lack of realism in the specification of values on the screen. From a psychological point of view, the question is thus to discern under what conditions the concrete experience of the working of tools and the reaction of materials can be a resource faciliting the programming of the machining of a part.

This finding brings us back to the question of efficacy. What can it be here? Is it the efficacy of carrying out the work demanded of them quickly, or does efficacy reside in the quality obtained, knowing "lost" time to be necessary for visualisation, for checking back on work already done and for anticipating the concrete action that the machine will carry out, in view of minimalising the risk of errors? It is not certain that the students consciously asked themselves this question, either because their lengthy schooling perhaps never required an ability to evaluate their own performance, its efficiency and its costs; be it because this ability has been little developed in view of the fact that scholastic gains are often perceived in the short-term. The efficacy expected could also be elswhere - but nobody seems to have thought of this and thus

to have reflected upon and evaluated it - in knowledge which can be acquired through difficulties encountered and thus through the solutions worked out in order to overcome them.

Other important aspects of the Technical College are also reflected in the observations which we have reported here. In effect, the study of the curriculum structure has permitted us to perceive the highly symbolic and nevertheless marginal aspect of this practical work. Shown off to advantage by the college each time that its public image is at stake, the training activities on the Flexible Manufacturing System form only a small part of the course and are not part of the final assessment for the technicians diploma, this notably because State regulations and professionnal training have not yet integrated all the technological changes in their assessment systems. The marginalisation of this practical work is not only that of its insertion into the College but also that attributed to it by the subjectivity of the students. The latter, through numerous remarks, let us known that they were not sure that this was a real machine and a real industrial exercise. In effect, they machine resin and not metals (for reason of security and visibility of operations), also use of this software is not widespread in the factories in the area. Moreover, as there is no standard in this regard and each automation system has specific characteristics, the students do not see the relevance of this learning situation. Some of them are interested in the possibility of getting a complicated device to work (this is shown in the attraction, sometimes even excitement which the final automatic machining engenders), but others, not having been invited to reflect upon the specific or general characteristics of the machine and software, remain sceptical regarding the point of working on a device which they will certainly not find as is, in their future professional life.

This takes us back to a problem of identity; we have seen the students struggling to save face and place themselves in a high position in their relations. Without doubt this has a connection with their insecurity regarding their professional image which leaves them doubting: is the most important thing for a technician understanding or know-how? The ethos of the profession of precision mechanics requires the acquisition, over years of apprenticeship, of the almost perfect mastery of classic machine tools, however, this requirement cannot be transposed onto new devices which are still in development and of which the College only has introductory objectives. What is it then to show yourself to be a good student or worker in this situation? Thus we can see that diverse psychological and social factors traverse these learning situations.

CONCLUSION

In this chapter, we have presented a piece of research based upon the observation of a live training situation within a Technical College. Its goal was to study the training problems which arise from the introduction of new manufacturing technologies and the way in which student technicians construct the new skills expected of them today in this domain. This led to a particular interest in the socio-cognitive interactions deployed during the practical sessions on automation.

A precise work sequence was placed under the "microscope", this without losing sight of the institutional and social context within which this sequence took place, with the aim of making appearent the interdependance of two phenomena: the micro-processes of the interactions and the more macro pedagogical, technical and social elements present in the lives of the students and of the school.

The learning situations observed revealed themselves, in an even more pronounced way than expected, to include not only cognitive and technical elements but also questions of relationship and identity. When facing difficulties in finding a solution, the students do apply their knowledge, but we also see them pushing themselves to finish quickly, trying to save face, showing ambivalent attitudes towards the automation, or even questioning themselves about the meaning or relevance of the task proposed. The detailed analysis of what happens or is said within a working group reveals traces of these diverse elements which, in one way or another, mark the modes of collaboration adopted.

In this context of activities containing multiple elements, it is important to grasp the manner in which the student technicians interpret the task which is required of them. The meaning which they give to this practical work situation thus appeared to be strongly influenced by the scholastic framework of their training; the students seemed to focus essentially upon carrying out the work asked of them as quickly as possible and obtaining a good mark. They show a utilitarian rapport with the technical device, using a method of trial and error to get it to work without necessarily seeking to understand how it works. The objective, which could be to deepen thier understanding of the device, escapes them, moreover this objective is not made explicit in the teacher's instructions.

Regarding the question of the efficiency of sociocognitive interactions, our study shows that it is interesting to consider two levels of reality: on the one hand, the

different pedagogical changes that our observations suggest: notably learning objectives to be redefined, evaluation criteria to be made explicit, time management and organisation of group work to be restructured. On the other hand and more subjectively, the impression that the students have of the efficiency of their own activity as a function of their understanding of the objectives to be achieved. The goal of training technicians to master sophisticated tools with rapidly evolving technology, necessitates the rethinking of both the pedagogical activity involved and the understanding of the profession and its demands.
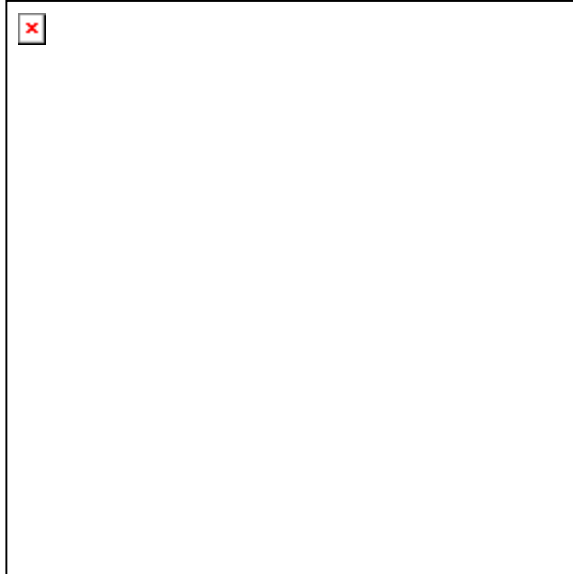
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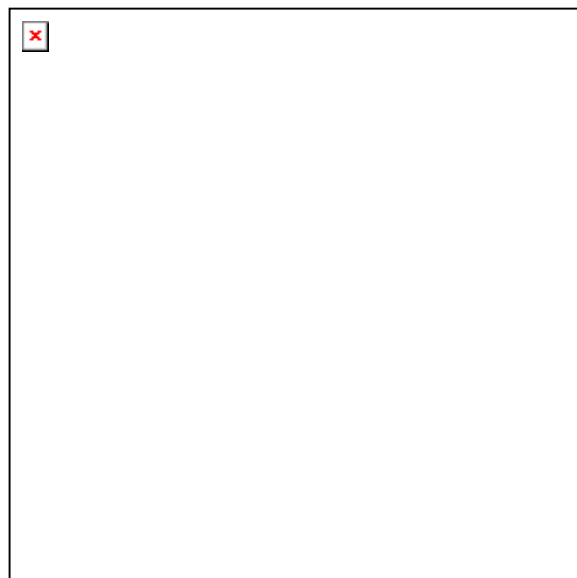
Bearison, D. J. (1991). Interactional contexts of cognitive developpement: Piagetian approaches to sociogenesis. Norwood N.Y.,: Ablex.

Bell, N.,Grossen, M., & Perret-Clermont, A. N. (1985). Sociocognitive conflict and intellectual growth. In M. W. Berkowitz (Eds.), Peer Conflict and Psychological Growth San Francisco: Jossey Bass.

Benavente, A.,da Costa, A. F.,Machado, F. L., & Neves, M. C. (1993). De l'autre côté de l'école. Berne: Peter Lang.

Blaye, A. (1989). Nature et effets des opposition dans des situations de corésolution de problèmes entre pairs. In B. e. Garnier (Eds.), Construction des savoirs-Obstacles et Conflits Québec: Cirade, éd. Agence d'Arc.

Blaye, A.,Light, P., & Rubtsov, V. (1992). Collaborative learning at the computer; how social processes "interface" with human-computer interaction. European Journal of Psychology of Education, 7(4), 257-268.

Brossard, M., Wargnier, P. Rôle de certaines variables contextuelles sur le fonctionnement cognitif des élèves en situation scolaire. Bulletin de psychologie, XLVI(412), 703-709.

Collins, A.,Brown, J. S., & Newman, S. (1989). Cognitive Apprenticeship: Teaching the Crafts of Reading, Writing and Mathematics. In L. B. Resnick (Eds.), Knowing, Learning, and Instruction Hillsdale, New Jersey: LEA.

Crook, C. (1995). On Resourcing a concern for Collaboration Within Peer Interaction. Cognition and Instruction. Special Issue: Processes and products of collaborative problem solving: some interdisciplinary perspectives., 13(4), 541-547.

Dillenbourg, P., Baker, M., Blaye, A., O'Malley, C. (1995). The Evolution of Research on Collaborative Learning. In P. Reimann Spada, H. (Eds.), Learning in Humans and Machines London: Pergamnon.

Doise, W., & Mugny, G. (1984). The social development of intellect. Oxford: Pergamon Press.

Donaldson, M. (1978). Children's Mind. Glasgow: Fontana.

Emler, N., & Valiant, G. (1982). Social interaction and cognitive conflict in the development of spatial coordination. British Journal of Psychology, 73, 295-303.

Flahaut, F. (1978). La parole intermédiaire. Paris: Le Seuil.

Forman, E. A. &. M., J. (1993). Vygotskian perspective on children's collaborative problem-solving activities. In N. M. E.A. Forman C.A. Stone (Eds.) (Eds.), Contexts for learning: sociocultural dynamics in chidren's development. New York, Oxford: Oxford University Press.

Garduno Rubio, T. (1996) Action, interaction et réflexion dans la conception et la réalisation d'une expérience pédagogique: l'Ecole Paidos à Mexico. Université de Neuchâtel.

Gilly, M. (1980). Maître-élève: rôles institutionnels et représentations. Paris: Presses Universitaires de France.

Gilly, M.,Fraisse, J., & Roux, J. P. (1988). Résolutions de problèmes en dyades et progrès cognitifs chez des enfants de 11 à 13 ans: dynaniques interactives et socio-cognitives. In A. N. Perret-Clermont & M. Nicolet (Eds.), Interagir et connaître Cousset (FR): Editions Delval.

Golay Schilter, D. (1995). Regards sur l'organisation et les enjeux de l'enseignement à l'Ecole Technique de Sainte-Croix (Document de recherche No. 4). Séminaire de Psychologie. Université de Neuchâtel.

Granott, N. (1993). Patterns of Interaction in the Co-Construction of Knowledge. In H. Wozniak & K. W. Fischer (Eds.), Development in Context. Acting and Thinking in Specific Environments. Hillsdale, New Jersey: LEA.

Grossen, M. (1988). L'intersubjectivité en situation de test. Cousset (Fribourg): Editions Delval.

Grossen, M.,Liengme Bessire, M.-J., & Perret-Clermont, A.-N. (1997). Construction de l'interaction et dynamiques socio-cognitives. In M. Grossen & B. Py (Eds.), Pratiques sociales et médiations symboliques Berne: Peter Lang.

Healy, L.,Stefano, P., & Hoyles, C. (1995). Making Sense of Groups, Computers, and Mathematics. Cognition and Instruction. Special Issue: Processes and products of collaborative problem solving: some interdisciplinary perspectives., 13(4), 505-523.

Hennessy, S., & McCormick, R. (1994). The general problem-solving process in technology education. In F. Banks (Eds.), Teaching technology (pp. 94-108). New York et Londres: Routledge, The Open University.

Howe, C., Tolmie, A., Green, K., Mackenzie, M. (1995). Peer collaboration and conceptual growth in physic: task influences on children's understanding of heating and cooling. Cognition and instruction, 13(4), 483-503.

Hoyles, C., & Forman, E. A. (1995). Introduction. Cognition and Instruction. Special Issue: Processes and products of collaborative problem solving: some interdisciplinary perspectives., 13(4), 479-482.

Hoyles, C.,Healy, L., & Pozzi, S. (1992). Interdependance and autonomy: aspects of groupwork with computers. Learning and Instruction, 2, 239-257.

Hoyles, C.,Healy, L., & Sutherland, R. (1990). The Role of Peer Group Discussion in Mathematical Environments No. ?). Institute of Education, Departement of Mathematics, Statistics and Computing.

Hundeide, K. (1985). The tacit background of children's juggements. In J. V. Wertsch (Eds.), Cuture communication and cognition: Vygotskian perspectives Cambridge: Cambridge University Press.

Iannacone, A., & Perret-Clermont, A. N. (1993). Qu'est-ce qui s'apprend? Qu'est-ce qui se développe? In J. Wassmann & P. Dasen (Eds.), Les savoirs quotidiens Freibourg (Schweiz): Universitätsverlag Freibourg.

Jackson, A. C.,Fletscher, B., & Messer, D. J. (1992). When talking doesn't help: an investigation of microcomputer-based groupp problem solving. Learning and Instruction, 2, 185-197.

Järvelä, S. (1995). The cognitive apprenticeship model in a technologically rich learning environment: interpreting the learning interaction. Learning and Instruction, 5.

Kaiser, C. (1996). Apprendre un métier technique aujourd'hui: représentations des apprenants (Document de recherche No. 8). Séminaire de Psychologie. Université de Neuchâtel.

Leplat, J. (1993). Ergonomie et activités collectives. Revue roumaine de Psychologie, 37(2), 103-118.

Light, P., & Blaye, A. (1989). Computer-based learning: the social dimension. In H. Foot,M. Morgan, & R. Shute (Eds.), Children helping children Chichester: John Wiley.

Light, P., & Perret-Clermont, A. N. (1989). Social context effects in learning and testing. In D. Gellatly,D. Rogers, & J. A. Sloboda (Eds.), Cognition and Social Worlds (pp. 99-112). Oxford: Oxford University Press.

Linhart, F. (1994). La modernisation des entreprises. Paris: Editions La Découverte.

Martin, L. M. W., Scribner, S. (1991). Laboratory for Cognitive Studies of Work: A Case Study of the Intellectual Implications of a New Technology. Teachers College Record, 92(4).

Martin, L. M. W. (1995). Linking thought and setting in the study of workplace learning. In L. Martin,K. Nelson, & E. Tobach (Eds.), Sociocultural psychology. Theory and practice of doing and knowing Cambridge: Cambridge University Press.

McLane, J. B., & Wertsch, J. V. (1986). Child-Child and Adult-Child Interaction: A Vygotskian Study of Dyadic Problem Systems. The Quaterly Newslewtter of the Laboratory of Comparative Human Cognition, 8(3), 98.

Mercer, N. (à paraître). The quality of talk in children's collaborative activity in the classroom. Learning and Instruction, 125-154.

Mercer, N., & Fisher, E. (1992). How do teachers help children to learn? An analysis of teachers' interventions in computer-based activities. Learning and Instruction, 2, 339-355.

Moscovici, S., & Paicheler, G. (1973). Travail, individu et groupe. In S. Moscovici (Eds.), Introduction à la psychologie sociale Paris: Librairie Larousse.

Muller, N., & Perret-Clermont, A. N. (in press). .

Perrenoud, P. (1994). Métier d'élève et sens du travail scolaire. Paris: ESF éditeur.

Perret, J. F. (1985). Comprendre l'écriture des nombres. Berne: Peter Lang.

Perret, J. F. (1997). Introduction de nouvelles technologies dans un établissement d'enseignement professionnel: logique d'équipement et logique de formation (Document de recherche No. 5). Séminaire de Psychologie. Université de Neuchâtel.

Perret-Clermont, A.-N., Perret, J.-F., Bell, N. (1991). The social construction of meaning and cognitive activity in elementary school children. In L. B. Resnick Levine, J.M., Teasly S.D. (Eds.) (Eds.), Social Shared Cognition Washington, DC: American Psychological Association.

Perret-Clermont, A. N. (1980). Social interaction and cognitive development in children. London, New-York: Academic Press.

Perret-Clermont, A. N., & Nicolet, M. (1988). Interagir et connaître. Cousset (FR): Editions Delval.

Pléty, R. (1996). L'apprentissage coopératif. Lyon: Presses Universitaires de Lyon.

Pontecorvo, C. (1990). Social context, semiotic mediation and forms of discourse in constructing knowledge at school. Learning and Instruction, 2, 1-27.

Rabardel, P. (1995). Les hommes et les technologies. Paris: A. Colin.

Rogoff, B. (1995). Observing sociocultural activity on three planes: participatory appropriation, guided participation, and apprenticeship. In P. d. R. J. V. Wertsch & A. Alvarez (Eds.) (Eds.), Sociocultural studies of mind. (pp. 139-163). Cambridge: Cambridge University Press.

Rommetveit, R. (1979). On common codes and dynamic residuals in human communication. In R. Blakar (Eds.), Studies of Language, Thought and Verbal Communication London: Academic Press.

Saint-Dizier, V.,Trognon, A., & Grossen, M. (1995). Analyse interlocutoire d'une situation de corésolution d'un problème arithmétique. In Congrès des Sciences Sociales Suisses. Atelier de la Société Suisse de Psychologie, . Berne:

Säljö, R. (1991). Piagetian controversies, Cognitive competence, and assumption about human communication. Educational Psychology Review, 3(2), 117-126.

Säljö, R., Wyndhamm, J. (1993). Solving everyday problems in the formal setting: An empirical study of the school as context for thought. In S. Chaiklin & J. Lave (Eds.), Understanding practice. Perspectives on activity and context (pp. 245-254). Cambridge: Cambridge University Press.

Schubauer-Leoni, M. L. (1986). Le contrat didactique: un cadre interprétatif pour comprendre les savoirs manifestés par les élèves en mathématique. European Journal of Psychology of Education, 1(2), 139-153.

Schubauer-Leoni, M. L. (1993). L'"algèbre" vue par des professeurs du secondaire inférieur: démarche comparative en fonction des contextes institutionnels. In J. F. Perret & E. Runtz-Christan (Eds.), Les manuels font-ils école? Cousset (Fribourg): Delval / IRDP.

Schubauer-Leoni, M. L., & Grossen, M. (1993). Negotiating the Meaning of Questions in Didactic and Experimental Contracts. European Journal of Psychology of Education, 8(4), 451-471.

Stroobants, M. (1993). Savoir-faire et compétences au travail. Une sociologie de la fabrication des aptitudes. Bruxelles: Editions de l'Université de Bruxelles.

Trognon, A. (1991). L'interaction en général: sujets, groupes, cognitions, représentations sociales. Connexions, 57(1), 9-26.

Trognon, A. G., C. (1993). Résoudre conversationnellement un problème technologique. Nancy: Laboratoire de Psychologie, GRC Université de Nancy.

28

Verillon, P., & Rabardel, P. (1995). Cognition and Artifacts: A Contribution to the Study of Thought in Relation to Instrumented Activity. European Journal of Psychology of Education, 10(1), 77-101.

Vion, R. (1992). La communication verbale. Analyse des interactions. Paris: Hachette.

Winnkamen, F. (1990). Apprendre en imitant? Paris: Presses Univeristaires de France.

Woods, P. (1990). The happiest days? How pupils cope with school. London: The Falmer Press.