# Towards a cognitive theory of student cooperation in CAI

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*Abstract*

An advanced CAI program is used to do cognitive experiments comparing cooperative CAI with individual CAI. The program is based upon the instructional model of Berlin & White which prescribes a transfer of the student through a cognitive matrix representing the subject matter. Elements of this matrix are characterized by 2 factors, level of abstraction and level of movement (static, animation, and direct manipulation). Students are required to travel through the matrix towards higher levels of abstraction using adjacent elements in the matrix.

In an exploratory study freshman female Psychology students worked in pairs or individually. The pairs were composed in such a way that interactions between personality (extraversion / introversion) and intellectual ability (IQ) could be studied. The sessions are videotaped and the video-protocols are analyzed in the framework of a first order cognitive model which predicts superior performance of the pair composed out of an introvert, high IQ and an extravert, low IQ student.

The results of these studies will be used to adjust the cognitive model of cooperation. Such a model has implications for each cooperative learning activity, not only for CAI. Furthermore the results are going to be used to implement features in the courseware itself specifically geared at enhancing the cooperation of the students.

## *Introduction*

CAI is thought to be an effective way of teaching because the teaching actions are ideally based upon the specific individual cognitive state of the learner. Cooperative CAI is therefore a 'contradictio in terminis'. The cognitive map of two or more learners collaborating in the same CAI lesson might be quite different and a teaching strategy appropriate for one might be detrimental for the other. Studies on cooperative CAI do never show negative achievement scores when compared with the individual training (Johnson et al, 1985; Mevarech et al, 1987). Several explanations can be given for these findings. In the first place it appears that many CAI-lessons are not that adaptive to the individual cognitive status as they could be. For instance mastery learning based programs virtually are based upon an average student model.

Secondly, cooperation might have benificial effects upon the learning of both learners thus counterbalancing potential negative effects of less individually fitted teaching actions. (This paper does not deal with the more consisent findings of a beneficial effect of cooperation on social behaviour).

The beneficial effect could arise from two factors (Mevarech, 1988). The first one reflects the poor quality of many CAI-lessons today. Many machine-user interfaces in CAI-lessons are so bad that frequently misunderstandings in the communication occur. The frequency of these miscommunication is thought

to decrease if more than one user is present.
The more interesting reason for a potential beneficial effect is that cooperative CAI induces peer-teaching which has been established outside the context of CAI as a superior teaching approach (Webb, 1982). It is of interest that in the field of 'Intelligent' Teaching Systems several research programs now try to develop an artificial learning companion rather than a artificial teacher in order to mimic the peer-teaching situation (Self, 1985).

*Dynamics of Cooperation*
The inconsistency of the experimental data with regard to cooperative CAI might be explained by the fact that in the majority of studies no effort was undertaken to specify cognitive relevant pairing criteria.
It is clear that just putting two students in front of a terminal does not yield an optimal cooperation. Therefore some research has been done on optimal pairing. Most of this research studies the effect of a single factor in the pairing like 'Intelligence' or 'Gender' (Johnson et al, 1983; Dalton, 1988).
In the present exploratory study two factors are considered. This is done on the basis of a zero order model of the peer-teaching process. In this model we suppose that the optimal situation arises when the least capabel of the two partners is an extravert and exposes his/her misconceptions while the more introvert and more capable of the two takes mostly the role of a peer tutor.

*Method*
Subjects
As subjects 6 subjects (freshman psychology) participated in the experimental (cooperative) condition while 12 subjects were used in the control (individual CAI) condition. 3 pairs were formed from the 6 experimental Ss using intelligence and introversion measures. The pairs were composed as folows.
Average IQ/ Extravert with Average IQ / Extravert (pair 1)
Average IQ/ Introvert with Average IQ / Introvert (pair 2)
Low IO / Extravert with High IO / Introvert (pair 3)
Due to limited availability of student with identical pretreatment knowledge the pair High IQ/ Extravert with Low IQ / Introvert could'nt be formed.

*Treatment*
All pairs followed a CAI-lesson on Statistics. The CAI-lesson has been developped after an extensive analysis of most common misconceptions in the target-group. The teaching strategy is consistently based upon the instructional model of Berlin & White (1988). This model prescribes a transfer of the student through a cognitive matrix representing a concept or nodein the subject matter. Elements of this matrix are characterized by 2 factors, level of abstraction and level of movement (static, animation, and direct manipulation). Students are required to travel through this matrix

towards higher levels of abstraction using adjacent elements of the matrix. The concepts are represented in a tree-like network which is worked through from the more general towards the more specific concepts. Once a concept has been treated the student is allowed at any moment to visit the concept again. The lesson is implemented using the authoring environment Course of Action which proved to be a stimulating tool to create well structured lessons with a uniform user-interface which, we hope, does not suffer from inadequacies resulting in communication errors.
All experimental sessions are videotaped in such a way that interactions between the subjects and the CAI-lesson screen is visible.

*Data analysis*
In contrast with traditional Aptitude Treatment Interaction research our analysis will focus on qualitative analysis without bypassing a quantitative analysis. Cognitive ATI research is expected to produce cognitive process models whereas traditional ATI-research mostly yielded behavouristic input-output relations (Kamsteeg, 1989). For instance in exeriments exploring the effect of Gender-pairing (Dalton, 1988) a major recommendation follows from direct observations of the pairs. It was observed that competitive behaviour between males and females increases dramatically. And a major recommendation from that study was that this effect should be taken into account in the instructional design phase for coopareative CAI. Because our ultimate goal is the development of specific CAI lessons which intensify the positive effects of the peer-teaching effect in cooperative CAI it is mandatory to get at a process model of cooperative CAI.
Quantitative analysis will be done using scores on a representative test taken one day after the treatment. However due to the limited number of experimental pairs these results can only be of limited value.

*Hypothesis & explorations*
Our hypothesis pertains to the zero order model sketched above. We expect superior achievement of the pairs which are composed of HIGH IQ-introvert with LOW-IQ-extravert subjects. Qualitative explorations will use the interaction protocols. The non verbal interactions will be scored according to a scoring scheme developped by Leary (1957)

*Results*
Quantitative
In table I the mean post-test scores in the CAI and the CCAI condition are given. A t-test between the two groups does not yield a significant difference (t=1.37; df=16). This is not surprising since we expect mostly positive effects from specific pairings.

CAI-ind. Cooperative CAI

| | | |
|---|---|---|
| N | 12 | 6 |
| Mean posttest score | 14 | 12 |
| Standard Deviation | 2.13 | 5.15 |

Table 1: Scores after treatment

Therefore the post-test scores per pair in the CCAI condition is given in table 2

| | | IQ (z) | Extrav. (z) | Posttest |
|---|---|---|---|---|
| Pair 1 | Extravert/ Av. IQ | .55 | 1.78 | 16 |
| | Extravert/ Av. IQ | 1.00 | 0.88 | 15 |
| Pair2 | Introvert/ Av. IQ | 0.65 | -1.14 | 12 |
| | Introvert/ Av. IQ | 0.20 | -1.48 | 6 |
| Pair 3 | Introvert / High IQ | 1.41 | -0.85 | 15 |
| | Extravert / Low IQ | -1.47 | 0.49 | 8 |

Table 2: Scores for each member of each pair

The most pronounced effect appears to be that the pair consisting out of two introverts did obtain a combined score of 9 which is significantly less than the average score of the individual students. The score of the (very) Low IQ subject in pair 3 (8) is higher that of the average IQ student in pair 2. This suggests that the interaction in pair 3 certainly was inducing more learning in this weak student. Although this is what we expected from our simple model we did not anticipate that pair 1 would score the highest. In order to understand these figures a qualitative analyses of the protocols is required.

*Qualitiative*
The qualitative analysis is in progress at the time of submission of this report. Data will be available at the time of the conference.

## References

Berlin, White (1988)

Dalton, W.D, (1988). The effects of cooperative learning strategies on achievement and attitudes during interactive video. In Proceedings of Int.

Conf. "Computers, Educations, and children", Urgench, USSR, oct. 1988.

Johnson, D.W., Johnson, R.T., & Maruyama, G. (1983). Interdependence and interpersonal attraction among hetergoneous and homogeneous individuals: A theoretical formulation and meta-analysis of the research. Review of Educational Research. 53 (1), 5-54.

Johnson, R., Johnson, D. & Stanne, M.B. (1985). Effects of cooperative competitive, and individualistic goal structures on computer-assited instruction. Journal of Educational Psychology, 77, 668-677.

Kamsteeg, P.A. (1989). Cognitive ATI research: A simulated Laboratory Environment in (PCE) Prolog. To be presented at AERA 1989.

Leary, T. (1957). Interpersonal Diagnosis of Personality. New York. The Ronald Press Company, 1975.

Mevarech, Z.R., Stern, D. & Levita, I. (1987). To cooperate or not to cooperate in CAI: That is the question. Journal of Educational Psychology, 80, 164-167.

Mevarech, Z.R. (1988). Learning with computers in small groups: Cognitive and social processes. Proceedings of the 2nd EARLI conference, Tübingen, FRG, sept. 1988.

Self, J. (1985). The Application of Machine Learning to Student Modelling. Proc. of the 2nd Int. Conference on AI & Education. p. 93-94. spt. 1985, University of Exeter.

Webb, N.M. (1982). Student interaction and learning in small groups. Review of Educational research, 52, 421-445.