Title

Collaborative Cognition

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COLLABORATIVE COGNITION

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INTRODUCTION

This paper attempts to show that a central function of human tutorial dialogue is what we will call public, or collaborative, cognition, whereby the tutor, with help from the student, makes overt the usually private cognitive processes which lie behind problem solving. In this way the tutor and student together produce the processes which the student will eventually be called on to do by him or herself (for example, on an exam). This phenomenon has not, to the best of our knowledge, been documented before for any adult interaction and has not been addressed in the tutoring literature (something like it has been discussed in the language development literature; see Ochs & Schieffelin, 1983; Vygotsky, 1978).

We provide support for this hypothesis about tutoring by analyzing two important phenomena in our tutoring data: (1) use of analogies, and (2) reading word problems. We have found it especially useful to concentrate on these issues since they have both been the source of some controversy in cognitive science.

We also briefly discuss the mechanisms which we believe produce the externalization of internal processes.

BACKGROUND

The data on which this study is based were collected as part of a larger project on human tutorial dialogue. For this larger study, we brought together experienced tutors (graduate students from Physics, Chemistry, Computer Science and Math, at the University of Colorado) and students actively seeking tutoring (most were undergraduates). We then video-taped each tutor-student pair in three contexts: face-to-face, terminal-to-terminal, and student-to-computer (where the student thought s/he was using a computer tutor but in fact was interacting with his/her human tutor). Only the first context is relevant to the present report.

In this passage, when the analogy is first produced, the student appears not to understand (she doesn't respond), but after the tutor suggests one of the pieces internal to the base ("it's got mgh"), the student is able to formulate another internal piece ("it's got potential energy up here"). Now the relevant structure of the base has been established. The tutor then goes on to provide two relations which map the base to the target ("this guy describes what kind of gravitational field there is" and "this guy happens to be one meter from"), and the student is able to produce the final mapping ("he's like the stone"); the analogy now appears to be completely constructed. In this example, then, the tutor and student publically go through the cognitive process of first producing the relevant internal structure of the base, then mapping this structure to the structure of the target: this passage is thus a prototypical example of what we have called collaborative cognition. The two participants work together (obviously the tutor leads the work) to make explicit what might otherwise go on "in the head" of just one participant.

WORD PROBLEMS

In recent work, Dellarosa (1986), and Dellarosa, Kintsch, Reusser & Weimer (1987) have shown that young children's difficulty with arithmetic word problems lies in their lack of linguistic sophistication, their inability to go from the linguistic description (the word problem itself) to the desired conceptual representation. Our research both challenges supports this finding and challenges it. It supports the finding in that the students in our study clearly had difficulties with what one might loosely describe as "understanding what the question was really asking for"; that is, they could not easily go from reading the problem to setting up the answer, even if they in fact knew how to solve such a problem. This indicates that Dellarosa and Kintsch are exactly right; what causes difficulty is the mapping, if you will, between the text and the conceptualization.

However, given that our students are college-level, taking very difficult courses, we cannot assume that the trouble arises from a lack of linguistic sophistication; by all measures, these students are fully developed linguistically. Why, then, do college students find word problems problematic? Our answer is that the correct interpretation of a word problem (that is, discovering the correct unknown and knowns) is a matter of convention (schema-driven, in a sense, with critical key words and phrases), and each student must learn these conventions to solve the problems at hand. Moreover, not only are they a matter of convention, but they are a field-specific matter of convention, such that one must learn the conventions for each discipline (perhaps even for each new course in a university curriculum). In order to know what the problem is "really" asking for, one must be exposed to the conventions of problem interpretation.

The tutors that we have studied take interpretation as one of their central tasks; that is, one of their major goals appears to be to teach their students how to read the problems. This is not to say that there is no conceptual level instruction going on; obviously there is. But both participants appear to recognize that this conceptual knowledge will not get a student through an exam if s/he cannot go from the problem to the conceptual level.

The fact that tutors engage in this behavior is supported by examples like the following, wherein the tutor and student explicitly address what the problem is asking for.

T: [reading problem] How close must two electrons be if
the electric force between them is equal to the weight,
of either at the earth's surface.

.

.

S: So this is the formula I picked out. What they want
is the force.Right?
T: Right.
S: No they want how close they should be.
T: Right, but that's what that is, right?
S: Yeah.

The following tutor comments further demonstrate the general concern:

T: [reading problem] Given three point charges, fixed
at three corners of a square. Find the electric field
and tendency vector ee, at the corner pee, with no
charge, this is exactly like the problem we just did.
S: Right.
T: And show the direction with a carefully drawn arrow.

So, you'd have to find the angles of it.
S: Aha.

It should be clear from these examples that tutors are concerned with the issue of interpreting the problem. Now we need to ask how the tutors go about this task. Our claim is that they go about this task by making explicit, making public, some version of their own thoughts when they solve problems, e.g. what sorts of questions they ask themselves at a given point, what certain kinds of key phrases they look for, and how to judge if a problem is "the same" as some other problem. In other words, the tutors make public the schemas they believe are necessary for understanding certain kinds of problems.

A clear example of this phenomenon follows.

T: [reading problem] What is the speed of a three
hundred and fifty EV electron. Okay.
(1.2)
T: So the main thing here, I mean, when you look at that,
what is electron volts, what kind of a what are we
talking about.
.
.
T: So they want you to relate speed to energy.
S: Oh, okay.
.
.
T: When you look at this, you know you got this
350 electron volts, and you go- and you always
go, on my God what what is an electron volt, and
then if you can any way fool around with the units,
to figure out well what is it I'm talking about,
you know, and you go well it's q times v and you
look over your equation and you go okay well that's, work
and energy are the same thing.

In this passage the tutor models for the student how to go from what is explicitly given in the words of the problem to other formulations of the same facts, to arrive at the "real" question the problem is posing. In her final comments she even gives a *general* strategy for how to get from the superficial structure of the problem to what "I'm talking about." She models this process by making overt some version of her own internal cognitive steps (what this "version" is will be clarified below.)

CONCLUSIONS

We have demonstrated in this study that one of the main tasks of a tutor is to make public processes which might otherwise take place privately, within the "head" of one person. This modeling of normally private problem-solving behavior is invaluable for students because it allows them to participate in, to whatever extent they are able, a process which is otherwise inaccessible to them and which they will soon have to be able to do alone.

It is important to note at this point that in making their internal processes explicit the tutors are not merely going through the steps they would go through if they were working a problem alone (although this does happen on occasion); clearly those procedures are too compiled to be of much use to a novice. Nor do they (usually) make explicit the internal processes of the current student; clearly that would be of no learning value to the student. So what the tutors do is engage in making explicit the ideal cognitive processes of a good novice, not of an expert and not of the exact student sitting before them (Anderson et al, 1986). However, the tutors do this not by imagining an abstract good novice, but by projecting the particular student involved into the role. That is, they display how **this particular student** would ideally behave faced with this problem. This tactic allows the student to see some extended version of his/her own cognitive processes successfully solving problems. In this way the student is maximally encouraged, inasmuch as s/he sees him/herself at a level beyond the current level.

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