DOCUMENT RESUME

ED 423 140	SE 061 785

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TITLE	Parent-Child Interaction in Science Problem Solving: Facilitating Semiotic Uptake.
PUB DATE	1997-03-00
NOTE	30p.; Paper presented at the Annual Meeting of the American Educational Research Association (Chicago, IL, March 24-27, 1997).
PUB TYPE	Reports - Research (143) -- Speeches/Meeting Papers (150)
EDRS PRICE	MF01/PC02 Plus Postage.
DESCRIPTORS	Constructivism (Learning); *Discourse Analysis; Elementary Education; *Parent Child Relationship; *Parents As Teachers; *Problem Solving; Science Activities; *Science Education; *Semiotics

ABSTRACT

This paper reports on a study that consists of the analysis of the discourse of mother-child dyads (N=32) as they interacted during the performance of three science activities that increased in difficulty. Partial dialogues of three high achieving dyads during the solution of the task are presented and examined for evidence of semiotic uptake. The Zones of Proximinal Development (ZPD) of both the mother and the child are exposed in the action sequences as they construct a solution to the problem. The study provides a way to capture the mediational tools inherent in social speech which, when made available in a timely fashion, seem to invite the child's own transformation or appropriation. (Contains 25 references.) (DDR)

Parent-Child Interaction in Science Problem Solving: Facilitating Semiotic Uptake

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Paper presented at the

1997 Annual Meeting of the

American Educational Research Association

Chicago, Illinois

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Abstract

Family teaching interactions are the subject of increasing interest int he science education literature. Many of these studies are guided by the Cultural historical (CH) model using the Zone of Proximal Development (ZPD) (Vygotsky, 1978) metaphor. In an effort to make a more dynamic assessment, a thorough examination of the processes occurring in the ZPD should be developmental and must focus on mediated action. Instances where the "semiotic uptake" (Wertch and Stone, 1985) of prior neutral stimuli, such as parental utterances guides in the solution of a problem should be made visible.

The study consists of an analysis of the discourse of thirty-two mother child dyads as they interacted during the performance of three science activities that increased in difficulty. Since the third task seemed to provoke more maternal regulation among high achievers during its solution, an assumption was that instance of semiotic uptake were more likely to have occurred during the solution phase of this task. Partial dialogues of three high achieving dyads during the solution of the third task are presented and examined for evidence of semiotic uptake. The high achieving child was seen to make almost immediate instrumental use of mother's cues, as well as making use of maternal cues given several conversational lines earlier. At times, the action sequences exposed both mother's and child's ZPD as they co-constructed the solution for the problem. Methodologically, the study provides a way to capture the mediational tools inherent in social speech, which when made available in a timely fashion, seem to invite the child's own transformation or appropriation.

Parent-Child Interaction in Science Problem Solving: Facilitating Semiotic Uptake

Madelon F. Zady, Pedro R. Portes and Kent Del Castillo

Family teaching interactions are the subject of increasing interest in the science education literature (Epstein, 1992; Hollifield, 1995; Jones, 1990; Mafnas, 1993; Rillero & Hegelson, 1995). Developmental studies of parent-child interactions, as well as of teacher-student interactions, have revealed certain mediational constructs as scaffolding (Griffin & Cole, 1984), assistance (Tharp & Gallimore, 1988) and parental regulation (Wertsch, Minick & Arns, 1989). These genetic studies appear inspired partly by the cultural historical (CH) model.

The main foundations for the cultural-historical (CH) framework stem directly from Vygotsky's (1978) conceptual and methodological (see Davydov & Radzikhovskii, 1984) structuring for a broad psychology that links culture to complex psychological functions through learning. Although learning and development are interrelated, it is learning that leads development (Vygotsky, 1984; Karpov & Bransford, 1995). However, research on learning needs to be more developmental (Van der Veer & Valsiner, 1994). To that end, three lines of research were outlined for understanding the mind: phylogenetic, sociogenetic and microgenetic. The latter is relevant to the current study and the literature linking parent-child interaction with concept formation in science or cognitive development in general.

A problem in most current CH research is that the zone of proximal development (ZPD) metaphor is invoked as a way to account for learning, however the process still remains largely unexplained. The ZPD is defined by those [mental]:

> Functions that have not yet matured but are in the process of maturation, functions that will mature tomorrow but are currently in an embryonic state. These functions could be termed the "buds" or "flowers" of development rather than the "fruits" of development. The actual developmental level characterizes mental development retrospectively, while the zone of proximal development characterizes mental development prospectively (Vygotsky, 1978, pp. 86-87).

Research has generally described some circumstances under which external assistance helps performance and lends support to the theoretical construct of the ZPD. It seems that the main value of the ZPD construct lies in discovering certain activity patterns that aid the development of budding functions in the learner that will soon become the fruits of tomorrow, and which are evidenced in solo performance. Perhaps a key problem in this line of research lies in the design and methods employed to study development. "Only when psychological phenomena are viewed in their process of change can they be adequately explained" (Valsiner, 1990, p. 61). In attempting to surmount this challenge, some experimental work on concept development was initiated by Vygotsky which merits revisitation.

A dynamic assessment of how external assistance is connected with cognitive development is explored through a method renamed by Vygotsky as the functional method of <u>double stimulation</u> (Van der Veer & Valsiner, 1994b, p. 167). The double stimulation method is aimed at uncovering development of new psycholgical capabilities as these are transferred from the inter-psychological plane to the intra-psychological one (Van der Veer & Valsiner, 1994b).

More simply, this method may be understood as a paradigm where the subject is placed or finds herself in a problem-solving situation, and where some means or tools are available with which a solution could be reached. These means or stimuli are originally in a neutral state. They dwell initially outside the person's consciousness or actual level of develompment (AZD) in the sense that their connection to solving the task has not been made instrmentally before. The restructuring of the task that occurs in the ZPD often involves an action sequence through which the subject selects and then converts some of these neutral stimuli into a <u>stimulus-means</u>, which are then used to achieve a solution.

For a more thorough examination of the processes occurring in the ZPD, a study should be developmental, and the unit of analysis must be subjective as well as objective, and must focus on the <u>mediated</u> action (Wertsch, 1991). The subjective refers to aspects of the problem-solving situation where, in a Wertschian sense, the person is now "acting-with-mediational-means." The "semiotic uptake" (Wertsch and Stone, 1985) of prior neutral stimuli, such as parental utterances, becomes (historically) irreversible once internalized in the mind. Once new means become internalized, they lead to change externally as well as in the cognitive structure. This may be inferred from a new capability that did not exist before, that emerges with some assistance usually and which eventually transforms behavior.

The double stimulation method is important in that "it creates the conditions under which a subject's course of action toward an experimentally given goal makes explicit the psychological processes involved in that action" (Valsiner, 1990, p. 66). The application of the method helps to account for processes that allow the individual to "make history" in the sense of mastering a concept or solving a problem, thus modifying the present into the past or bringing the future into the present. As Valsiner (1990) notes, the dependent variable is not an outcome but rather the action sequence that leads to such an outcome. Taking this conceptualization still further, the learner's intra-psychological activity can be seen as both a dependent and an independent variable. In the teaching-learning process, the external assistance remains an independent variable, yet its assessment depends on the learner's internal response, a dependent variable. This response, in turn, functions as a new independent variable determining whether the assistance was effective in bringing about a new unassisted performance capability (an outcome or dependent variable). To address this complex situation, a method is needed to examine the extent of covariation between external and internal information processing events. For such a dynamic, the research question is different and requires a focus on the change process itself. How the person constructs a new understanding of the problem and comes to employ a new (semiotic) tool in dealing with an environmental demand becomes the object of study. (For a fuller discussion, see

Portes, Smith, Zady and Del Castillo, 1997.)

Purpose of the Study

The present study attempts to shed light on microgenesis and to advance the understanding of the mechanisms that propel change in children's science cognition. The study intends to show how children make instrumental use of parental assistance, and how it is provided in those few occasions where a child manifests a "semiotic uptake" thus serving to further the work of a previous presentation by Portes, Smith and Zady (1995). One goal of the study is to examine patterns of assistance in parent-child interactions in solving a series of science tasks that vary in difficulty level. Another goal is to evaluate the utterances of the dyads with reference to the intellectural skills hierarchy (Gagne, 1985) and to see if there are differences in the attainment of the higher levels when comparing parent and child. The question that guides the study is: By using this variant of the double stimulation experiment involving joint problem solving, can a child be observed uptaking mother's neutral stimulus and later making instrumental use of this cue to solve a science task?

Method

Sample Description and Rationale

The sample of thirty-two mother-seventh grade student dyads had participated in a previous study (Author 1994). Although every effort was made to obtain a representative sample from the pool of volunteers (N=89), it was difficult to find families of low achievers. Only one student with an Caifornia Test of Basic

Skills (CTBS) Normal Curve Equivalent Science (NCES) score of less than 10 was available, and the next lowest score was 27. The strategy employed called for selecting the lowest sixteen science achievers from the volunteer pool and sixteen volunteers with NCE science scores of 70 or above. This decision, while risking spurious correlations, was made in order to gain a clearer conceptual picture of differences in interactions and cognitive supports. Thus, 16 students (6 male and 10 female) with low science achievement (NCES mean = 36.4), and 16 students (7 males and 9 females) with high science achievement (mean = 83.6) were selected. With respect to SES, efforts to overcome the achievement-level-SES confound were not successful, as there were also not that many students with high achievement and low SES. The median family income for high achievers was approximately $44,000 and $11,000 for low achievers. The average parental education levels were 13-16 years and 12-15 years respectively for each group.

Procedure

Thirty-two mother and child pairs were invited for a joint one-hour videotaped interview. The interview began with a warm-up period during which the experimenter asked the parent and child questions concerning science. The questions centered around home activities and science learning.

After the warm-up questions, three science activities were assigned. Written instructions were given before each one, and the mother was told that she could help at any time (no time limits). More specific details about the tasks employed and directions are lengthy and can be found elsewhere (Author, 1994).

The tasks were arranged in order of increasing difficulty. The first task was a sinking/floating block experiment that involved prediction. For the second task, the directions asked the dyad to make all possible pairs of five household chemicals (combinatorial logic) and to describe the appearance of each mixture. The third and most difficult task involved the testing of acids and bases. The directions stated, in the first step, color solution (Universal pH indicator with a greenish brown color) was to be mixed with a tube of vinegar. The dyad was to record the color change. (It turned red.) The dyad was told on the direction sheet that vinegar was an acid. In the same manner, a tube of soda turned greenish blue, and the dyad was told that soda was a base. The dyad was to construct an algorithm (make a generalization) from initial information and to use the algorithm to determine if four other unknown household solutions were acids, bases or neither. The science tasks were representative of tasks found in various science education resources (Fredericks & Asimov, 1990; Mullis & Jenkins, 1988; Newman, Griffin, & Cole, 1989)

The tasks were scored for points earned in portions successfully completed (see Author, 1994). The maximum possible score for each task was 100. (Reliability for scores .93 before resolution). Also noted were child's unassisted completions or mother-assisted completions as well as mother solves alone.

Interaction Coding Method

The interaction variables considered in this study are derived from prior research studies related to school achievement (Portes, 1982 & 1988) and adapted to fit the science tasks. This method allows for every observed action to be coded in sequence and is largely independent of content.

These categories or variables were designed to reflect aspects of metacognitive guidance, modeling, feedback, reinforcement, questions (Tharp & Gallimore, 1988), and other task-oriented mother-child interaction characteristics. These are listed below.

INTERACTION CATEGORIES C = child. M = mother.

PC1 C responds to M's question, comments, stimuli
PC2 M/C initiates and ends task operations
PC3 M asks open-ended questions **M open ques**
PC4 M ask close-ended questions (Yes/no answers) **M close ques**
PC5 C asks question or for feedback or help **C ques**
PC6 C agrees with M **C agree**
PC7 C interrupts M **C interrupt**
PC8 C refuses M's help or ignores M's stimulus
PC9 M/C rejects C/M's answer; demands more information; disagree
PC10 M/C finds tasks difficult; lacks confidence
PC11 M/C expresses confidence in self, capable
PC12 M/C egocentric speech
PC13 M/C general comments
PC14 M/C asks E for clarification/instruction/respond to cue
PC15 E cues
PC16 M/C imperatives or directives (Let's) (verb) **M imp**
PC17 M directs attention verbally, cues, prompts **M v cue**
PC18 M directs attention physically (points, manipulates) **M** p **cue**
PC19 M directs attention physically and verbally **M v/p cue**
PC20 M uses positive reinforcement/encouragement/agreement **M agree**
PC21 M interrupts, adds information **M interrupt**
PC22 M/C task irrelevant responses
MVP1 M gives verbal/physical (v/p) cues **M v/p cue**

Note: MVP1 represents a composite of the three categories of mother verbal, physical, or verbal and physical cuing.

One trained judge transcribed and coded the thirty-two transcripts into the parent-child interaction (PCI) categories. Two trained raters independently examined each of the thirty-two transcripts along with videotapes which consisted of the dialogue during the performance of all three tasks. They were kept blind with respect to student achievement. They scored behaviors according to the defined response categories (interaction variables) by counting the number of times each category occurred.

After independent scoring was performed, reliability for each measure was calculated by dividing the number of inter-rater agreements by agreements plus disagreements. The average reliability for the interaction variables was .84 and ranged from .81 to .89. Disagreements were then resolved by the raters and a judge. The average increased to .97 after disagreements were resolved.

Results

A variety of statistical selection strategies were used in order to select parent-child interaction (PCI) categories that were related to children's school science achievement (NCES). The interaction variables thus isolated were subjected to a principal components analysis in order to uncover the underlying structure of these measures and to provide an overall descriptive measure reflective of interaction style (Portes, 1988). The measures were defined by one general factor named the Cooperative Problem Solving (CPS) factor which correlated highly with achievement levels (see Author, 1994).

The CPS factor represents a style of interaction in which the mother often uses positive reinforcement, encouragement and agreement (.90). She freely interrupts as well as interjects additional information (.90). The child feels free to interrupt as well (.89) and tends to agree with mother (.85). Mother provides assistance in this style of interaction through closed questions (.84) and through verbal and physical cues (.84). The style of interaction reflects reciprocity, yet is largely mother-guided.

The success rates that high and low science achievers had in solving the three tasks in the PCI interview were also analyzed. Thask 1 was solved by both high and low achievers with low achievers receiving much maternal regulation. Task 2 received more maternal regulation, but many high achievers solved alone. Task 3 was difficult, and the low achievers could not complete the task, while the high achievers were successful only with mother regulation. Low achievers and their mothers tended to continue the combination and description process that was used in task 2. They did not, for the most part, following the printed directions for the third task. Nor was there much dialogue associated with the performance of the task.

Since the third task seemed to provoke maternal regulation among high achievers, an assumption was that instances of semiotic uptake were more likely to have occured during the solution phase of this task. In order to uncover such sequences the third task was subjected to a task analysis. The task's prerequisite skills, its procedural steps and the intellectual skills required to produce a solution (Gagne, 1985) were delineated as seen in Figure 1.

Figure 1. Task Analysis for Science Task 3

PREREQUSITE SKILLS:

1. Skill in reading and deciphering meaning
2. Skill in filling out a chart and writing
3. Mechanical ability to squeeze dropper and transfer drops
4. Color perception

PROCEDURAL TASK ANALYSIS	LEARNING TASK ANALYSIS
<u>Action Sequence 1.</u>	
1. Read over instruction sheet. Read first sentence of instructions: "Mix a few drops of color solution with vinegar." Squeeze dropper in color solution tube and pull up color solution	1A. Discriminate tubes labeled color solution, vinegar, soda, tubes A-->D.
Find tube of vinegar and squeeze drops of color solution into tube.	
Return dropper to color solution.	
Observe vinegar tube for color change.	1B. Discriminate color solution's color change from greenish/ brown to red.
Read 2nd sentence in instructions: "Record what happens on the sheet." Write in red for color change.	
Read 3rd sentence in instructions: "Vinegar is an acid."	
<u>Action Sequence 2.</u>	
2. Read 4th sentence: "Mix a few drops of the color solution with soda."	
Squeeze dropper in color solution tube and pull up color solution	
Find tube of soda and squeeze drops of color solution into tube.	
Return dropper to color solution.	
Observe soda tube for color change.	2A. Discriminate color solution's color change from greenish brown to greenish/blue.
Read 5th sentence in instructions: "Record what happens on the sheet." Write in blue for color change.	
Read 6th sentence in instructions: "Soda is a base."	2B. Discriminate words acid and base

Action Sequence 3.

3. Read 7th sentence: "In the different tubes, mix the color solutions with solutions ABCD and record what happens."

Squeeze dropper in color solution tube and pull up color solution

Find tube A and squeeze drops of color solution into tube.

Return dropper to color solution.

Observe tube for color change.

Write in red for color change.

3A. Discriminate color solution's color change from greenish/brown to red.

3B. Develop concrete concepts: color solution, vinegar, soda, A-->D.

3C. Develop defined concepts: acid/base, chart completion

Make decision to check acid, base or neither.

3D. Develop defined concept: the change in color of the color solution when added to another solution gives important information about acid/base status. The color solution is a test.

3E. Establish rules:
If red color then acid.
If greenish/blue color then base.
If neither of these colors then solution is neither acid nor base.

Run through above sequence for tubes B, C, D.

3F. Use the rules consistently to identify unknown solutions (solve problem).

Make generalization.

Note: Tube A turned red. Tubes B and C turned greenish. Tube D turned purple. Color perception differed for the dyads. Some saw the soda as greenish blue and called any green solution a base and the purple solution a neither. Some saw the soda as blue and called any green solution a neither and the purple solution a base. A dyad was judged on consistency of response.

Discourse from the solutions for task 3 were then analyzed according to the intellectual skills (IS) categories which the utterances represented as well as according to the parent-child interaction (PCI) categories which they represented. Transcripts were then examined for instances in which mother held a higher level of intellectual skill as compared to her child and was able to provide the child with some stimulus that he would in turn uptake or appropriate and use to solve the problem.

Partial dialogues of three high achieving dyads during the solution of task three are presented here. The intellectual skills (IS) which can be inferred from the dialogue appear in the left margin. The PCI categories represented by the utterances appear in the right margin.

Dyad 002 IS = Intellectual Skills Hierarchy PCI = Parent-Child Interaction

IS	Dialogue	PCI
	253C (taps tube on table) Well if that was an acid (points), then this is an acid. (points) Then this is probably an an acid.	
	254M (checks acid)	
	255C That one's acid.	
M 3C 3D	256M Well, it says up here (points to paper) vinegar is an acid and soda is a base. So if you are checking these (points to tubes ABCD) with this (points to vinegar tube) to see what it is then we	M v/p cues
	256Ci We we're trying to know what the color is?	C interrupt C ques
	256Mi We already know that.	M interrupt M v cue
M 3D	257M Whether it's an acid or a base.	M v cue
	258C Right. If (points to tube) this is an acid or a base? (picks up color solution tube)	C agrees C ques
M 3D	259M No. That's (points to color tube) this is this is your test to see if these solutions are acid or base.	M disagree M v/p cues
C 3D	260C Oh. We already (touches vinegar and soda tubes) know what those are. (uptake)	C responds
M 3E	261M And we know that (points to vinegar and soda tubes) these that's	M v/p cue

	an acid and that's a base.	
C goes on to 3F	262C OK. So, that's an acid (touches tubes), and that's a base too (touches tube B).(C **uptake M261**)(**problem solved**)	**C agrees** **C responds**
	263M So, B turned bluish green (writes green/blue for solution B and checks base).	**M v que**

Dyad goes on to solve the problem with a score of 100%.

In this case, it appears that the cues which mother gave on lines 256, 259 and 261 finally led to the child's correct identification of the solutions.

Dyad 021 IS = Intellectual Skills Hierarchy PCI = Parent-Child Interaction

IS	Dialogue	PCI
	191Ci Generalization (reads) what can you say about	
	192M ABCD	**M v cue**
	193C Oh, That's ah	**C responds**
M 3D	194M Ah, the green ah is a base (points to chart) The ones that turn green are bases. Is a base. Right?	**M v/p cue** **M close ques**
	194Ci Yes	**C interrupt** **C agree**
	195M Wouldn't you say that?	**M close ques**
	196C I guess	**C agree**
	197M Would you say	**M close ques**
	198C I don't know what to say about. I have no idea.	**C responds**
M 3D developing 3E, 3F	199M The vinegar turned red so the ones that are red would be acids. (points to chart)	**M v/p cue**
	199Ci Um good point.	**C interrupt** **C agree**
	200M and this (points to tube)	**M v/p cue**
	201C And the soda would be solids and liquids.	**C responds**
	202M What?	**M open ques**
	203C Baking soda is more of a sss--	**C responds**
	204M That has nothing to do with this	**M disagree** **M v cue**
	205C OK. Never mind. (looks at E) Uh.	**C agree**

M mis- cues color	206M Now purple is a combination of ah red and blue. (laughs) so we get green. Well, I--	M v cue
	206Ci Red and green	C interrupt
M loses 3E	207M Green is yellow and blue. Would we say that this (points to tube) is a perfect pH? I mean the pH is---	M v/p cue M close ques
	208C It's ah They are all bases.	C responds
M 3D	209M No. They are not all bases. The base the soda's a base (points to paper)	M disagree M v/p cue
	209Ci No one this is (demonstrates with tubes then pauses.) Woops!	C responds
M re- gains 3E	210M Ok. Look. Vinegar is acid. (points to paper) Soda is a base. Vinegar turned red. So those that	M imp M v/p cue
	211C It's OK! OK! The acids turned red. No the acids are lighter colors (points to tubes) (C picks up cue and then loses it)	C agree C disagree
M loses 3E again	211Mi Reds base.	M interrupt M v cue
	211Ci The acids are lighter colors, and the bases are uh are are darker colors.	C interrupt
	212M How can you make that generalization?	M open ques
	213C 'Cause, look. Dark, dark. (points to tubes)	C responds
	213Mi Well, why would you say that this (points to tubes)	M v/p cue M open ques
	213Ci Light.	C interrupt
M gets 3E again	213Mi is either an acid or a base. Why isn't it neutral? Why is it neither? Why can't it be neither?	M interrupt M open ques
	214C Cause look how dark it is.	C responds
M has 3E	215M Well, look at the color combination, Jim. (points to tubes)	M v/p cue M imp
	216C OK. (laughs) (looks at E)	C agrees
M has 3E	217M It's not red and it's not green. And they are telling you that red is acid, and green is base.	M v cue
	218C So, it's a mixture.	C responds
M has 3E	219M So, it's neither. It goes under the neither column. (points to paper) Does that make sense to you? OK?	M v/p cue M close ques
C has 3E	220C OK (shakes head yes). A is an acid though.	C agrees
M has 3E,F	221M A is acid. Anything else acid? The other two are bases.	M agrees M open ques M v cue
C loses 3E	221Ci B acid	C interrupt C responds
	221Mi No	M interrupt

C struggles with 3E	221Ci No B is	M disagrees C interrupt C agrees
M 3F	221Mi B is green, C is green so they are both bases. Does that suit you? (checks chart)	M interrupt M v cue M close ques
	222C Yeah.	C agrees
	223M OK. So what can you say? What generalizations can you say?	M agrees M open ques
C has 3F	224C (as M writes, C makes this response) Uh if they are base they are green. If they are acid they are red.	C responds
	224Mi (writes and says) If they are neither	M interrupt M v cue
C has 3F	225C Uh. If they are neither, if they are not red or green or or shades of the color shades of red or green If they are not shades of red or green they are neither. **(Problem solved)**	C responds

In lines 224 and 225, the child finally used the cues which the mother had given in lines 194 and 199, as well as in line 217. In this case, the mother struggles to go up the conceptual hierarchy and appears to be only a step or so beyond her child's level. However, through her presistence and cuing, it appears that the child achieved the rule-using level of the hierarchy by the end of the task as witnessed by his spoken generalization.

Dyad 028 IS = Intellectual Skills Hierarchy PCI = Parent-Child Interaction Categories

IS	Dialogue	PCI
	241C Hum.	
	242 M&C (look at tubes)	
	243C Uh. Well, for generalization, they all kida stay at the top.	
	244M Um huh. (shakes head yes)	M agree
	245C Uh.	
M has 3D	246M I think what it's suggesting is that (points to paper) Do we think	M v/p cue

approx- imates 3E cues 3F	that because the ah the acid the vinegar (points to tube) turned pink (picks up tube) and the soda turned blue (points) do we think that that (points to other tubes) means that anything about these.	
C at- tempts uptake 3F	246Ci (touches tube A) That this is an acid and	C interrupt C respond
M loses 3F	247M (shakes head yes) And these are base or something (points) but (puts pencil down, shrugs) I don't know.	M agree M v/p cue
	248C (points to tubes)	
C up- takes 3D goes on to 3E	249C Well, if it's colorwise, then I bet that that is ah baser er ah acid. Right? That's acid	C respond C uptake C ques
	249Mi Maybe.	M interrupt M agree
C 3E	250C (points to tubes) And these two are neither, and I don't know about that (points) to cause that tube D. That's like purple. A connection with red isn't it?	C ques
	251M Um huh.	M agree
	252C So it could that could be an acid or it could be a neither or it could be a base.	
M loses 3E	253M (shakes head no) So we really don't know.	M disagree
C ap- prox- imates 3F	254C Right. So we don't know about D, and I'd say B and C are neither. And A is a acid	C agree C respond
M 3F	254Mi (picks up tube) Because they just picked up the color of the color?	M interrupt M close ques
C 3F	255C Huh? Because they (points to tube) picked up the same color as vinegar and this (points) these two picked up that color didn't change colors they, right, picked up the color of the color. (laughs and looks at M) **C internalizes cue from M254 in mid-sentence**	C ques C agree
	256M (laughs and looks at C)	
	257C That's my guess	
	258M OK.	

Dyad went on to successfully complete the task. In line 246 the child interrupted with a conclusion which reflected the processing that her mother was doing of the information, even though that processing was progressing with errors and false starts. And, the child began to process the question-cue, which mother interrupted to interject, during the child verbal analysis on line 255. This internaization experience is emphasized by the laughter which followed the episode, that is the "Ah Ha" event.

Discussion

These descriptions of how assistance was provided where the child's problem solution was regulated are somewhat revealing. The dialogues of these three high achieving dyads during the performance of the same science task show the mother to be quite focused on the solution of the task. There is a high degree of interaction characterized by intersubjectivity, as evidenced by proleptic events and interruptions. Yet, each case is unique.

In prior work (Portes, Smith, Zady & DelCastillo, in press; Author 1994) assistance provided by the mother to lower achievers appeared to be rather different. Analysis of parental regulation during the third and most difficult task showed that low achieving dyads mostly continued the combination and description activities of the second task despite what was written in the instructions. Low achievers and their mothers were not able to complete task three with any great degree of success.

Conversely, task three was routinely solved by high achievers however only with M regulation. One conclusion was that high achievers and their mothers demonstrated the priorly derived cooperative problem solving (CPS) factor (Author, 1994) interaction categories during the discourse of their usually successful completion of task three. And in the warm up interview, mother of high achievers more often admitted to helping their children with science homework or projects. The implication here is that these "snapshots" of problem-solving styles are indicative of how development has been mediated historically in the family environment.

The current analysis consists of an even closer examination of how mother helped her higher achieving child to come to a successful conclusion for task three. These transcripts show that initially mother does not solve the problem outright, rather she is approximating the right answer. It is as though her own ZPD (distal zone of develpment or DZD) is exposed. If she is observed with reference to the intellectual skills (IS) hierarchy, mother can be seen in the process of developing discriminations, concrete and defined concepts, rule use and problem solving. In all three of these cases, the mother seems to "climb" the IS hierarchy and to cue at least one step ahead of her child's level of processing.

As the mother constructs solo, her thoughts turn to the co-construction with her child. The task demands being complex, M's metacognitive awareness cues her that she must bring C up to where she is. Secondly during the teaching event, she is consolidatinng what she has learned, and this allows her own thought processes to go further up the hierarchy. There is a dual purpose for mother's metacognition here. First she makes the decision not to go all way with the concept, and then, by verbalizing for her child, she verbalizes for herself. This is a case of "other regulation serving as self-regulation."

In problem solving situations, M assistance is characterized pragmatically as cues that enter the child's consciousness (semiotic uptake). Although it may be seen that, in some instances, cues fail or remain in a neutral state, at other times, the child appears to make almost immediate instrumental use of M's cues. In still other instances, a cue which was given several conversational lines earlier turns out to be the stimulus means which the child is using to guide his utterances about the task.

From the dialogue of dyad 021, initially it is not clear that the mother-helper is operational. She must self-regulate before providing other-regulation. However, as seen in the transcript for dyad 028, even when M loses her footing and moves backwards down the IS hierarchy, the cue that she gave prior to this can still serve the child, and the child can make instrumental use of it. Such interactions show how problems are solved, that is, not in the head apriori but rather in an interpsychological process.

Importantly, it is these very action sequences that were needed to expose M's ZPD and child's ZPD. The process is dynamic, and the action/test serves in the construction of the concept for the dyad, but it also serves to provoke verbalizations of thought and to make the process of thinking observable. In this manner, such an action sequence can be seen to represent a variant of the double stimulation method.

The dynamic processes that accompanied concept attainment or successful task completion in this study no doubt are found not only in science settings but also in any complex situation which needs some types of rules to be formed. While some classrooms can provide for these types of interactions, it may be the home learning environment that is more important. Parents of those who do well in school must exert mental effort in the home settings during the completion of homework or projects. Children who did well in science in this study appeared to require this external support to be there. When school tasks overwhelm the parental unit, then the children do not receive the benefit of this type of dynamic process needed for conceptual development.

Although the above findings may prove helpful, there still remain two very important questions. The first of these being: Would the child have been able to solve the task without the parental insight? The second question is: If the child were presented with a parallel task, could she have generalized the solution? Of course, the design of this double stimulation experiment does not allow for answers that would be considered other than speculative. Some evidence does exist to partially address the prior question, however. Two dyads (003 and 006) were composed of mother and very high achieving child (NCES > 95). Very high achievers performed task three independently while their mothers mostly looked on as their children completed the chart. Eventually the addition of color solution to the last tube (D) produced a discrepant event--the solution turned purple. The outcome was totally unexpected, as no other tube had produced this color before. At this point, both high achievers turned to their mothers and asked for help. During the assisting event, the dyads demonstrated high intersubjectivity with the parents holding back until sensing when to assist through a variety of means. They tended to do so through proleptic understanding. They had fun and expressed confidence. In this particular study (Author, 1994), not even the highest achievers were able to solve task three without maternal regulation.

As to the question about generalization of the skills acquired during the tasks, the answer is not readily available. There was no post hoc test for the generalization of the "skill" learned in task three. The third task represents a basic science manipulation that of using a tool (pH testing) to determine an attribute of a substance--acidity (apply). However, the dyad was not given the tool outright. The task had an extra mental demand in that the dyad had to establish the rule or tool and use it consistently to determine the attribute. Prior to this, the dyad had performed the less demanding first task, a sinking/floating block task with prediction. The child was to put wooden and steel blocks into a tank of water (test), to check off if they sink or float and, on the directions, they were asked whether it was the size or type of block which determined whether the block would sink or float. Then the dyad was asked to predict if different size blocks not present would sink or float (apply). The task was similar to task three in that the dyad had to apply the rule consistently, however the development of the rule or test in task one was guided by a written question. In addition, there were only two outcomes in task one (sink or float). In task three, there were three outcomes (acid, base or neither), there was a discrepant event (purple solution), and the students were generally unfamiliar with the equipment. High achievers and low achievers had about the same rate of successful outcomes on task 1 with the high achievers receiving less mother regulation. The results differed remarkably on task 3, with high achievers receiving much mother regulation. Low achievers could not solve even with mother's help, and there was no evidence of skill uptake. Perhaps this last outcome reflected the low achievers' misunderstanding of the task demands or their inability to read the directions. In retrospect, it would have been most useful to build a check for generalization into the design of the experiment.

Conclusion and Limitations

Although a longitudinal study of how newly acquired means undergo fossilization was unfeasible for the present research, a microgenetic approach was adopted in a "teaching experiment" that my be regarded as a variant of the double stimulation method. The study attempted to show how children make instrumental use of assistance, relative to how it is provided on those few occasions where the child manifested the "semiotic uptake" during the observation. This approach may be used in future research and helps to "pave the way" for interpretive analysis centered on instances where the double stimulation method may be applied.

This approach to the double stimulation method provides for a theoretical pursuit of those rare moments in discourse analyses where cognitve change seems to be provoked. Methodologically, the study provides a way to capture the mediational tools inherent in social speech, which when made available in a timely fashion, seem to invite the child's own transformation or appropriation. It is clear that it is not the types of interaction measures that matter. Rather, their sequence, timing and frequency are to be understood in context with the task demands, the intersubjectivity and individual characteristics found in each case. The in-depth analysis provided here supports the notion that certain communication frequencies or waves tend to be characteristic of different activity settings in which the child's development takes place. The use of the double stimulation approch thus appears valuable in connecting how various personnel, scripts and task demands impact development and are utilized by the individual.

The limitations of the study are many and directly related to research recommendations for the future. The observations need to be expanded over time. The tasks limit generalizations and need to be varied to include more culturally relevant material as well. More information is needed about the role of personnel, their goals, beliefs and other characteristics that mediate children's activity (Tharp, Gallimore and Goldenberg, 1993). The use of this method also calls for investigation at other points of development through cross sectional or longitudinal designs. Other important design issues may require attention in extending this line of CH research.

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