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AUTHOR Tudge, Jon
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ABSTRACT

Researchers studied the effect of cognitive conflict between peers in a collaborative problem-solving task in which the relationship between participants could not be described as "expert-novice" and in which development was potentially possible for all. A total of 156 subjects between 5 and 9 years of age, inclusive, participated in the study. Subjects were required to predict the direction a beam would tip when different numbers of weights were placed at differing distances from the fulcrum. Seven increasingly sophisticated rules for prediction have been distinguished. On the basis of pretest rule use, children were assigned to one of three treatment conditions: individuals retested as controls, an "equal rule" group pairing subjects who used the same rule, and an "unequal rule" group pairing subjects who used different rules. Children in each pair were of the same age, sex, and class in school. During the treatment phase, disagreements in prediction were resolved by discussion. The first posttest was administered approximately 3 days later and the second, 1 month later. Pairs did only slightly better than control individuals. Equal rule pairs did not show signs of development. Among unequal rule pairs, "lower partners" improved and "higher partners" declined. Concluding discussion examines three possible explanatory factors: amount of arguments, quality of reasoning, and cognitive state of the child. (RH)

# Beyond conflict: the role of reasoning in collaborative problem solving



Jon Tudge

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Few developmental psychologists would deny the importance of social context in children's cognitive development. It is only in the last fifteen years or so, however, that psychologists in the United States and Europe have begun to examine, empirically, the ways in which factors in the immediate social context exert their effect. This focus has been particularly apparent in the area of mother-infant interaction (Ainsworth and Bell, 1969; Stern, 1977) and, increasingly of late, mother-father-infant interaction (Clarke-Stewart, 1978; Lamb, 1981; Parke, 1979). Some researchers have also examined the effect of the interaction between mother and child in the context of problem-solving tasks (Bee, 1975; Hess and Shipman, 1965; Wertsch, 1980).

A good deal less attention has been paid to the effects of peer social interaction on the cognitive development of the participants, although the situation is beginning to change. Peer interaction is particularly significant as children, from the age of five or so, begin to spend more of their time with their peers than with either their parents or teachers (Barker and Wright, 1955; Hartup, 1983).

The main question of interest is the extent to which interaction between peers, collaborating to solve a problem, aids their thinking about the problem. The task most commonly used by researchers who have examined this issue is one taken from the conservation paradigm. There are two reasons for this. One is that the two groups of psychologists who have been most actively involved in this research (Doise and his colleagues in Switzerland and Murray and his co-workers in the United States) have been strongly influenced by Piagetian theory. The second reason is of more substantive importance. To show cognitive development, one requires evidence of change in some cognitive sphere that will be accepted as development. Researchers have used conservation as the experimental measure because a change from nonconserver to conserver status fulfils the Piagetian criterion of development. This criterion is widely accepted, even by non-Piagetians who do not grant that a new stage of development has been entered. The change is accepted as evidence of development for three reasons: because it allows the child to take more of the task-relevant variables into account (for example, two dimensions rather than one in the conservation of volume); because it is a change that persists over time; and because the new understanding is not restricted solely to one domain.

The form that the research takes is generally as follows. Subjects are pretested, individually, to determine their status as conserver or nonconserver. For the treatment, some children act as a control group. They are simply re-tested individually. Other children are paired, most commonly in such a way that a nonconserver

is paired with a conserver, although sometimes two nonconservers are paired. The children are presented with a set of problems dealing with conservation of length, for example, or volume, and asked to reach agreement about the stimulus materials. As one might expect, the nonconserver initially disagrees with the conserver about the length or volume of the transformed materials. A discussion then ensues, until agreement is reached, whereupon the next problem is presented. Finally, one or more posttests occur, in which all children are re-tested individually in order to determine whether the nonconservers have attained conservation.

An impressive consistency of findings has been reported by researchers working in this field (Ames and Murray, 1982; Botvin and Murray, 1975; Doise, Mugny and Perret-Clermont, 1975; Murray, 1972; Rosenthal and Zimmerman, 1972; Silverman and Geiringer, 1973; Silverman and Stone, 1972). Up to 80% of nonconservers have become conservers after having been paired with a conserver, a figure far in excess of that commonly obtained by researchers who have attempted to "train" conservation (Murray, 1982). The conservers, on the other hand, do not regress.(1)

What is the mechanism for development in this context? Piaget (1926, 1932) believed that children discussing their different points of view, or "quarrelling" as he termed it (1926, p. 65), is influential in bringing about cognitive development. Scholars

(1) Regression of conservers was reported by Rosenthal and Zimmerman, after the conservers had heard an adult model provide nonconservation responses. Attempts at replication of this finding have failed, however, and it seems most likely that this "regression" was a purely temporary phenomenon, caused by the children complying with what they imagined the adult wanted.

currently working in this field have coined the expression "cognitive conflict" to signify discussion brought about by a difference in perspectives on a problem. When a nonconserver and a conserver are trying to decide whether liquid in a tall thin glass equals that in a glass that is short and fat, there is clearly room for such conflict.

The results of this research, however, may not be generalizable to social interaction about types of problem other than conservation. The conserver is always correct in his or her judgement and is, in effect, an "expert", with the nonconserver tantamount to a "novice" who is always wrong. The nature of this relationship, in which one partner has reached his or her developmental ceiling, may be qualitatively different from those in which development is possible even for the more advanced partner. If one wishes to argue that social interaction is beneficial for cognitive development in general, one must be able to show its potency in areas other than conservation.

The present research was therefore designed to examine the effect of "cognitive conflict" between peers in a collaborative problem-solving task in which the relationship between participants cannot be described as "expert-novice" and in which development is, potentially at least, possible for all.

## Subjects and procedure

156 subjects, aged from 5-9, participated in the research. They were drawn from an open-enrollment public elementary school in downtown Ithaca, NY.

A balance beam, similar to that employed by Siegler (1976, 1981) was used. The task required that children predict which way a beam

Breakdown of subjects, by age and gender

| | male | female | mean age |
|---|---|---|---|
| kindergarten | 25 | 26 | 66.6 |
| 1st-2nd grade | 26 | 30 | 82.9 |
| 3rd-4th grade | 20 | 29 | 111.7 |

would tip when different numbers of weights were placed at differing distances from the fulcrum. Seven increasingly sophisticated rules for prediction can reliably be distinguished (Tudge, 1985). The methodology fitted the established form for this type of research - pretest, treatment, and two posttests - with improvement measured by the change from pretest score (rule use). For the pretest and posttests the children were tested individually, to establish which rule was used. On the basis of pretest rule, children were assigned to one of three treatment conditions.

1. A control group, in which the children were again tested individually.

2. An "equal rule" group, in which each child was paired with another who used the same rule on the pretest.

3. An "unequal rule" group, in which the partners used different rules. The child who had used the lower rule was termed the "lower partner", the one who had used the higher rule being termed the "higher partner".

The children in each pair were of the same age, sex, and class in school. Disagreements in prediction were resolved by discussion. The first posttest took place approximately three days after the treatment (mean 3.89 days, SD 2.2), and the second posttest about a month later (mean 33.97 days, SD 4.14).

## Results

TABLE 1

Mean cognitive change, equal vs. unequal rule conditions

| | Equal rule (n=19) | Unequal rule (n=37) | F | p |
|---|---|---|---|---|
| Treatment mean | -0.316 | 0.216 | 1.24 | .270 |
| SD | (1.34) | (1.84) | | |
| 1st posttest mean | -0.421 | 0.054 | 1.29 | .260 |
| SD | (1.17) | (1.62) | | |
| 2nd posttest mean | -0.316 | 0.171 | 1.32 | .256 |
| SD | (1.20) | (1.62) | | |

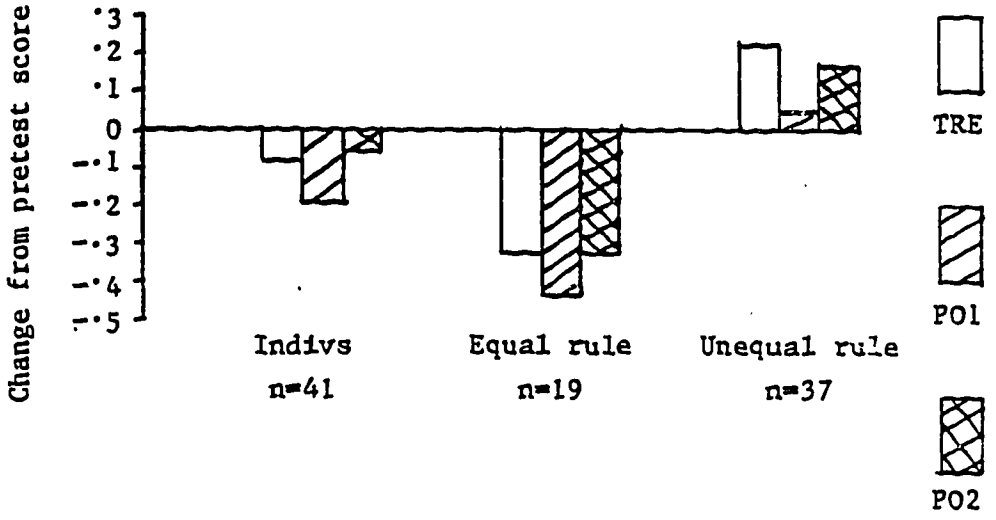


Figure 1: Mean cognitive change, by condition, over time

The basic quantitative results of this research have been presented more fully elsewhere (Tudge, 1986), but to summarize them in brief, the effects of social interaction were a good deal less

apparent than is the case with interaction between conservers and nonconservers. Compared to the control group of individuals, pairs did only slightly better - a difference that was not significant. Being paired with a child who used the same rule did not lead to development - children actually declined slightly, on average. As Table 1 and Figure 1 indicate, children in the "unequal rule" condition, where cognitive conflict was built into the interaction, fared somewhat better than their peers in the "equal rule" condition, although not to a significant degree.

TABLE 2

Change from pretest, by condition, over time (individuals)

| Treatment | Means | SD | N |
|---|---|---|---|
| Control group | -0.098 | .889 | 41 |
| Equal rule | -0.210 | .713 | 19 |
| Low partners | 0.842** | .898 | 19 |
| High partners | -0.722** | 1.179 | 18 |
| **First posttest** | | | |
| Control group | -0.195 | .928 | 41 |
| Equal rule | -0.263# | .562 | 19 |
| Low partners | 0.684** | .885 | 19 |
| High partners | -0.722** | .958 | 18 |
| **Second posttest** | | | |
| Control group | 0 | .900 | 38 |
| Equal rule | -0.368# | .831 | 19 |
| Low partners | 0.684** | .885 | 19 |
| High partners | -0.647* | 1.057 | 17 |

# = P(.10, * = p(.05 ** = p(.01, *** = p(.001,
T different from 0 (no change)

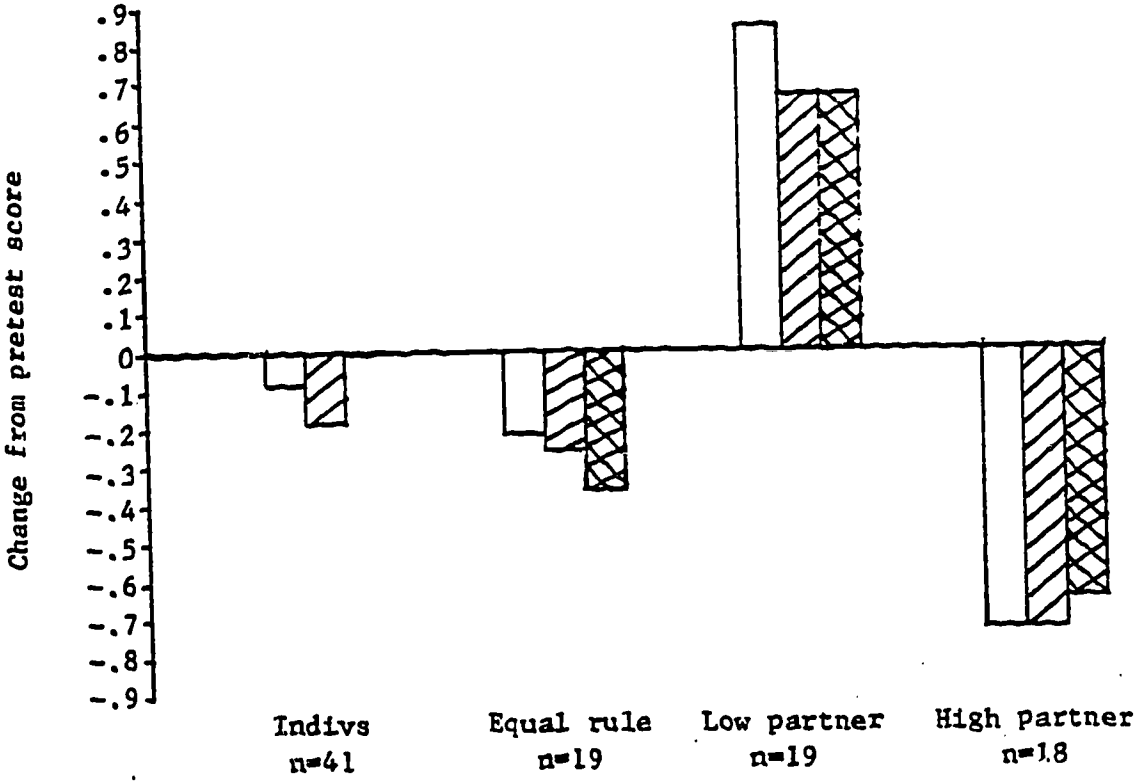


Figure 2: Mean cognitive change, by condition, over time (individuals)

The children in the unequal rule condition were of two different types, however - "lower partners", who had used a lower rule at the time of the pretest than their partners, and "higher partners". The lack of significant difference between children in the equal rule and unequal rule conditions was caused by the fact that the lower partners improved greatly (on average almost one rule) while the higher partners declined by almost the same amount. (See Table 2 and Figure 2.) The cognitive conflict was the same for both children, but those children paired with a partner who used a higher rule did significantly better ($p<.001$) than their peers paired with a partner who used a lower rule.

This summary provides an indication of what happened, but sheds little light upon the reasons for these results. Rather than infer the mechanisms which bring about cognitive development, it is necessary to examine the actual process of development (or regression). I would therefore like to spend the remainder of this paper examining three factors which might be considered important explanatory variables.

The first relates to the amount of arguments in which the partners engaged. Some research has suggested that too little argument or too much in the course of interaction is not conducive to cognitive development (Bearison et al., 1986; Light and Glachan, 1985). This was only somewhat born out in the present research. As Table 3 indicates, children who did not argue at all fared worse than those who argued about at least one of the configurations of weights. The number of arguments, however, was not a significant factor.

TABLE 3

The effect of arguments, over time (% of individuals)

| | | No arguments (n=10) | Arguments (n=45) |
|---|---|---|---|
| DECLINE | Treat | 30.0 | 24.4 |
| | Post1 | 30.0 | 22.2 |
| | Post2 | 30.0 | 26.7 |
| NO MOVE | Treat | 60.0 | 42.2 |
| | Post1 | 70.0 | 55.6 |
| | Post2 | 60.0 | 44.4 |
| IMPROVE | Treat | 10.0 | 33.3 |
| | Post1 | 0 | 22.2 |
| | Post2 | 10.0 | 28.9 |

"Number of arguments" is still a relatively gross measure of interactional processes. A more fine-grained examination was therefore conducted of the arguments themselves, in order to examine the actual processes of development. Analysis of the interactions revealed that the single most crucial component of the interaction was the quality of the reasoning expressed by the participants. When partners disagreed in their predictions, discussion (or cognitive conflict) ensued. In the course of the discussion, each partner used arguments to justify his or her prediction about the movement of the beam. The arguments to which each partner was exposed could be below his or her initial level of thinking (as reflected in the pretest rule used), at the same level, or above.

As Table 4 and Figure 3 demonstrate, the effect of the quality of the reasoning was striking. The treatment clearly had a powerful effect; change (either improvement or decline) occurring at the time of the treatment remained in effect over two posttests, the second a month after the first. The type of reasoning to which children were exposed in the course of the interaction with their partners was the most significant factor in bringing about cognitive development. It was more significant, in fact, than being paired with a partner who had initially used a higher rule at the time of the pretest, because in the course of the interaction there was no one-to-one relationship between rule use and quality of reasoning.

Children who were exposed to reasoning at a higher level (irrespective of the relationship between the rules used by themselves and their partner) were overwhelmingly more likely to begin to use a

TABLE 4

The effect of level of argument

| | | Low level (n=39) | Same level (n=38) | High level (n=29) | F | p |
|---|---|---|---|---|---|---|
| Treatment | mean | -0.795 | 0.026 | 1.138 | 15.24 | .0001 |
| | SD | (0.89) | (0.54) | (0.83) | | |
| 1st posttest | mean | -0.769 | -0.079 | 0.931 | 9.91 | .0001 |
| | SD | (0.78) | (0.49) | (0.96) | | |
| 2nd posttest | mean | -0.564 | -0.135 | 0.964 | 10.50 | .0001 |
| | SD | (0.88) | (0.54) | (0.84) | | |

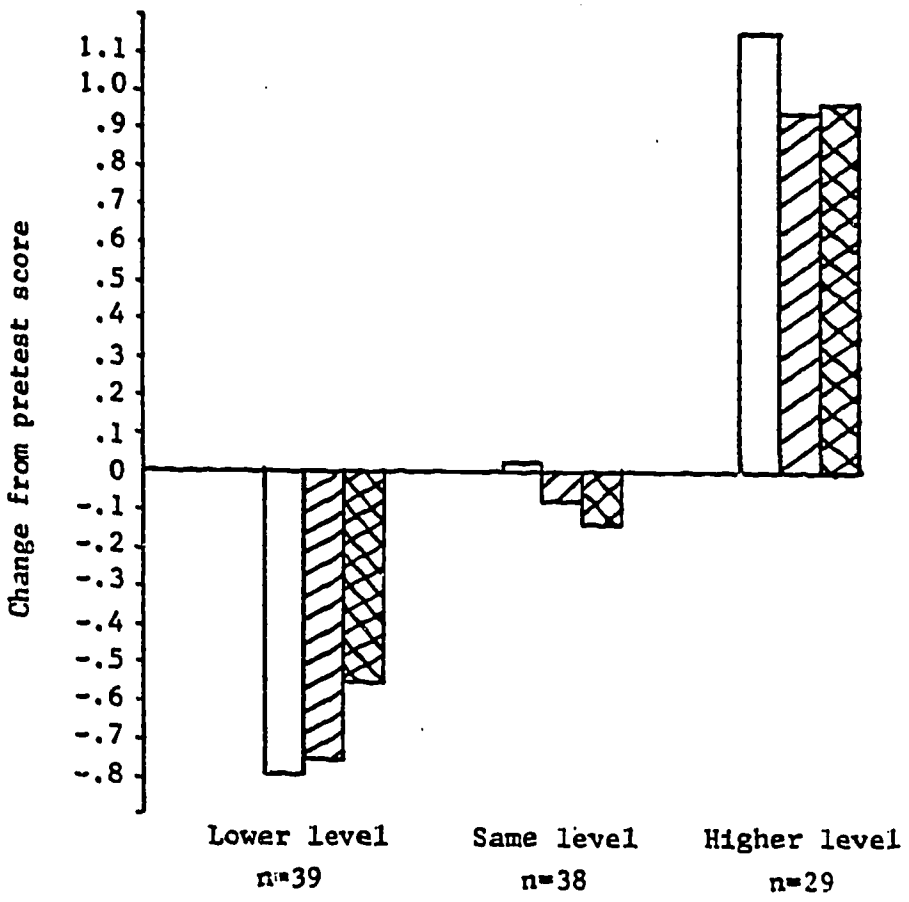


Figure 3: The effects of quality of argument

higher rule. Children who heard reasoning at the same level as their own pretest rule were likely to continue to use that same rule. Of children who heard reasoning at a lower level, half came to use a lower rule, while the other half continued to use the same rule.

Chi-square analyses reveal that the effect of the type of reasoning to which the children were exposed was highly significant ($p<.0001$). It was clear, moreover, that the effects did not vary across condition. In other words, the effects of the type of reasoning used were more important than whether the child's partner was higher, lower, or at the same level. Although far more children who were "lower partners" were likely to hear reasoning at a level above their pretest rule (19 out of 36 in this condition heard a higher level argument) than children who were "higher partners" (only 2 out of 36 heard an argument above their pretest level) it is clear that the type of reasoning heard was a crucial variable in determining the extent to which improvement was likely to occur.

The third factor of interest is the cognitive state of the child. By this is meant the beliefs about the task that each child brought to bear in the course of trying to solve the problems.. Of the five rules that children in this research used to predict the workings of the balance beam, rules 1 and 2 allow confident predictions of all configurations of weights on the beam. (They may not be correct predictions, but they can be made with confidence.) Moreover, they both have a coherent theoretical framework which is supported, in some situations at least, by environmental feedback. Rule 1, for example, works perfectly in many weighing situations where greater weight on

one side causes that side to fall, while equal weight results in balance.

The remaining three rules incorporate a measure of uncertainty. Children using rule 0-1, for example, were not sure about the fate of the beam when there were equal numbers of weights on either side of the fulcrum. Children using rule 1-2 were aware that distance was a relevant variable, in addition to number of weights, but were uncertain as to when it should be considered. Children who used rule 2-3 were able to take both number of weights and distance into account in all situations except when a larger number of weights was closer to the fulcrum.

This degree of uncertainty, which results from not having a coherent framework into which one's beliefs about the world can be set, is a crucial factor in regulating the nature and direction of cognitive development in an interactional setting. For example, when an "uncertain" rule user was paired with a higher partner who used a "confident" rule, in every case the former improved.(2) The "confident" rule user was able to provide the framework that took account of the variables of interest in a coherent way. On the other hand, when the "uncertain" rule user was the higher partner, and was paired with a "confident" rule user, the situation was reversed - 6 of 13 declined, while only 1 improved (only at the time of the second posttest). The lower rule, in this case, does not take into account as many of the relevant variables (rule 1 does not take account of

(2) The 8 children in this situation all improved at the time of the treatment and first posttest; for 6 of them the improvment remained in effect at the time of the second posttest, while 2 reverted to their original rule.

distance, for example), but it does so in a coherent, systematic, fashion. The uncertainties of this rule are thus traded for the relative certainties of a rule that is less advanced but could be held with more confidence.

As one might expect, there was an interaction between the quality of reasoning to which the participants were exposed and their cognitive states. The children who heard reasoning at a lower level but who were not convinced by it were, as one might expect from the discussion about types of rule, those who had used a "confident" rule at the time of the pretest. "Uncertain" rule users, hearing arguments at a lower level, were likely to fall back.

## Conclusion

The aim of this research was to keep the form of the research as similar as possible to that conducted earlier, while removing the content from the conservation paradigm. In so doing, it allows an assessment of the reasons for the difference between the results reported here and those reported by Piagetian researchers. The relationship between the conserver and nonconserver can be likened to that between an "expert" and a "novice". The conserver, after all, knows all that is to be known in that particular domain of conservation, and will always provide a conservation response. As far as Piaget was concerned, one of the hallmarks of conservation is that conservers are aware of the "logical necessity" of their views. It is not necessary to accept this position; indeed, some Piagetians and many non-Piagetians dispute it (Murray, 1981). Nevertheless

conservers, in common with other "experts", are likely to be a good deal more confident of their beliefs than nonconservers, and are thus likely to be more convincing. Data provided by Miller and his colleagues strongly supports this contention (Miller and Brownell, 1975; Miller, Brownell and Zukier, 1977).

Confidence, of course, may be misplaced. Conservers not only have particular beliefs, however, but a theoretical framework into which to place them, a framework which takes into account the relevant variables in a coherent fashion. A child who has attained conservation of volume, for example, is able to understand that while the liquid in a tall thin glass might be higher, it is actually no more than the same amount poured into a glass that is shorter but wider. Feedback from the environment supports this belief - orange juice does not increase in volume, unfortunately, when transferred to a taller, thinner, glass.

It is for these reasons that a conserver is unlikely to be swayed by the arguments of a nonconserver and that he or she is therefore unlikely to regress. Conservers do so, if at all, when paired with an adult who gives nonconserving responses, and then the available evidence suggests strongly that this "regression" is purely temporary.

The relationship between conservers and nonconservers may thus be qualitatively different from that between children who do not fall into this expert-novice relationship. In many situations in which a pair of children is trying to solve a problem, neither child is an expert, and there is no reason to suppose that one is necessarily more confident of her views than another. In cases like this the

possibility for regression is not removed, as it is when a conserver is paired with a nonconserver.

As researchers working in the Piagetian tradition have noted, cognitive conflict, brought about by a difference in perspective, is indeed an important variable. It does not, however, lead solely to development, as they infer; on the contrary, depending on the situation, it is as likely to lead to regression as to development. The results of this research strongly suggest that it is necessary to specify the conditions under which peer interaction is taking place. It is insufficient to state that there must simply be a difference of perspectives, or that discussion has to ensue. Some attention must be paid to the cognitive states of the participants, and to the reasoning they are displaying in the course of collaborative attempts to solve problems

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