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ABSTRACT

This study investigated the relationship in conceptual change scores between members of dyads paired for a photosynthesis simulation exercise. The relationship between an individual's epistemological sophistication and understanding of photosynthesis was also examined. The sample consisted of 255 biological sciences majors enrolled in a biology laboratory class at a large midwestern university. Subjects worked individually, and in high scoring, low scoring, and mixed pairs. Subjects' epistemological sophistication comprised one set of independent variables and was determined by a 21-item instrument. After completing the survey, students were given a 15-minute presentation and a written simulation guide and told to proceed. It was found that an individual's post-test score could be significantly predicted by their partner's post-test score. It is assumed that markedly more active members of dyads played a more active role intellectually and conversationally than the more passive member and that this active member may have processed information about the simulation exercise more deeply than the passive member. (LH)

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STUDENT EPISTEMOLOGICAL BELIEFS AND CONCEPTUAL CHANGE ACTIVITIES: HOW DO PAIR MEMBERS AFFECT EACH OTHER?

by

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Chicago IL, March 24-28, 1997

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Student Epistemological Beliefs and Conceptual Change Activities: How Do Pair Members Affect Each Other?

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Objectives: Epistemological beliefs have been shown to influence conceptual development and the potential for conceptual change; there is also evidence that learners, when placed in dyads or larger collaborative groups, may have their attitudes and achievement influenced by others. This study investigated the relationship in conceptual change scores between members of dyads paired for a photosynthesis simulation exercise. Dyad members were paired according scores on a measure of epistemological sophistication. This study also examined the relationship between individuals' epistemological sophistication and their development of conceptual understanding of photosynthesis.

Hypothesis 1: Controlling for pretest scores, subjects' epistemological sophistication scores will be significant predictors of their conceptual understanding posttest scores.

Hypothesis 2: Regressing on subjects' posttest scores, the epistemological sophistication scores of subjects' partners, and the posttest scores of subjects' partners will be significant predictors.

Theoretical framework: Epistemic motivation has been defined as one's beliefs about knowledge itself and the process of building knowledge (Boyle, Magnusson & Young, 1993). Kruglanski (1989, 1990) suggested that a learner's motivation toward knowledge as an object (epistemic motivation) influences knowledge acquisition. Schommer (1993a, 1993b) described several dimensions of epistemological belief including belief in the simple versus complex nature of understanding, and, belief that knowledge has a strong right/wrong duality versus belief that knowledge is context dependent. Using Schommer's framework, Windschitl and Andre (1996) found that learners with high epistemological sophistication performed better than learners with low epistemological sophistication in an cardiovascular simulation exercise.

Concerning dyads, generally positive learning results have been noted for pairs and larger groups in primary and secondary settings (Johnson & Johnson, 1985; Johnson, Johnson, & Stanne, 1986; Webb, Ender, & Lewis, 1986; Webb, 1987). In a study of peer collaboration, Lumpe and Staver (1995) found that students working in groups developed more scientifically correct conceptions about photosynthesis than students working alone. Research with post-secondary students on group composition and achievement has been less positive. It has been suggested that college students are more homogeneous in terms of ability and/or are less likely to be attuned to the academic shortcomings of their group members, precluding some of the positive influences that more capable group members could have on less capable members (Hooper, Ward, Hannafin & Clark, 1989). The present study investigated, in part, the effects of pairing students with partners who had either highly similar or highly dissimilar epistemological beliefs about knowledge and learning. Subjects interacted with each other during a computer simulation exercise designed to facilitate conceptual change.

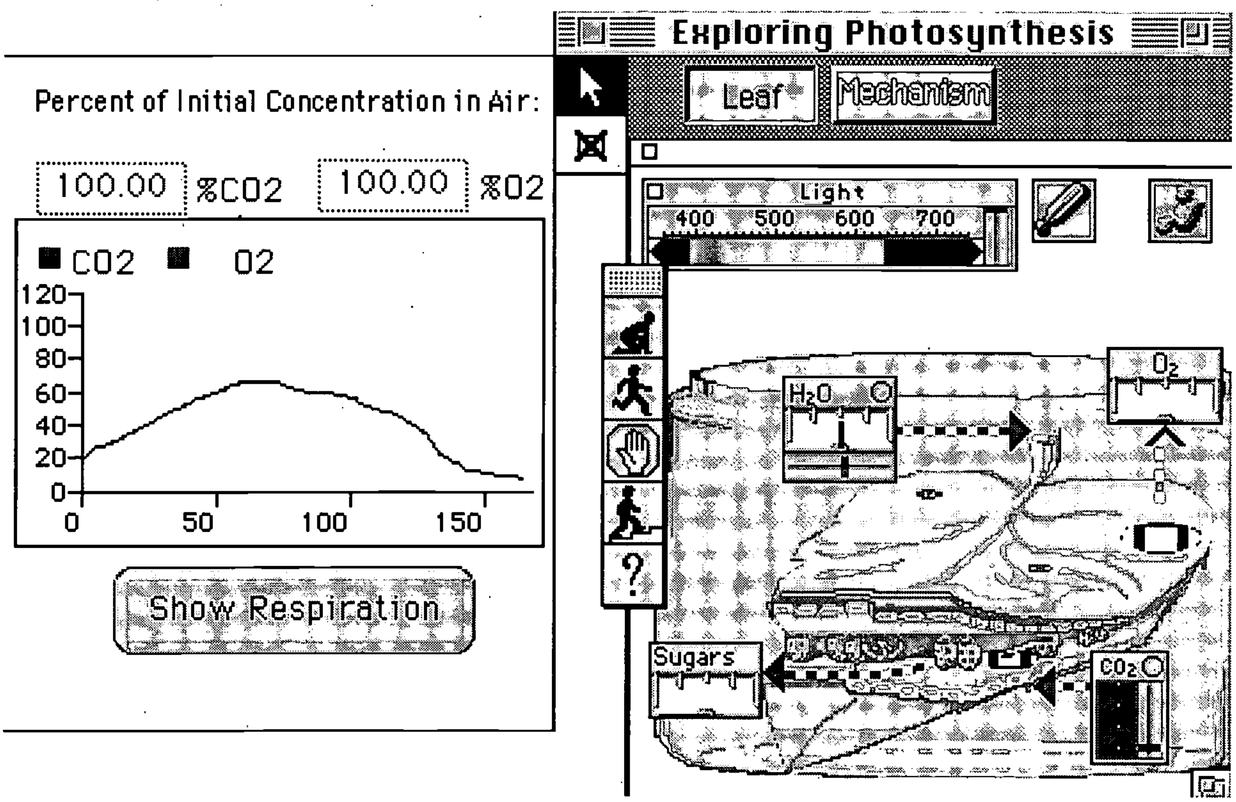
Sample: The sample was composed of 255 biological sciences majors, enrolled in a biology laboratory class at a large midwestern university in the fall of 1995.

Design: Five types of subject pairings were arranged to ensure a suitable number of different pair types for analysis of Hypothesis 2. Placement in these pairs was based on subjects' scores on a measure of epistemological sophistication which was administered during the first week of the experiment:

1. Some subjects worked as individuals (*single*) on the photosynthesis simulation exercise.
2. Subjects in the *high-high* pairs scored above the mean (of all subjects) on epistemological sophistication and were paired with individuals who also scored above the mean.
3. Subjects in the *low-low* pairs scored below the mean on epistemological sophistication and were paired with individuals who also scored below the mean.
4. Some subjects, placed in mixed pairs, scored below the mean for epistemological sophistication (*low-mixed*) and were paired with individuals who scored above the mean. The more epistemologically sophisticated partners in these pairings were part of the fifth subject condition.
5. Some subjects, placed in mixed pairs, scored above the mean for epistemological sophistication (*high-mixed*) and were paired for the simulation exercise with individuals who scored below the mean for epistemological sophistication.

Materials: Subjects' epistemological sophistication comprised one set of independent variables and were determined by a 21-item instrument; the theoretical construct measured was "belief in the complexity of acquiring knowledge." Typical items, rated on a five point agree-disagree Likert-type scale, are: "You will get confused if you try to integrate new ideas in a textbook with knowledge you already have about a topic" (negative) and "If a person can't understand something within a short amount of time, they should keep on trying" (positive).

Pre- and posttests were multiple choice instruments composed of questions used in a previous study on alternative conceptions (Amir & Tamir, 1990). Items dealt with topics such as limiting factors to photosynthesis, the cycling of O_2 and CO_2 in nature, and plant respiration.



A computer simulation that modeled the photosynthetic and respiratory processes in plants was used for the exercise. Each subject was given her/his own written guide to use as a reference and to record predictions, data, results, and conclusions. The exercise was composed of three parts entitled: *Respiration versus Photosynthesis*, *What Affects the Rate of Photosynthesis?*, and *Limiting Factors to Photosynthesis*. Two of these conceptual areas, limiting factors (Amir & Tamir, 1990) and relationships between photosynthesis and respiration (Amir & Tamir, 1990; Eisen & Stavy, 1988; Hazel & Prosser, 1994), were specifically identified from a group of related studies on alternative conceptions.

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Procedure: In Week 1, subjects completed the epistemological survey and pretest, and were given a demonstration of the photosynthesis simulation. In Week 2, students were given a 15-minute presentation that described the concepts of limiting factors to photosynthesis and the relationships between respiration and photosynthesis. Common alternative conceptions in these two areas were explicitly addressed and students were encouraged to note how explanations of certain phenomena based on alternative conceptions would not accurately predict physiological responses. Then, students were each given a written simulation guide, seated at a computer station with their partner or individually, and allowed to proceed. Throughout the exercise, subjects were prompted to make predictions about phenomena by writing statements or creating graphs in the written guide. The exercise emphasized student exploration and did not provide simple, overly-structured approaches to "finding" answers. In Week 3, students took the posttest.

Results: The mean pretest score for all subjects was 2.26 out of 6 possible (SD= .37) or 38% correct (Table 1). The mean posttest score for all subjects was 6.39 out of 9 possible (SD= 1.59) or 71% correct. The order of pair-type results with respect to posttest means is: *high-high* subjects (M=6.77, SD=1.44), *high-mixed* subjects (M=6.68, SD=1.57), *single* subjects who fell *above* the epistemological mean (M=6.58, SD=1.28), *single* subjects who fell *below* the epistemological mean (M=6.21, SD=1.86), *low-low* subjects (M=6.15, SD=1.68), and *low-mixed* subjects(M=5.95, SD=1.65).

Hypothesis 1 stated that, when controlling for pretest score, the subjects' epistemological sophistication scores would be significant predictors of their conceptual understanding posttest scores. In order to account for variance associated with prior knowledge, pretest score was entered, followed by epistemological score. In the final regression stage (Table 2), epistemological belief was found to be a significant predictor of posttest score (Beta= .18, $p < .01$). Pretest score *was not* a significant predictor of posttest score (Beta= .06, $p = .32$).

Hypothesis 2 stated that, regressing on subjects' posttest scores, the epistemological sophistication scores of their partners and their partners' posttest scores would be significant predictors. Students were paired with their partners as a single unit of analysis. To avoid violating assumptions of independence of the data points, one individual of each pair was randomly selected to have his/her posttest score regressed on. Variables were entered in the following order: pretest score of individual, pretest score of partner, epistemological score of individual, epistemological score of partner, product of epistemological scores (to account for interactions), and the posttest score of the partner (Table 3). The final stage of the regression indicated that partners' posttest score was a significant *negative* predictor (Beta= -.24, $p < .05$), and that the remaining variables were not significant predictors: pretest score of individual (Beta= .11, $p = .30$), pretest score of partner (Beta= -.06, $p = .58$), epistemological score of individual (Beta= -.30, $p = .87$), epistemological score of partner (Beta= -.45, $p = .83$), and product of epistemological scores (Beta= .67, $p = .81$). Higher posttest scores of individuals, then, were indicative of lower posttest scores for their partners.

Discussion: It was found that an individuals' posttest scores could be significantly predicted by their partners' posttest scores; this relationship was negative. Given that pretest scores for partners were accounted for in the analysis, some interaction is likely to have occurred between paired subjects during the course of the exercise. Informal observation of the subjects during the experiment revealed that many pairs had one member who was more verbally active, tending to express what she/he was thinking, and was consistently articulating to the other member what perceived relationships were emerging from the simulation exercise. The other members of the observed pairs were often (although not always) passive recipients of their more verbal partners' reasonings; this more passive member often responded with a simple "yea" or "okay" to initiatives and conclusions proposed by the more active member. It would be reasonable to assume that if pairs of subjects had a markedly more active member, that this member would be more likely to play an assertive role intellectually as well as conversationally, and that this active member may cognitively process information about the simulation exercise more deeply than the passive member. Because analysis of the first hypothesis indicated a positive relationship between epistemological belief and posttest score, the more epistemologically sophisticated member in many pairs may have assumed the more active role. This explanation would account for the higher performance on posttest scores by more epistemologically sophisticated subjects as suggested in the first experimental hypothesis and also for the negatively associated posttest scores of paired subjects.

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One purpose of this study was to determine if learners' epistemological beliefs play a role in conceptual change. This hypothesis was supported by the results of the first regression analysis. The epistemological survey measured the learners' belief in the complexity of acquiring knowledge. Even though the instrument attempted to measure beliefs, many of the item statements could also be strong indicators of actual behaviors, specifically behaviors such as the implementation of learning strategies. Within the photosynthesis simulation exercise, subjects were asked to speculate about phenomena, make and test predictions, and draw conclusions from their hypothesis testing. This instructional model, which emphasized student exploration, apparently favored the more epistemologically mature subjects and was not as productive a learning environment for less epistemologically mature students. Epistemologically less mature students tend to believe that knowledge is simple and certain (Schommer, 1993a, 1993b). An instructional approach that provides rigidly structured paths to specific conclusions, or simple dispensation of answers may be more consistent with these students' approach to learning. Epistemologically less mature students are likely to find an approach that emphasizes higher order thinking skills and self-construction of knowledge less compatible with their beliefs of knowledge attainment. Thus, the conditions of this simulation exercise may have induced more positive motivation for learning in the more epistemologically mature students and negative motivation for learning in less epistemologically mature students.

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Table 1. Means and standard deviations of pre- and posttest scores grouped by level of subjects' epistemological sophistication. [a]

	Low epistemological subjects		High epistemological subjects		All subjects	
	Pre	Post	Pre	Post	Pre	Post
	M SD	M SD	M SD	M SD	M SD	M SD
Total	.35 (.21)	.67 (.19)	.34 (.23)	.75 (.16)	.34 (.22)	.71 (.18)

[a] Means are expressed as proportion correct, i.e. .20= 20% correct.

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Table 2. Regression on posttest score using pretest score and epistemological score as predictors. [a]

PREDICTOR	B	Beta	t	p
Pretest score	.08	.06	1.10	.32
Epistemological belief	.80	.18	2.92	.01**
Constant	3.19		3.00	.01

** $p < .01$

[a] Final solution.

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Table 3. Regression on posttest score using pretest score, pretest score of partner, epistemological score, epistemological score of partner, interaction of epistemological scores, and posttest score of partner as predictors. [a]

PREDICTOR	B	Beta	t	p
Pretest score	.17	.11	1.10	.30
Pretest score of partner	-.07	-.06	-.55	.58
Epis. belief	-1.49	-.30	-.17	.87
Epis. belief of partner	-1.92	-.45	-.21	.83
Epis. belief X Epis. belief	.56	.67	.24	.81
Posttest score of partner	-.27	-.24	-2.23	.03*
Constant	12.65		.37	.71

* $p < .05$

[a] Final solution.

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