Commentary

Early Science Instruction

Addressing Fundamental Issues

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Kuhn and Dean (this issue) make a valuable contribution to the challenge of increasing the scientific reasoning skills of low-performing urban sixth graders. They describe a procedure that was highly effective in the short run, and they show how difficult it is to achieve long-term transfer with anything less than extremely detailed and direct instruction. In addition, their work raises important questions about the way that psychologists have approached the topic of children's scientific thinking. Although I concur with Kuhn and Dean about the significance of these questions, in this Commentary I offer a set of answers that differ from theirs. My comments concern matters of emphasis, definition, and effectiveness.

TOO MUCH FOCUS ON THE CONTROL-OF-VARIABLES STRATEGY?

Kuhn and Dean assert that "the literature on the development of scientific thinking has overemphasized control of variables" (p. 869). Although much of my research has focused on the control-of-variables strategy (CVS; Klahr & Li, 2005), there is a sizable literature on many other aspects of scientific thinking, including analogy (Goswami, 1991), causality (Gopnik, Sobel, Schulz, & Glymour, 2001), explanation (Keil & Wilson, 2000), epistemology (di Sessa, 1993), hypothesis testing (Klahr, 2000; Sodian, Zaitchik, & Carey, 1991; Tschirgi, 1980), and evidence evaluation (Koslowski, 1996), as well as Kuhn's own extensive research on evidence and theory. This substantial body of research (reviewed from different perspectives by Lehrer & Schauble, in press; Klahr & Simon, 1999; Wellman & Gelman, 1998; and Zimmerman, 2000) challenges the claim that CVS has been studied "almost to the exclusion of any other aspects" (p. 869).

DID KUHN AND DEAN USE AN ALTERNATIVE TO DIRECT INSTRUCTION THAT FOCUSED ON SOMETHING OTHER THAN CVS?

Kuhn and Dean offer their study as a remedy to this "misplaced" focus that has "constrained investigation" of scientific reasoning. However, a close examination of their training procedure reveals that it epitomizes the very emphasis on CVS that they eschew, because their instructional manipulation was highly similar to the manipulations used in many studies aimed at teaching students the importance of isolating potentially causal variables while holding others constant. Their Earthquake Forecaster displayed a fixed set of five binary variables and a single outcome measure ("earthquake risk"). Students were asked to design experiments to determine which variables are causal and which are not.[1] Kuhn and Dean's "minimal intervention" began after the initial session in which students learned how to use the interface. At the outset of the 2nd through 12th sessions, the experimenter suggested that students

> try to find out about just one feature to start. . . . Today let's all try to find out for sure about the [target variable for that session] to figure out if it has anything to do with the earthquake risk. (p. 868)

Thus, the children were not only instructed to focus on a single variable, but also told precisely what that variable should be. Given that the children were told at the start of each of 11 weekly sessions to find out about one thing in an experimental design problem comprising a small, well-defined set of binary variables, it seems that the children could have inferred that they could find out about one thing best by varying only that one thing while holding others constant. Kuhn and Dean claim that their intervention is qualitatively different from the kind of CVS training used by other researchers, but the similarities are striking. For example, Chen and I (Chen & Klahr, 1999) told children to vary only one thing and hold the other constant. During pretest, posttest, and transfer trials, children were asked to "find out whether X makes a difference. . . ."

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[1] Although Kuhn and Dean suggest that their context is more "authentic" than the contexts used in other research of this type, one can question the authenticity of asking low-income sixth graders in a Manhattan public school to use a computer interface to discover the effects of water pollution and temperature, soil depth and type, and elevation on a gauge displaying level of earthquake risk.

TRANSFER OF TRAINING IN OTHER STUDIES OF CVS?

Kuhn and Dean imply that other researchers' efforts to teach children about CVS have failed to demonstrate transfer. But the children in my study with Chen (Chen & Klahr, 1999) transferred both the procedural and the conceptual aspects of CVS (a) to less supported situations (no probe questions or instruction in posttests), (b) to different contexts, (c) to different tasks (with superficial features different from those of the original learning tasks), and (d) to tasks performed after delays of several months. Nigam and I (Klahr & Nigam, 2004) demonstrated that children who mastered CVS were better able than others to generate a wide range of valid critiques regarding other children's science-fair posters. This difference of interpretation may derive in part from the fact that, as Barnett and Ceci (2002) pointed out in their insightful review, "transfer" itself is still not a well-defined construct with widely accepted operational definitions.

TRANSFER OF TRAINING IN KUHN AND DEAN'S STUDY?

Kuhn and Dean's instruction was effective at getting children to generate evidence from which they could make valid inferences, but only in the short run. On the immediate assessment (involving the same context as in the previous 12 weeks), 9 of 12 students made two or more valid inferences (out of three possible). Although there was no pretest, it is reasonable to assume—with this challenging student population—that the direct and oft-repeated instruction to focus on a single variable caused this high level of performance. However, on the transfer assessment (which represented only a superficial "withdrawal of the instructional context"), only 4 of 12 students made two or more valid inferences, and by the delayed assessment (in which children were tested again with the Earthquake Forecaster), only 3 of 12 did so.

CONCLUSION

Much remains to be learned about how to improve children's scientific inquiry skills. One way to advance understanding of this question would be to apply what we are trying to teach to children to our own research designs.

Acknowledgments—Mari Strand Cary, Zhe Chen, Mandy Jabbour, Junlei Li, Jay McClelland, Robert Siegler, and Corrine Zimmerman provided helpful critiques of previous drafts.

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(RECEIVED 6/10/05; ACCEPTED 6/14/05;
FINAL MATERIALS RECEIVED 6/16/05)