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Computer Experience and Cognitive Development: A Child's Learning in a Computer Culture*

by R.W. Lawler

Fifty years of research into human learning has provided us with remarkably little insight into the way that one person learns. The reason is simple; most research has been concerned with the product rather than the process of learning. A methodology that invovles setting learning goals, is just not sufficient to understand the genesis of knowledge.

Lawler suggests that 'bricolage' (roughly translated as 'tinkering', or calling on existing cognitive equipment to fulfill loosely formed objectives) is more important than goal-directed planning in driving human learning. Objectives are generated from elaboration of recent achievements or the encapsulation of earlier failed enterprises. Thus, each learner 'has a set of different, alternative objectives to take up as chance puts the means at his disposal'. Given that considerable time may elapse between the formation and resolution of objectives, then the investigation of learning must be extensive, essentially recording 'all the young child's mundane interchanges with his workday world', whether immediately relevant or not, and attempting to relate current learning to its precursors, in order to build up a model of the emergence of cognitive structures and problem-solving processes. It is fraught with practical and methological problems: 'Insight cannot be scheduled, so the observations of the subject must be continual and protracted; the data collection must be an everyday part of the subject's life in which he participates willingly for his own reasons.'

Lawler has been fortunate in being able to observe and influence one child, his daughter, Miriam, through most of her learning for the six months following her sixth birthday. This 'Intimate Study' is an uniquely detailed investigation of a child's learning; it is also the first extensive account of the influence of a computer culture on a child's development. The computer is more than a instrument of teaching. It provides, through the discipline of artificial intelligence, a notation for describing cognitive structures and their changes, a channel of communication between parent/teacher and child/learner, and a catalyst for cognitive development.

Pursuing the metaphor of learner as 'bricoleur', or handyman, Lawler suggests that a child approaches a new problem by selecting items from his personal 'bag of tools', in the form of knowledge and procedures useful in the past that appear to fit the surface features of current problems. Some of these cognitive tools (which Lawler calls

* Ellis Horwood, Chichester, 1985, (distributed by John Wiley and Sons, Inc.)

'microviews') are procedures capable of solving particular problems (such as adding two numbers); others coordinate clusters of task-rooted microviews by invocation.

The difference between this and most other 'society' theories of mind is that, rather than cooperating in the solution of a problem, the microviews compete with each other to intepret a problem, deforming it if necessary to fit a pre-existing framework. Thus, a child may possess a 'count' microview to solve simple addition sums and a 'serial' microview (with 'count' as an ancestral sub-element) for a more complex, multi-column sum. These microviews 'compete among themselves in a race for solution, a race open to bias by the presentation of the problem, and they invoke the knowledge of ancestral microviews where appropriate. (Such is conceivable even when an invoked ancestor is simultaneously a competitor)'. Insight may arise from the failure of one microview to solve a problem, or from the ability of two seemingly disparate microviews to reach identical solutions (as when a child realises that column addition and finger counting both produce the same result).

Lawler then confronts the difficulty of accounting for major, rapid changes in problem-solving behaviour: the 'stage changes' described by Piaget. 'My description of a stage. . .recognizes its existence as a robust phenomenon but eliminates its significance as a theoretical construct for psychology. A stage is not more than the achievement of a common level of performance across those clusters of cognitive structures which are potentially able to be influenced by a specific cognitive ideal'. This 'cognitive ideal' (equivalent to Papert's notion of a 'powerful idea') is a catalyst for learning, a framework on which to hang new cognitive structures. It might be a quite local microview, such as the realisation that number is conserved, which then impels the child to seek 'conservations' of something in other domains of experience, such as volume of liquid.

It is here that Lawler (following Papert) makes a strong claim. If stage changes are no more than the diffusion of a powerful idea across a cluster of microviews then it should be possible, by offering a child an appropriate catalyst idea, to markedly influence cognitive development, perhaps even to alter the order of emergence of Piagetian stages. 'From such an inquiry arises Papert's conjecture that the Piagetian formal stage follows the concrete stage because the experiences which might generate its ideal are not part of everyday culture.' But if a child can be given an appropriate catalyst, a concrete experience that helps him to reason about his thinking and problem solving, then this may spark off formal, reflective thought in other areas. 'Papert has speculated that the experience of computer programming, in the immediate future, may come to serve just such a role. It would be a strong result if someone remote from the formal stage developed through programming experience characteristics of thought related to those typical of formal thinkers. This study has produced such a result.'

To substantiate this claim Lawler needs to show first that the child is capable of analytic, reflexive thought, characteristic of formal operations, and second, that this has arisen from programming computers. His descriptions of Miriam's abilities are, at first sight, persuasive. Consider the following dialogue, in which Miriam predicts what might happen if a piece of thread wound round a reel were pulled.

Miriam:	If I pull this [the string end]. It might go rolling this way. [Rotational gesture at the wheel in a sense indicating motion toward the string end.]
Bob:	[Rotates the axle as she described it.] It might roll this way?
Miriam:	Yes. Although that isn't my best speculation. I speculate it's gonna go towards you.

He describes Miriam's 'clear articulation of alternate outcomes' as 'quite surprising for one so young'. Yet there are only two sensible ways for the reel to move and in an immediately preceding exchange he, as experimenter, challenges her initial prediction:

Miriam:	[Cupping her hand around the wheel.] This will go rolling off [gesture away from the direction of pulling the string]. This [pointing to the string end] will come pulling off. This will pull. And this [the string] will give this the pressure [hands on the axle where the string goes round it] to go. [Hand gesture away from pulling direction of the string.]
Bob:	Pressure? [Miriam looks uneasy when challenged on the word]. And something's gonna make it roll? That's your best speculation, right?
Miriam:	Yeah. [Miriam reaches out her hands.] Can I try it?
Bob:	I'm not sure what you said is true.
Miriam:	Neither am I.

This is only one of many vignettes which Lawler uses to illustrate his claims, but it does show the inevitable difficulties of interpreting intimate verbal protocols. Other vignettes, such as the series that describe Miriam's skills in arithmetic and her progress in learning to play the game tic-tac-toe, are detailed and tenable. They support his model of learning and although they add weight to the contention that computer programming can equip a child with a framework for reasoning, they also raise important questions. Why have other researchers, such as Statz, and Pea and Kurland, found little improvement in children's reasoning and problem solving abilities after extensive experience of programming? Why, if microviews compete to solve new problems, are people so bad at transferring skills between isomorphic problems? By what means does a mind adjudicate between competing microviews? Lawler suggests that simple contention is sufficient. A cluster of microviews attempt to solve a particular problem and the fastest wins. This seems intuitively unsatisfactory, suggesting that the brain has multiple parallel processes for high-level problem solving, all churning away simultaneously, but only one is successful and available to subsequent recall.

Computer Experience and Cognitive Development is the best available description of a single child's development of knowledge and intelligence, and of the influence of a computer culture on a young child's learning. As Lawler states, 'The objective is theory development. I make no claim to propound a complete theory of mind. I struggle to describe coherently some of the processes that may obtain in the development of mind. In its weakest description, this 'theory' is a cluster of ideas, richly exemplified, exhibiting what it might mean if one saw mind as a system of disparate, active structures.' Since this theory is both testable and the subject of important claims about learning, teaching and mental development, it deserves to be pursued.

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