

## Symbol Systems and Thinking Skills: Logo in Context

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Imagine yourself as a visitor to a traditional farming society in West Africa. You have arrived as a cross-cultural psychologist to study whether and how literacy affects the way people think. Let us begin by peering into your mind to find out why you are here.

The acquisition of literacy had long been claimed to promote the development of intellectual skills. Prominent historians and psychologists had long argued that written language has many important properties that distinguish it from oral language, and that the use of written language leads to the development of highly general thinking abilities, such as logical reasoning and abstract thinking. Piagetian studies in other cultures had made clear that the kind of abstract thinking associated with formal operations did not develop in oral cultures. By contrast, when one looked at cultures that used written language, various cognitive tasks revealed high logical competencies.

But you had observed that studies bearing on this claim had always been done in societies such as Senegal or Mexico, where literacy and schooling were confounded. Perhaps schooling is responsible for these changes in thinking, rather than the use of written language per se.

The reason you have travelled to Africa is that you plan to test, for the first time, the cognitive effects of literacy independently of schooling. The society you are studying--the Vai--does not transmit literacy in the Vai written language through formal schooling. Their reading and writing are practiced and learned through the activities of daily life.

The Vai invented their written language a mere 150 years before, and have continued to pass on literacy to their children without schools.

Like all the psychologists before you, you have brought along suitcases filled with standardized psychological testing instruments and stimuli for experiments on concept formation and verbal reasoning. Results from performances by the Vai with and without written language experience will tell you whether possessing literacy affects the way these people think.

But as you look over your results from several years of work, you see no general cognitive effects of being literate in the Vai script. For example, the literate Vai were no better than the nonliterate Vai in categorization skills or syllogistic reasoning. Literacy per se does not appear to produce the general cognitive effects on higher thinking skills you expected.

So you mull over this fact for some time. How could this be? The arguments were so plausible for why written language would affect the

way people think. You wonder--could the studies have been done more carefully?

But before continuing this research strategy, you realize that there is a radically different way to think about your project. When you arrived you took for granted the grand theory that literacy will have its general effects, and then looked to see if it did so by testing for general intellectual benefits. But with several years of survey and ethnographic observations under your belt, you have come to better understand the tasks that Vai literates encounter in their everyday practices of literacy. But how does this relate to your experiments?

What you decide you could do instead is to actually look to see how literacy is practiced in the Vai culture. What is done with the written language? And then you ask a very different type of research question: How could what the Vai people do specifically with the written language affect their processes of thought? You decide to let your fieldwork on literacy practices dictate the design of "outcome" tasks and you gain a great deal of precision in your hypotheses for the cognitive effects of literacy.

This reorientation literally turns your theory-driven paradigm of looking for general cognitive effects of literacy on its head. You have shifted from making general predictions in terms of developmental theory about concrete behaviors, to starting with concrete observations of literacy behavior and building up to a general functional theory of literacy's effects.

With this new approach you find that the Vai use their written language primarily for letter-writing, and for recording lists and making technical farming plans.

Then you begin a new phase of your research project, seeking out cognitive effects of specific literacy practices rather than literacy per se. You design new tasks for assessing literacy effects that draw on related skills to those required by the practices you observe, but which involve different materials.

What you find when directed by this new functional perspective are dramatic cognitive effects of literacy. But they are more local in nature. For example, letter writing, a common Vai literacy practice, requires more explicit rendering of meaning than that called for in face to face talk. So you refine a communication task where the rules of a novel board game must be explained to someone unfamiliar with it, either face to face or by dictating a letter for an absent person. You find, lo and behold, that performances of Vai literates are vastly superior on either version of this task to those of nonliterates.

This is no mere parable. It is an account of an extensive five-year research project carried out by Professors Sylvia Scribner and Michael Cole (1981). It is the account of an intellectual voyage not so far removed from what I have to say about what children learn with Logo, for we can fruitfully apply the schema of this Vai story to questions about the cognitive effects of programming.

Here, too, there are persuasive and intuitively appealing arguments for why people should become better thinkers by virtue of the use of a powerful symbol system such as the Logo programming language. It is alleged that children will acquire general cognitive skills such as planning abilities, problem solving heuristics, and reflectiveness on the revisionary character of the problem solving process itself. The features of programming literacy assumed here include the necessarily explicit nature of writing program instructions, the strategic and planful approaches ingredient to modular program design, and experience with the logic of conditionals, flow of control, and with program debugging.

But for programming languages, unlike written language, we do not have the benefit of known historical and cultural changes that appear to result in part from centuries of use of the written language. The symbol systems provided by programming languages are relatively new. They have certainly changed the world; we now live in an information age because of achievements made possible by these languages. But what does it mean for how individuals think and learn?

Let us move our West African story to the context of the American Classroom. Here again we enter as psychologists, looking for general cognitive effects, much like the first literacy questions of the African enterprise.

Of course we assume that we know what kind of a mind-altering substance programming is (having been so affected ourselves), and we assume that "programming intelligence" and the kinds of programming activities carried out by adults will affect children too.

But we should give pause--for we have entered another culture. What will children do with a programming language in a discovery-learning situation, Logo's "learning without curriculum" pedagogy, without benefit of being shown what kinds of things can be done, or being taught about the powers of the system or of thinking skills?

Nonetheless, without benefit of such hindsight, what do our psychologists in the Logo classroom do? They too look for programming's "effects," guided by somewhat the same kind of thinking that possessed the first phase of the Vai studies. The primary difference was that instead of testing for increments in general intelligence, or concept formation, they thought they were looking at more specific effects, quite plausibly linked to programming activities. Planning skills were the central focus, not abstract reasoning, which is only indirectly related to programming.

The psychologists' reasoning went something like this: Both rational analyses of programming and observations of adult programmers show that planning is manifested in programming in important ways. Once a programming problem is formulated, the programmer often maps out a program plan or design that will then be written in programming code. Expert programmers spend a good deal of their time in planning program design, and have many planning strategies available, such as problem decomposition, modular documentation, subgoal generation, retrieval of

known solutions, and evaluative analysis and debugging of program components (e.g. Pea & Kurland, 1983).

Our psychologists studying the cognitive effects of Logo created planning tasks to reveal the development of different planning strategies, and of skills at plan revisions analogous to program revisions. In two different studies, after a year of Logo programming, these psychologists found no effects of programming on performances in these planning tasks (Pea & Kurland, 1984). Children improved with age and practice on the planning tasks, but non-programmers did just as well after a year's time as did Logo programmers. Once again, like the researchers in West Africa, we must reflect on our first set of assumptions for framing the research questions, and reconsider the meaning of our research findings.

Let us take a different, functional or activity-based approach to programming. Consider "programming" not as a given, whose features we know by virtue of how adults do it at its best, nor as what it looks like in its ideal text-book forms, but as a set of practices that emerge in a complex goal-directed cultural framework of thought, emotion, and action.

Viewed in that way, by analogy to the Vai studies on literacy practices, we see that programming is as various and complex an activity matrix as literacy. Just as one may use one's literacy in Vai society to make laundry lists rather than analyze and reflect on the logical structures of written arguments, so one may achieve much more modest activities in programming than dialectics concerning the processes of general problem solving, planning, precise thinking, debugging, and the discovery of powerful ideas. One may, in particular, write linear brute-force code for drawing in turtle graphics.

Stated baldly, from a functional perspective we may see that powerful ideas are no more attributes inherent "in" Logo than powerful ideas are inherent "in" written language. Each may be put to a broad range of purposes. What one does with Logo--or written language--or any symbol system, for that matter--is an open matter. One must come to these powerful ideas and potentially fertile grounds for developing general thinking skills through discovery, or through learning with the guidance of others. Independent discovery and practice of Logo recursion, for example, may be a very rare spontaneous occurrence. The Vai have not spontaneously got onto the logical features of written language, philosophy, and textual analysis that written language allows. Likewise, most of our students--from grade school up through high school--have not spontaneously got onto the programming practices, such as structured planful approaches to procedure composition for reusability as building blocks in other programs, use of conditional or recursive structures, or careful documentation and debugging, that Logo allows.

For the Vai, one could imagine introducing new logical and analytic uses of their written language. Similarly, one could imagine introducing to children the Logo programming practices many educators have taken for granted will emerge. In either case, we would argue that without some functional significance to the activities for those who are learning the new practices, there is unlikely to be successful, transferrable learning. Serving some purpose--whether being able to solve problems

one could not otherwise, satisfying an intrinsic interest in complex problem solving, or achieving solidarity with a peer group who define their identity in part by "doing" Logo or written language--is a necessary condition for the symbolic activities we are interested in promoting to be ones our learners find a commitment to.

It is my hunch that wherever we see children using Logo in the ways its designers hoped, and learning new thinking and problem solving skills, it is because someone has provided guidance, support, ideas for how the language could be used. They will have pointed the way through examples, rules, and help in writing programs and discussing the powerful ideas. To call these rich activities "learning without curriculum" is misleading, and an overly narrow view of what constitutes curriculum, for any projected path toward greater competency that another person helps arrange can be thought of as a curriculum.

There are many profound consequences of this more general account of what is involved in thinking about Logo as potential vehicle for promoting thinking and problem solving skills. A functional approach to programming recognizes that we need to create a culture for Logo, in which students, peers and teachers talk about thinking skills, display them aloud for others to share and learn from, a culture that continually reveals how programming is a vehicle for learning general thinking skills, and that builds bridges to thinking about other domains of school and life. Such thinking skills, as played out in programming projects, would come to play functional roles in the lives of those in this culture. Dialog and inquiry about thinking and learning processes would become second nature, and the development of general problem solving skills so important in an information age would be a common achievement of students. This vision could be realized. I imagine that important cognitive effects of programming, or of literacy are possible, but only when certain uses of these symbol systems are practiced, not the ones most engaged in today. There is far too much faith today that Logo carries with it guarantees of cognitive outcomes, and I have fears that when these profound changes are not found, educators will be prematurely discouraged.

Where are we left after these two continents of travel? With the bright sound of an optimistic chord. There are many streams of Logo activities and research that should go on, for plurality and diversity provide exciting grounds for emergent ideas. Communication among groups, such as this forum provides, will help in the formation of a broad community exploring these issues. These streams will no doubt embody a diversity of assumptions about what will best help create the culture of Logo I have referred to, in which one will be more likely to find the cognitive effects on thinking skills so many take for granted. Similar Logo cultures may arise that center on math learning, or programming.

It is uplifting that there are so many positive energies in education today. The enthusiasm for Logo as a vehicle of cognitive change is an exhilarating part of the new processes of education one can see emerging. Cultures with thinking tools like Logo can be created. But we must first recognize that we are visitors in a strange world--at the fringe of creating a culture of education that takes for granted the usefulness of

the problem solving tools provided by computers, and the kind of thinking and learning skills that the domain of programming makes so amenable to using, refining, and talking about together.

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