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LOGO will force teachers to become more like master teachers who guide others on the path of teaching and learning.

On first encountering LOGO; some questions for further research*

by Michael J. Streibel

I am always amazed that I can still experience all the excitement and anxiety of a beginner when encountering a new computer language. So it was when I encountered LOGO. Here was a rigorous, interactive and yet forgiving computer language that allowed me to create "objects-to-think-with" (Papert, 1980). I quickly went through the examples in the manual and marvelled at the ease with which I could manipulate graphics (Abelson, 1981). My years of hard work programming graphics in BASIC and FORTRAN seemed to melt away. I also began to study Turtle Geometry and became excited about the possibility of portraying complex concepts from finite differential geometry in a visual form (Abelson and diSessa, 1980). Finally, I was impressed with how high-level concepts such as recursion and top-down logic could be represented so easily in a computer language. My initial wonder is over now and it is time to investigate the educational utility of LOGO.

Several questions come to mind when investigating the educational utility of LOGO: 1) What kind of learning experience does LOGO provide? 2) Can LOGO be used as an efficient learning tool within the school curriculum? and 3) What is the role of the teacher in a LOGO learning environment? These questions are important to consider. LOGO gives a user a sense of mastery before that user has developed a thorough understanding of the content area with which he or she is working. This aspect of LOGO is very attractive because it provides a built-in motivator for learning. LOGO also has a simplicity of syntactical and semantical structure which make LOGO very easy to learn. This feature of LOGO brings us to the first question.

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What kind of learning experience does LOGO provide?

The LOGO language has been designed so that, no matter what a person is doing with LOGO, that person is always solving problems in a "top-down" procedural manner (Papert, 1980). An example should make this clear. Suppose you were asked to describe a fish tank. How would you proceed? You could describe all the things that other people know about fish tanks. You could also describe your own experiences with fish tanks. The number of ways to describe fish tanks is immeasureable. Each type of description can then be organized into a top-down hierarchy. Let us say that a fish tank includes a container, blue water, brown pebbles, green plants and swimming fish. In LOGO, this description would become:

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TO FISHTANK
  CONTAINER
  WATER
  PEBBLES
  PLANTS
  FISH
END
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The LOGO procedure called "FISHTANK" constitutes a wholistic event which is made up of smaller component events. Each component of the description, such as the statement "CONTAINER," is broken down into yet smaller components until some "primitive" level of LOGO is reached. Primitive statements in LOGO include commands such as "FORWARD 100" or "RIGHT 90." The top-down approach results in a hierarchy of descriptions in which each statement refers to an entire entity or event on one logical level while also referring to a set of procedures for generating that entity on the next lower level. LOGO, in other words, encourages the user to look at all events in a top-down procedural manner.

There are many consequences of the top-down procedural approach: 1) objects are treated as events and described in terms of the processes that bring about those events, 2) events are broken down into a hierarchy of subevents, 3) events at any level are described in clear, natural and explicit terms, and 4) errors at any level of the description are easily found and corrected. Each of these aspects of the top-down approach helps a person break complex problems into more manageable ones. This is the case no matter what the subject matter. What are the drawbacks of this approach?

First of all, vague, fuzzy, intuitive and "tacit" ideas are banished in the top-down procedural approach. The fish tank described above could not contain a component which could not be broken down into the primitive statements of LOGO. Vague ideas that are embodied in the LOGO code are considered "bugs" that have to be "debugged." Debugging procedures are a central feature of LOGO and involve translating all the terms of a problem into syntactically and semantically correct statements. A vague idea such as "PRETTY FISH" has no place in LOGO unless "prettiness" can be defined. In real life, on the other hand, the word "pretty" is used quite often without specifying exactly what is meant. This, therefore, poses a problem with LOGO because human beings often think about and solve problems in a fuzzy manner. Furthermore, human beings do not always reach some final clarity of thought when they solve problems.

Second, LOGO encourages the use of "local" procedural descriptions. This feature has its advantages and its disadvantages. A circle, for example, is described from the perspective of a person who is part of, and creating, the circle. In LOGO, this translates into instructions such as "move forward one unit" and "turn right one degree until you get back to where you started." Ableson and diSessa describe how LOGO can be used to teach finite differential geometry—a very local procedure-oriented area of mathematics. The same area of mathematics, geometry, can also be expressed in more abstract terms. Hence, a circle can be defined by the formula $x^2 + y^2 = r^2$. The terms of this abstract equation refer to a Cartesian frame of reference that is external to the actual circle. A person who represents a circle with an abstract equation is undergoing a different kind of experience than a person who is drawing a circle. How can LOGO provide the experience of non-procedural kinds of knowledge? Mathematics was used as an example here but the same question can be asked for other subject areas.

Finally, LOGO offers a great temptation for a user to remain at lower experiential levels. LOGO is an excellent tool for portraying certain ideas in visual form. This may very well be attractive to a "visually literate" population that has grown up with television and other visual media. Geometry is certainly more engaging when one can see a graphic representation of certain ideas unfold before one's eyes. But when does one let go of the graphic representations? In the learning process, it is very important to know when to leave experiences behind and when to start dealing with abstractions. While LOGO also permits the non-visual construction of concepts, the temptation to remain at more immediate experiential levels is strong.

In answer to the first question, therefore, LOGO provides two very general learning experiences for a student: 1) a top-down problem-solving experience, and, 2) a local procedure mode of thinking and describing. LOGO also provides an immediate "mathing" experience of finite differential geometry. Top-down problem-solving is one of the best ways to tackle any complex problem, and local procedure modes of thinking emphasize the process nature of events (Higgins, 1979). These modes of thinking are very useful for creating "objects-to-think-with" (Papert, 1980). These modes of thinking also take a long time to develop. This problem leads us to the next question.

Can LOGO be used as an efficient learning tool within the school curriculum?

There are many ways of defining learning efficiency. Unfortunately, a whole generation of behaviorists, educational psychologists and instructional technologists have assumed that the concept of learning efficiency requires the fragmentation of the curriculum into behavioral bits and pieces (Callahan, 1962). In contrast to behavioral theorists, however, "top-down" theorists stress the importance of high-level goals. Hence, communication skills, problem-solving skills and evaluation skills are considered the long-term "basics" no matter what the cognitive or developmental level of the learner. From the top-down viewpoint, the integrated activity is always stressed and used as the criterion for evaluating learning gains. In the behavioral approach, on the other hand, mastery of the part is required and evaluated before moving on to mastery of the whole—a bottom-up approach to learning.

An example from language arts can clarify the difference between these two approaches. In the top-down approach, a teacher would encourage a grade-school child to communicate an idea or feeling in writing no matter how incorrect the spelling or grammar. The primary emphasis would be on the wholistic goal (the intended communication) with secondary emphasis on increasing precision. A written communication would be evaluated in terms of how well the child at his or her stage of development communicated an idea. In the behavioral or bottom-up approach, a teacher would insist that a child master the modules on letter drawing, spelling and grammar before attempting to communicate an idea in writing. The example here exaggerates the characteristics of the two approaches in order to highlight their differences. These two types of learning theories are nevertheless very much alive. LOGO embodies the top-down approach, whereas traditional computer-assisted-instruction (CAI) tends to embody the bottom-up approach.

The two types of learning theories described here embody very different notions of learning efficiency. Carter (1981), in his article "LOGO and the Great Debate," describes the parameters of the debate between the top-down and bottom-up theories. In a LOGO learning environment, learning efficiency seems to revolve around the issue of "learning how to learn," whereas in the drill-and-practice CAI environment, learning efficiency revolves around mastery of component facts, concepts and skills. Both types of learning efficiency are needed at different times in the learning process. For now, however, we will focus on the notion of learning efficiency in the LOGO top-down approach.

Seymour Papert (1980), one of the main developers of the LOGO computer language, believes that "debugging" procedures are the key to learning how to learn. Learning efficiency in LOGO must therefore deal with the efficiency of debugging procedures. How does one learn to debug a program (or an idea)? According to Papert, a person debugs a program (or an idea) by articulating the steps for reaching the intended goal—all well and good. Experience with debugging, however, has shown that debugging sessions last many hours. LOGO users report having lost all track of time when debugging a program. Is this process an efficient use of time? If these extended debugging sessions are absolutely essential for LOGO to be a successful learning tool in the school, then the K-12 curriculum will have to be radically restructured. The only other option would be to allow a teacher or even an advanced student to act as a kind of guide for the LOGO learner.

Using LOGO as an efficient learning tool also involves human beings in another way. Learning how to learn requires mastery of a wide range of heuristic strategies, such as problem-formulation techniques (Polya, 1945). How are these strategies acquired? Very often it takes group problem-solving sessions to generate and then evaluate these strategies (Johnson and Johnson, 1975). LOGO serves as the environment within which these strategies are tested. Learning efficiency in this case deals not so much with right and wrong answers as with better or worse strategies for solving particular problems. Since it is often hard to tell which strategy is most suitable until after a problem is solved, the experienced judgement of a teacher becomes a critical factor in the efficient use of LOGO. This factor brings us to our final question.

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What is the role of the teacher in the LOGO environment?

This question boils down to asking what a teacher does when teaching a student how to learn. My own experience has led me to develop an analogy between a LOGO teacher and a master teacher. A master teacher in any field knows the particular subject matter very well and also knows how to learn that subject matter. With this knowledge, a master teacher guides students towards certain skills and values. A master teacher is as much concerned with a student's learning autonomy as with a student's mastery of the particular subject matter. Learning autonomy and subject-matter mastery are not quite the same thing, although they are interrelated. Master teachers, in other words, empower students with the ability to learn.

LOGO provides a very good environment for learning how to learn. Young children working with teachers and LOGO often take the lead while exploring a particular program idea. It seems especially important for teachers to "back off" in such situations even though the student's approach might not produce the desired results. The principle here seems to be to help students gain an increasing control over the learning process. Coping with potential failure seems to be more important in learning how to learn than marching towards mastery.

The LOGO teacher's interaction with students eventually takes on a guidance and co-learning aspect. These guidance and co-learning sessions are far more effective for the student's mastery of an idea than leaving the student totally alone with LOGO. Guidance and co-learning sessions need not be one-on-one but can involve a group of many students. Learning with LOGO, in other words, is most efficient when an experienced guide is part of the process—a guide who does not lead as much as point the way.

The LOGO teacher's interaction with students also forces the teacher to spend a lot of time learning the particular subject matter. This may very well be a result of the teacher's intimate guidance and co-learning role. Teachers who want to use LOGO in their classrooms can therefore look forward to intensive, life-long learning as part of their profession. This experience differs sharply from a teacher's experience in a CAI classroom. In the latter case, a teacher acts more like an "'instructional manager'' than a co-learner.

The difference between the teacher's role in LOGO and in traditional CAI has to be examined further. Baker, in his book on computer-managed instruction (CMI), discusses the managerial aspects of a teacher in a CAI/CMI environment (Baker, 1978, 1981). For example, in CAI/CMI, a teacher records, assigns, evaluates, arranges, reports, organizes and coordinates with the help of a computer. These functions are not really new because they are performed every day by teachers as part of their profession. However, these functions are highlighted in computer-assisted and computer-managed instruction. What happens in the LOGO environment? Does a teacher still spend as much time supervising instruction as in CAI/CMI? Not likely! In LOGO, a teacher spends more time on guiding and co-learning than on grading and report-writing.

LOGO also forces teachers to recognize potential learning problems and learning successes in students as part of the guidance and co-learning process. Since many problem-solving strategies pay off only at the end of a long and arduous process, teachers can not rely as much on objective tests of student performance. Rather, teachers are forced to rely on their experienced judgments. This situation contrasts sharply with the type of evaluation that takes place in mastery-based, individualized CAI lessons. In the latter case, student progress depends on an objective demonstration by the student of each component skill (Carter, 1981).

Several things can now be said about the teacher's role in the LOGO environment. Teachers who wish to use LOGO in their classrooms can look forward to a very active teaching/learning experience. This is the case because LOGO works best when the teacher acts as a guide and co-learner for the student. Teachers will also have to deal with a student's failures and turn them into occasions for further learning. Teachers, in effect, will have to become autonomous learners who guide others on the same path. Finally, teachers will have to rely on their experience and intuitive judgements as they guide novice learners.

Summary

In summary, we can now treat the three questions asked earlier as a unit. Learning to use LOGO to create "objects-to-think-with" in any subject area is a way of learning how to learn in that area. LOGO shifts the focus of learning from component facts and concepts to wholistic skills without sacrificing precision at the component level. It does this by providing a rigorous and well-defined environment where a learner can experience high level concepts, top-down problem-solving approaches, and local procedural thinking. It may not be as useful for creating vague, fuzzy, or even contradictory "objects-to-think-with." Finally, LOGO will force teachers to become more like master teachers who guide others on the path of teaching and learning.

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