Goal-Based Scenarios:

Case-Based Reasoning Meets Learning by Doing

Roger C. Schank

Learning from experiences is the fundamental process of case-based reasoning. Taking case-based reasoning seriously as a cognitive model implies that experiences play a fundamental role in human learning as well. This has important effects on what and how to teach. This chapter examines the types of knowledge acquired from experiences. Based on this analysis, it argues for a new approach to education in which case acquisition plays a central role.

There has always been a great deal of lip service given to the idea of learning by doing, but not much has been done about it. In fact, John Dewey remarked in 1916, in his book *Democracy and Education*:

"Why is it that, in spite of the fact that teaching by pouring in, learning by passive absorption, are universally condemned, that they are still so entrenched in practice? That education is not an affair of "telling" and being told, but an active constructive process, is a principle almost as generally violated in practice as conceded in theory. Is not this deplorable situation due to the fact that the doctrine is itself merely told? But its enactment in practice requires that the school environment be equipped with agencies for doing ... to an extent rarely attained."

There are two important reasons why learning by doing isn't our normal form of education. First, it is quite difficult to implement without "doing devices." How can we teach history by doing? What does it mean to teach literature by doing? In many cases, it is difficult to define what doing might mean with respect to a given subject and to attempt to implement a realistic sense of doing in a classroom setting. When there are "doing devices" available, it is easier to implement learning by doing. Driving can easily be taught in a learning-by-doing manner, for example, because students can reasonably be placed behind the wheel of a car. This can be done because cars are relatively inexpensive and relatively safe. When this is not the case, when the necessary equipment is too expensive or unsafe, or where there is no equipment at all, learning by doing is usually abandoned as a teaching philosophy. There is, of course, another reason why learning by doing isn't the primary teaching model in the schools. Educators and psychologists have not really understood why learning by doing works, and thus are loathe to insist upon it. They can't say exactly what it is that learning by doing teaches. They suppose that it teaches real life skills, but what about facts, the darlings of the "drill-them-and-test-them" school of educational thought?

To consider learning by doing from a psychological point of view, we must think more about learning in real life, which is, of course, the natural venue of learning by doing. There is, after all, something inherently artificial about school. Natural learning means learning on an "as needed" basis. In such a learning situation, motivation is never a problem, we learn because something has caused us to want to know. But school has no natural motivation associated with it. Students go there because they have no choice. The same is true of most training situations. Trainees don't usually elect training. And, while they may well choose their jobs, they can hardly know that they need certain information in order to do their
jobs better. They can only know this because they are told. Training rarely comes after someone has done badly at his job. Businesses try to anticipate such situations, to avoid mistakes on the part of their employees. Thus, they provide training in anticipation of real problems and employee-perceived needs. This concept, of training in anticipation of need, is an important reason why businesses are often ineffective in training.

One of the places where real life learning takes place is in the workplace, "on the job." The reason for this seems simple enough. Humans are natural learners. They learn from everything they do. When they watch television, they learn about the day's events. When they take a trip, they learn about how to get where they are going and what it is like to be there. This constant learning also takes place as one works. If you want an employee to learn his job, then, it stands to reason that the best way is to simply let him do his job. Motivation is not a problem in such situations since employees know that if they don't learn to do their job well, they won't keep it for long.

Most employees are interested in learning to their jobs better. One reason for this is, of course, potential monetary rewards. But the real reason is much deeper than that. If you do something often enough, you get better at it -- simple and obvious. When people really care about what they are doing, they may even learn how to do their jobs better than anyone had hoped. They themselves wonder how to improve their own performance. They innovate. Since mistakes are often quite jarring to someone who cares about what they are doing, people naturally work hard to avoid them. No one likes to fail. It is basic to human nature to try to do better and this means attempting to explain one's failures well enough so that they can be remedied. This self-correcting behavior can only take place when one has been made aware of one's mistakes and when one cares enough to improve. If an employee understands and believes that an error has been made, he will work hard to correct it, and will want to be trained to do better, if proper rewards are in place for a job well done.

In general, most businesses are aware that the more experience an employee has with a given situation, the more effective he is in that situation. It would seem to follow, therefore, that the best way to teach anybody is to let them work on a job that requires the skills we are trying to teach. This is a bit circular since it means letting an employee attempt to use skills that we know he doesn't have in order to teach him those skills. The best way to learn how to do a job is to simply try doing the job, with no preparation in particular, but with an expert available for help as needed. Although this is the best way to learn from the perspective of the employee's natural learning process, it might well not be the preferred choice of either the employee of the employer.

Employers have to be very tolerant to allow learning by doing to be the dominate teaching method for training because of the potential for costly errors made by novice employees. Most employers are unwilling or unable to do this. Employees don't really want to do this either. People are afraid of public failure, and nothing could be more public than failing on the job.

One obvious answer is the use of simulations for training. The best of the current simulators built for training purposes are the air flight simulators. Modern flight simulators are phenomenally real. Inside, they look like cockpits down to the last detail. They bounce and rattle and jolt, and what you see out the window are pictures that accurately portray whatever airport you select from whatever perspective your airplane would be putting you in at the moment. It looks like the real thing. It feels like the real thing. And so, you can take off and land at will, going in and out of your favorite airports. You can try things out and see what happens. You can crash and try to figure out what you did wrong. After enough time, you can teach yourself how to fly. Of course, it helps to have someone next to you whom you can ask for help, and it also helps a great deal if the person beside you is not in a panic about his own imminent demise because of your inadequacies as a pilot.
In the use of a simulation of this type, what exactly is learned? That is, when someone learns by doing, what is it that he is learning? It is important to answer this question for two reasons. First, we want to know if a student or trainee has learned whatever it is we were supposed to be teaching him. To know this, it is important to know what we were intending to teach him. Second, there will be times when learning by doing will be difficult to teach. If what was to be learned in this fashion could be taught by some other means, we will indeed try. It is critical then to understand what is learned so that we don't make the mistake of teaching something else, like facts, and assuming that this kind of teaching will be an effective substitute.

To begin to think about what learning by doing actually teaches, consider the following:

Suppose I decided to open a school that taught about the art of dining. Some people know good food and good wine and we might ask what is it, exactly, that they know? This domain is a good one to discuss because it is one with which everyone is somewhat familiar and is one for which there do not exist prejudices about what one "should know." There is no cultural literacy movement in the world of fine dining. So what could we teach in such a school?

We could teach how to order in a restaurant; how to select a wine; how to understand what is likely to be good in a particular place; how to eat certain foods, and so on. But it would indeed seem rather foolish without getting to eat. If you want to know what Korean barbecue, sushi, chestnut puree, or truffled egg tastes like, you've got to eat it. If you want to know whether the sushi you had was typical of what sushi should taste like, you have to have sushi a second time. If you want to know the extent to which freshness matters in sushi, you have to eat sushi that isn't fresh and then eat some that is especially fresh. To gain this experience in a restaurant means asking about when the sushi was made, when the fish was bought, when it was caught, and so on.

In short, learning about food means eating it, thinking about what you ate, eating things like what you have already eaten in order to contrast one experience with another, and asking questions to determine other information that may help you make sense of your experiences. Still, this doesn't tell us exactly what it is that we are learning when we are learning by doing. It does tell us one important thing we are doing, however. We are acquiring experience. Experiences, or cases, are a critical element in understanding what is learned when one learns by doing.

When we eat sushi for the first time and then feel we want to understand all the possibilities for sushi, both good and bad, we know that this means eating more sushi. It may also mean eating sashimi, and eating rare tuna in a restaurant that grills tuna steaks. The more we eat, the more we become experts on the possibilities with respect to raw fish.

To put this in terms of case-based reasoning, a learner is interested in acquiring sufficient cases such that he can learn to detect nuances. He wants to be in a position to compare and contrast various experiences. To do this, he needs to have had those experiences, and he needs to have properly labeled those experiences. This labeling process is what we refer to as indexing. Indexing means taking an experience and giving it a name. So, we might call an experience of eating sashimi "sushi without the rice leaves blander taste experience due to lack of contrast in textures." Or, we might call eating sashimi "sushi without the rice." There is no right way to index, but it is clear that the former index is richer than the latter and thus is likely to lead to better remindings. In other words, someone who had used the former index might get reminded of other foods where rough and smooth textures are found in the same bite.

One conclusion here is that if you want to know about food - eat. Someone telling you about how something tastes, in effect, giving you a vocabulary for describing tastes, is not of great value. The experiences that build up a knowledge base cannot be obtained vicariously. One must have experiences,
not hear about them. The reasons for this are simple. Hearing about them means that the teller has crystallized his own experiences, shortened them, summarized them, and in effect has taken from them the material of indexing, the stuff from which we can build our own index. One cannot index on someone else's experience largely because that experience, as transmitted, will omit many of the details that are the fodder for indexing.

How we index cases is highly idiosyncratic. Indexing has a great deal to do with learning in that what we learn from an experience depends entirely on the indices that we assign to that experience.

Apart from cases and indices to cases, what exactly is learned when one learns by doing?

For many educators, this might seem to be an unimportant question. As long as students learn to do what they were trying to do, they have learned the right stuff. We need not ask exactly what they have learned unless we are seriously interested in what learning is all about. Of course, if we wish to design new educational systems we must be interested in precisely this question. It is all too easy for United Airlines to say that they know how to train pilots - they use flight simulators and allow their pilots to learn by doing. Similarly, any parent can say that he knows how to teach a teenager to drive: Sit him or her behind the wheel, grit your teeth, and let them go.

The problem is that it isn't all that easy to know what you are trying to teach all the time, and it is often tempting to preach rather than teach. Just because someone can fly an air flight simulator does not mean that you'd trust him to deal with any extraordinary situation. When you have taught your child to drive, you nevertheless fret each time he takes the car out for a spin. Can he handle wet conditions? What about drinking and driving? Even though we cannot anticipate every possible condition in a simulator, lectures about the evils of drinking and driving may not necessarily teach the lesson.

What are the implications of this for education? We must, as best as we can, teach students to do things, rather than having them be told about what others have done. Learning is the accumulation and indexing of cases and thinking is the finding and consideration of an old case to use for decision-making about a new case. Critical to all this is the process of expectation failure and explanation. To make thinking beings, we must encourage explanation, exploration, generalization, and case accumulation. How do we do this?

Recently, in a graduate class of mine, which has in it a few undergraduates, we were discussing learning. The students were making a variety of assertions about learning which caused me to wonder whether we were all talking about the same phenomenon. I asked various members of the class what they had learned recently. One told me that he had learned that a wok will rust if left overnight with the cooking residue in it. Another told me that she had learned that cheap paint doesn't work as well as expensive paint. Another told me that she had learned that she could buy cough medicine across the street and didn't have to walk a long way for it as she had thought. Another told me that he had learned that I liked to sit in a certain place in the classroom. Another said that he had learned how to handle himself better in certain social situations. These learners were all graduate students.

The undergraduates, on the other hand, noted that they had learned various facts such as certain events in history or certain methods of calculation in mathematics. Why the difference? The graduate students were much older than the undergraduates. They had more daily concerns because their environment was not as sheltered as the undergraduates. In addition, the undergraduates were engaged in the process of getting As by learning what they were told. The graduate students were trying to find out about their new environment, living in new houses, cooking for themselves, trying to understand what was expected of them in graduate school. The graduate students were being forced, both in school and in life, to think for themselves. What method were the undergraduates using for learning? Basically, they were copying what
they were told. The graduate students were, on the other hand, experimenting, hoping to find out what was true by trying things out and attempting to make generalizations about what might hold true in the future.

All of this tells us that learning is essentially a discovery process. We are all natural learners. As babies, we discover things by ourselves before we can be told. Even when we understand enough to be told, we still need to try things out for ourselves. The understanding cycle - expectation failure - explanation - reminding - generalization - is a natural one. No one teaches it to us. We are not taught to have goals, nor to attempt to develop plans to achieve those goals by adapting old plans from similar situations. We need not be taught this because the process is so basic to what comprises intelligence. Learning is a natural act.

How do we enhance learning? One way to enhance learning is by doing. If you want to learn about food and wine you have to eat and drink. If you want to learn how to drive, you have to drive. If you want to learn to fly a plane, you need to, at least, fly a simulated plane. What does this tell us about training and education then? It tells us that we need to try and recall, when designing a curriculum, what it is we are trying to get students who had been through that curriculum to do. To put this another way, we need to transform all training and education so that it looks, feels, and is like doing.

This brings us back to the question of what would then be learned if all training and education were, in fact, doing. We have so far said that cases and indices to cases are learned in this way. But something more important and, unfortunately, considerably less interesting from an intellectual point of view is learned this way as well. To see what we mean here let's return to teaching a teenager to drive.

It is easy to agree that certain cases would be learned while driving. For example, I recently was waiting at a red light at an intersection and, when the light turned green, decided not to go forward. I decided to wait because I was crossing a four lane road and a bus was in the lane third farthest from me and was blocking my view of the lane that was farthest away. Although the light was with me, it had just changed and there was always the possibility that a car was running the light and I wouldn't be able to see it. As it happened, that was exactly what took place. My caution averted a serious accident. That caution was based on many prior cases of seeing people run red lights. My experience was quite useful.

Now, of course, we want young drivers to have enough experiences that they could make similar judgments. We all know that drivers are much more cautious after an accident. We hope that our teenager will not need to have an accident or near accident in order to acquire reasonable judgment, but we know that this is unlikely to be the case. We just hope they won't get hurt as they learn.

So, they are learning cases, but what else are they learning? Of course, they are learning how forcefully to press the brake, how to accelerate in the proper way, how to stop at a stop sign, how to enter a highway, how to turn the wheel, and other mundane things that experienced drivers never think about and have difficulty articulating when attempting to teach their teenage children. It is actually quite hard to say how to press the brake. We can try, but all we have are words and these are as useless here as they are in describing how tuna sushi is different from yellowtail.

What We Learn When We Learn by Doing

In a book that laid out the primacy of goals in comprehension (Schank and Abelson, 1977), an idea that was critical to understanding how humans decide what to do and understand what others do was developed in some detail. I am referring to the concept of scripts. Simply speaking, scripts were intended to account for the human ability to understand more than was being referred to explicitly in a sentence by explaining the organization of implicit knowledge of the world that one inhabits. Thus, when John orders sushi, we assume that he is in a Japanese restaurant; we know he might be seated at a sushi bar; we know...
that he is probably using chopsticks and not a fork; and, we can even assume that he is drinking Japanese beer. We assume these things because we know the sushi bar script. If we do not know this script, we cannot make such assumptions and thus might have difficulty understanding various sentences that refer to things we might be assumed to know.

Scripts enable people to understand sentences that are less than complete in what they refer to. When we hear "John ordered sushi but he didn't like it" we know that this sentence is referring to eating and to John's reaction to a type of taste sensation that he has never had before. We know this because of what we know about restaurants (the restaurant script) and because of what we know about a small specification of the restaurant script, namely "sushi tasting." When we hear that "John flew to New York, but he was very unhappy with the meal" we now must invoke the airplane script to understand it. We do not imagine he flapped his arms to get to New York, nor that he was in a flying restaurant. We can explain what happened to him by saying "well, airline food isn't very good" because we know the details of the airplane script and those details include that kind of information.

How do we come to know such scripts? The answer to this is very simple. We learn them. We learn them by practicing them over and over. We can learn them as children, by being taken to a restaurant many times and gradually learning each step of the restaurant script. We can learn them through expectation failure by seeing an aspect of a script fail to be true (chopsticks instead of forks, for example) and explaining the difference to ourselves, creating a new Oriental restaurant addendum to that portion of the everyday restaurant script. And, we can learn them as adults, by, for example, going on our first airplane ride, trying to understand its script and gradually modifying our understanding with each subsequent trip.

It is this last aspect of the learning process that is most important for education. When we go on an airplane trip for the first time, or indeed, when we do anything for the first time, we are highly dependent upon finding a reminding, that is, finding some prior experience that will help us understand the current situation. Reminding is the process by which case based reasoning takes place. When we attempt to understand anything, we do so by attempting to find something in our memories that looks sufficiently like it so as to be helpful in processing. The reminding process allows us to learn by causing us to constantly compare new experiences to old ones, enabling us to make generalizations from the conjunction of the two experiences.

Now, one of two things happens during this comparison process. Either we realize that the new experience is significantly different from the one that we have compared it to, or we realize that it is really very much like it. (I will ignore gray, in between, cases here.) When a new experience is found to be different from our prior closest memory, we must create a new case for it. We can use our prior knowledge of trains to help us out on our first airplane ride, but we soon realize that while the comparison may have been helpful for initial processing, airplanes are cases of their own. We can index airplanes in terms of trains, but eventually we will treat them as a new thing entirely.

We may not know to do this initially, of course. How can we know on one airplane ride not to treat it as a specialization of train travel? But on our tenth airplane ride, we will cease to need that comparison. Instead, in trying to compare each airplane ride to each other, we will have created an airplane script that predicts what airplane rides are like in general, including information that states that one should not expect much of a meal. This is, of course, the other aspect of the comparison process. Finding a new experience to be a lot like an old experience allows us to build the script.

So, we either use new cases as new material to add to our library of cases or we use new cases to help build up our detailed script knowledge. We can, of course, decide that our new case is of no interest whatever because it is exactly what we have experienced many times before. In that instance, no learning occurs at all. We shall consider further the significance of new case acquisition within the learning by
doing context later on. Now, we need to discuss further the significance of scripts in learning by doing.

In Schank and Abelson (1977), scripts were described as very large structures that covered whole experiences. The restaurant script, the airplane script, the hospital visit script, and even the car accident script were discussed and are typical of the extent to which we believed that script-based, that is routinized, behavior dominated the performance of actors in these scripts and also accounted for our ability to understand events that take place within the context of these scripts.

In Schank (1982), I recognized that what I was calling scripts were structures that encompassed similar aspects and that the independence of these structures in memory would not account for the fact that learning could take place across such structures. Thus, for example, one might pay for a restaurant meal, an airplane ticket, and a hospital visit in much the same way, that is, by going to a person seated behind a desk, presenting a credit card, signing and taking the receipt. Of course there are differences in paying in each situation, so one could argue that human memory would want to treat these as completely different entities, but this is unlikely. It is unlikely because, if one found that one had misunderstood how to sign the credit card receipt in one situation, learning how to do it properly in the next situation would be generalized across all the situations by a reasonable person.

The recognition that memory was made up of independent scenes such as "paying" that could be assembled in memory by larger memory structures made clear that entities such as restaurant served more as memory organization packets (MOPs). Thus, the MOP restaurant included scenes such as "paying" or "ordering" or "being seated," which, with the exception of some of the variables contained in the restaurant's version of "paying" or "ordering" were not substantially different from MOP to MOP. It thus became clear that scenes were major memory items, that scenes were "colored" by different MOPs in different ways, and that MOPs collected together various scenes in particular orders.

While the details of all this may not be important for our purposes here, certain aspects are very significant for understanding how learning works. Learning can, of course, take place in any memory structure. Memory structures are, by their very nature, meant to be alterable. However, when we learn about something that takes place in a restaurant, we need to know whether what we learned is about restaurants per se (and thus we need to alter the restaurant MOP), or about some aspect of restaurants that has significance beyond restaurants such as "paying" (in which case we need to alter what we know about a scene), or something that just happened to occur in a restaurant and has nothing to do with the MOP or scene in which it occurred (so we must alter what we know about some more abstract MOP, such as embarrassment or romance, that might have been operating at the same time in the same place).

What has happened to scripts in all this? Actually, they are still there. There are many highly routinized packages of events that are quite specific without any particular application beyond their immediate purpose. In Schank (1982) we said that scenes packaged scripts, that is, one scene might contain many small scripts. The difference between my use of the term in 1977 and in 1982 was one of scope. A 1982 version of script might be looking at the menu, putting ketchup on the hamburger, brushing one's teeth, or parking the car. These scripts seemed, unfortunately, not to be very interesting. Further it was easy to forget the new use of the term and people who used the term script continued to think of the 1977 variety. This matters a great deal as we shall see. So, I would now like to rename the 1982 scripts, calling them micro-scripts, thus making clear the smallness of their scope.

The reason why all this matters is that the object of learning in learning by doing is the acquisition of micro-scripts. The skills to which we refer when we ask about people's abilities almost always refer to micro-scripts. Let me explain.

Our abilities are bound up in micro-scripts. When we say we know how to do something, we are often
referring to one or more micro-scripts that we have acquired over the years. These micro-scripts are often quite unconscious. We cannot easily describe what we know to someone who doesn't have the right micro-script. They often consist of very low-level skills that we have practiced many times over the years. An important point here is that this practice almost never takes place for its own sake. We practice micro-scripts solely because we are constantly pursuing the same goal again and again. We never use a micro-script except in service of a goal.

Two good examples of a micro-script are "setting up a VCR for taping" or "sending electronic mail." I know how to do both of these things. Many people do not. I have had to learn each many different times. In the 25 years that electronic mail has existed, I have had to use probably ten different systems. Although I was told how to use each, I rarely remembered what was said long enough to try it out. When someone watched over my shoulder as I did it, I could do it, but then I would forget by the next try. In short, I learned how to use electronic mail by using it. I am quite adept at the two systems I now use, although I probably don't know all the features of either. Nevertheless, if you asked if I had the skill of using these two systems, the answer is clearly "yes." It should be obvious that I have no interest in how these systems work in any way. I do have interest in sending and receiving mail, however. The goal of sending and receiving mail caused me to try the systems until I got good at them. These trials were held in the course of use, not as outside practice. To put it simply, I learned the e-mail micro-script by doing the e-mail micro-script -- this is learning by doing.

A more common example is the use of the VCR. I got one of the first VCRs, and have had maybe ten of them over the years for various reasons. They all have different ways of setting up a recording, and I can operate all of them. I find them annoying to use, but I like to record and watch movies, so I have learned each system. If I am away from any of them for very long, I tend to forget how they operate. I know some generic stuff about how they work and this can help me re-learn what I need to know. But when I have relearned the micro-script I cannot do it quite efficiently. Micro-scripts tend to decay in memory if they are not used. But still, you could say that I have the skill of recording on my VCRs. I have learned those skills by doing them.

I am mentioning all this for a simple reason. Education ought to be, in principle, about learning cases and micro-scripts. We want students to know the exceptional cases from which they can learn and make judgments on their own about new situations. And we want students to know how to do things, to have sets of skills. But when we talk about the skills we want students to have, we often get confused by what we mean by the term, talking about what we want students to know, or how we want students to comport themselves and not about what we want them to do.

Students need to acquire micro-scripts so that they can perform the actions contained in them. However, micro-scripts are, almost by definition, very dull. Teaching them as objects in themselves, as things to be learned independent of what knowing them can do for you, is very difficult to do. On the other hand, students will easily acquire micro-scripts if they are acquired in the natural course of the pursuit of a goal that is of interest to the student. Micro-scripts must be taught in the service of a goal, or to put this more clearly, they ought not be taught at all. They need to be learned naturally in the course of the pursuit of a goal. This is what learning by doing is all about.

**How to Do It: Skills as Micro-scripts**

A proper teaching environment should contain all the skills that the curriculum designer wanted to teach, and then put them into some natural situation around which a set of actions culminating in a desired conclusion can be constructed. We can call such a set of actions a scenario. A goal-based scenario (GBS) allows a student to play one or more roles in a single or group situation that culminates in the accomplishment of some goal. That goal should be readily identifiable and seem real to the student. The
goal can actually be real (like driving or repairing a car) or only be play-acting (like running a simulated company and attempting to beat the competition.) In either case, the student must care about achieving the goal in order for the scenario to have any educational value. The scenarios can take as long as the designers want them to, from a day to a year. They can be built in software or partially instructor led, or completely paper-based. Case libraries are an important part of such a scenario. When a student has difficulties in achieving subgoals on the way to the main goal of the scenario, a teacher, whether real or electronic, needs to intervene. Such intervention is often in terms of a case, related as a well-told story, presented to the student immediately after a problem is encountered and the student indicates the need for help. Such case-based intervention can be in software, in video, or on paper. In chapter 5 Burke & Kass describe a system that does this.

The curriculum redesign process begins with an understanding of what skills are to be learned. Assessing what is a skill and what is not a skill is critical to this process. For this reason, understanding skills as micro-scripts is quite important. It is all too easy to see anything and everything as a skill. Certainly, reading, mathematics, management, and getting along with people are often talked about as being skills. But they are certainly not micro-scripts. They may be comprised of many micro-scripts -- certainly this is the case for reading and mathematics. And, indeed, there may well be micro-scripts for management and getting along with people. But identifying precisely of what actions such micro-scripts are comprised can be quite difficult. It is, in fact, part of the art of the curriculum design process to determine what exactly it is that people know when they are reputed to have a skill such that the micro-scripts that comprise such a skill can actually be practiced.

There are three broad classes of micro-scripts. Looking at micro-scripts according to this classification can help us understand more about them. These classes are cognitive, perceptual, and physical.

The examples we have used so far have been primarily cognitive micro-scripts. Cognitive micro-scripts naturally have a physical component (if they didn't nothing would ever happen). Thus, the VCR micro-script is mostly a prescription about what to do in a cognitive sense, the physical aspect being no more than button pushing. The skill of button pushing is not a particularly interesting one, nor is it the difficulty that would-be VCR programmers encounter that makes them incapable of getting the right program taped at the right time. The difficulties they encounter are cognitive, in knowing which button to push when, not in knowing how to push the button. Similarly, the e-mail micro-script involves only mouse clicks and keyboard strokes at the physical level. All cognitive micro-scripts have a physical component, although that physical component is quite often rather uninteresting and the knowledge of how to do it quite independent of the micro-script in question.

Purely physical micro-scripts do indeed occur-- typing and button pushing on a remote control device being two of them, for example. More interesting ones are bicycle riding, brake pedal pushing on a car, or tooth brushing.

Perceptual micro-scripts involve the recognition of things, such as recognizing individual people, noticing dangerous situations, or the perceptual part of hitting a baseball.

When we say that someone has a skill in the sense of skill that is appropriate here, we mean that he has a micro-script that might involve a primary cognitive micro-script and some physical and perceptual ones as well. This distinction is not that important here and we shall use the term micro-script to refer to a mental entity which might actually involve a mix of all three types of micro-scripts. Thus the following definitions apply:

A cognitive micro-script refers to knowledge about use. This knowledge is usually consciously available. That is, a person in possession of that knowledge can talk about it. If the sentence "John knows how to
use X" makes sense for a given X then X is a cognitive micro-script.

A physical micro-script refers to knowledge about operations. This knowledge is not usually consciously available. That is, a person in possession of a physical micro-script may not be able to talk about it. If the sentence "John knows how to operate an X" makes sense for a given X then X is a physical micro-script.

A perceptual micro-script refers to knowledge about observations. This knowledge is not usually consciously available. A person in possession of a perceptual micro-script may not be able to talk about it. If the sentence "John knows how to recognize an X" makes sense for a given X then X is a perceptual micro-script.

As we noted above, we are referring to what is commonly meant by skills. The problem with this word, and why we feel the need to avoid it, is that the word has no clear definition -- nearly anything can be a skill. We can say, for example, that someone is a skilled negotiator or is skilled at cooking. When we talk about skills, we are often referring to what we believe a person "knows how to do." Unfortunately, this can mean just about anything at all. Any human action or capability can be referred to as a skill, so the word offers us very little to go with if we want to teach skills. We are left in the position of saying that we want to teach just about anything.

What exactly is the problem here? Why shouldn't memorizing a list of biological terminology be a skill, for example? By any definition, it would be a skill, of course, since one could require it of students, some would be better than others, and we could say that they were more skilled in biology and give them a better score on an exam than those who were less skilled. But looked at in terms of micro-scripts, it becomes clear that the skill involved is a cognitive micro-script involving memorization. If we wanted to teach this micro-script, we would have to teach someone how to memorize, so that they became good at memorization rather than becoming good at biology.

One problem with the word "skill" is that we can say "John knows how to do mathematics" or "John knows how to do biology" and still feel comfortable that we are talking about skills because we are talking about knowing how to do something. The illusion is that mathematics or biology are a kind of thing one can learn to do. We might expect our employees to know how to do systems installation or to manage other employees, for example. But, although these may seem like skills, in each case they are really collections of a large number of micro-scripts. This becomes clear when one thinks about teaching someone to do any of these things.

You can't teach students to do biology, but you can teach them to dissect a frog (a physical micro-script), or relate diet components to biological functions (a cognitive micro-script), or interpret chemical equations (a perceptual micro-script). In fact, even these micro-scripts are likely to made up of many smaller micro-scripts (such as knife handling).

Similarly, you can't teach someone to do mathematics, but you can teach them addition (here changing a cognitive micro-script into a perceptual one over time), or how to prove a theorem in plane geometry.

In business, this means we have to stop thinking about teaching management techniques, or communication methods. Why? Because these are not micro-scripts. They tend to be taught the way high school biology is taught, as facts to be memorized, which as I have said, is only relevant to teach if memorization is the micro-script you want students to master. But if we want students to get good at managing or communicating we have to do something else.

There is an important difference between a skill that is teachable and a skill set that is, by itself, not teachable. Whatever doing biology or managing employees might be, these things cannot be only one
skill. They are collections of various, possibly quite unrelated, micro-scripts. If we confuse micro-scripts to be learned with simple headings that we have used to describe skill sets, we will cause the courses we design to lose their focus.

Recognizing the skill set to which a micro-script naturally belongs is critical to curriculum redesign. If one did need to learn some type of calculation to learn to do biology, for example, two very different ways to approach this problem exist. We could separate these skill sets in traditional ways, requiring a course in mathematics prior to biology, for example. This is pretty much what schools do today and it has disastrous consequences.

The first problem with this method is that by grouping these skills separately we risk losing the student's interest. By making a biology student take chemistry or calculus we risk killing off a budding biologist by making him focus on subjects that may not interest him and at which he may not have much talent. A second risk is that much of what else is taught in such prerequisites may not be at all germane to the needs of the biology student. What makes up a coherent course in mathematics is likely to be determined by someone who has an agenda other than helping the biology student be a good biologist. Finally, as a consequence of this, the aspects of mathematics most of interest to a biologist might be little dwelt upon by the mathematician. In fact, a biologist is likely to be the real expert when it comes to the mathematics he uses on a daily basis. The mathematician is more likely to understand, and therefore teach, the theory behind the necessary mathematics rather than the practice of such mathematics.

This problem is even more critical in the relationship between academic psychology and human resource management. It is all well and good to propose that psychology majors are good prospects for being human resources specialists. But if they are good prospects, it can only be because of their inherent interest in the subject, not because of what is taught in psychology courses. In the popular image, psychology majors have learned about how to get along with people and understand human relations. In reality, psychology majors have learned how to be miniature academic psychologists. They have learned how to run an experiment, how to do the relevant statistical analyses, and how to appreciate the various sub-specialties in academic psychology, none of which have much to with how to understand or get along with people better.

What should be done is to break down traditional academic lines and teach micro-scripts on an as needed basis. Doing this allows for the creation of goal-based scenarios that entail the learning of many different and often unrelated micro-scripts in the pursuit of a goal. To put this another way, a micro-script is something that fits into the following situation:

a1: I need John to do X  
b1: John doesn't know how to do X  
a2: Well, then teach him how to do X  
b2: That's easier said than done; learning to do X requires experience

Part of the point here is that, in business especially, one wouldn't have the above dialogue where X is "human resource management." In that case, a1 and b1 make little sense. X might be "to fire somebody," however. In that case such a dialogue might make sense. Further, it also makes sense that one can't learn to fire somebody except by firing somebody. This is the best way to spot a micro-script. If one can't learn to do it without actually doing it in practice, it isn't a micro-script. What this suggests, of course, is that the best way to teach a micro-script is in practice situations. If one wanted to teach "firing someone," practice scenarios would be constructed in which such talents could be learned, and experiences could be gained before one tried it out for real.

Looked at this way, biology is not a micro-script, but dissecting a frog properly is. Physics is not a micro-
script, but performing a calculation needed in a physics experiment is. Managing people is not a micro-
script, but making sure that an order is sent out on time is. Writing a report is a set of micro-scripts.
Computer programming is composed of many micro-scripts (learning how to do a loop, for example, is a
micro-script, as is writing that loop in C). Reading a financial report involves a multiplicity of micro-
scripts. Playing a musical instrument involves multiple micro-scripts. In short, if one has to learn to do
something, and it is relatively easy for an expert to tell whether or not one has done it properly, then we
are talking about a micro-script or a natural grouping of micro-scripts.

Confusion arises when we talk about major job classifications as if they are skills, when in fact they
comprise numerous micro-scripts that are often quite difficult to define. For example, being the president
of a large company could be talked about as if it were a skill. Upon closer examination, however, it is
clear that such a job must be comprised of many different micro-scripts. It is determining which ones
exactly make up such a job that gets everyone confused. A company president ought to be able to talk to
the press, make his board of directors see his point of view, get the most effort out of his immediate
subordinates, and so on. Some of these may be micro-scripts learned on the job, micro-scripts learned at
other times but applied in a new place, or brand new actions, taken for the first time, invented by the user,
which will eventually become micro-scripts if they continue to be of use.

When we attempt to determine where the needed micro-scripts lie, we may well discover that not only is
this a difficult task because of the normal English language use of the term "skill," but it is also difficult
because of the way in which courses have traditionally been taught. We are quite used to courses in
biology, or economics, or history, or psychology. Since the content of these courses is rarely looked at
from a micro-script-related point of view, their definition is usually quite micro-script independent.
Courses, after all, usually involve a number of issues that have nothing to do with micro-scripts at all.

First, courses almost always involve grades. This often means tests with quantifiable measures, which
more often means measures of vocabulary (often called concepts) rather than measures of actual
achievements. Sometimes, tests will test micro-scripts. (This frequently happens in mathematics, for
example). But most of the time tests are oriented towards getting a student to reiterate the teacher's point
of view, which is not a micro-script (except in a kind of perverted view of the term).

Second, courses tend to try to make the student into a kind of mini-scholar of the field in question.
Teachers are afraid that their students will have been in an English literature course and not have read
Dickens, or have been in a philosophy course and not know Plato, or in an economics course and not
know Malthus. Thus, most courses have a serious bent towards history of a particular field. This comes at
the expense of time spent on micro-scripts, that is, how to actually do anything is ignored, and, more
important, tends to shift the focus towards scholarship. Such a shift towards scholarship means that
courses will have a heavy emphasis on facts. (The "literacy lists of the field" are big here.) So, knowing
what a particular scholar said and being able to reconcile his view with particular conditions or with the
views of an opposing scholar become the meat of such courses and of the tests that provide the grades for
such courses.

The emphasis becomes one of reading about a subject (and being able to argue in a scholarly way about
that subject) rather than doing that subject. Thus, philosophy courses don't ask the students to "do
philosophy" but to read about those who have done philosophy. In the case of philosophy this may not
seem so bad. There have been great philosophers, the world does not change all that much in the really
important issues, and an argument could be made that all the important things have been said already.
Even so, the micro-scripts of philosophy, which I take to be original reasoned thought and argument, are
only peripherally taught if they are taught at all.

But matters become much worse when the courses under discussion are in fields where the great thoughts
have clearly not all been thought and where much remains to be learned. Two fields that come to mind are economics and psychology. Students are asked to read the great works but not to do much of anything expect spit back what they have read. The argument is that they should be learning to "do economics" or to "do psychology" but it is not at all clear what this might mean. The fact that this is not clear is part of the problem.

Of course, one can be cynical about such fields and say they contain no micro-scripts to be taught. But people engaged in such work do employ a number of micro-scripts, although they are often associated with other subject areas, such as statistics. The problem is twofold. First, just because practitioners can do good work in their field is no reason to suppose that they understand how they do what they do well enough to be able to teach the micro-scripts that they have. Second, even if they did know how to teach those micro-scripts, it would still be reasonable to ask if that micro-script is worth learning for the student who only wants to take one or two courses in psychology or economics. After all, wouldn't the students be better off with a survey of work in the field without attempting to teach them micro-scripts that take a very long time to learn and which they may never use?

This, then, is the essence of the argument. In education in general, there is a choice between a survey of past works in a field, or learning how to be a practitioner in that field. My argument is simple. Survey courses tend to teach to the test, emphasize the point of view of the instructor, leave students years later with very little memory of what they had learned in order to pass the test, and are generally a waste of time.

Micro-scripts on the other hand are testable in simple ways, are not biased towards the teacher's point of view, remain with students for a very long time, and provide a framework into which the work of the great masters of that skill can best be appreciated. Further, and this is the main point, mastery of micro-scripts builds confidence, is much more easily motivated in school, and the process tends to get students to think about what they are doing.

As an example, let's consider musical education. The argument here is that musical education ought to begin with learning to play an instrument and that, after the many micro-scripts relevant to an instrument have been learned, students will be better able to appreciate the work of musicians who have gone before them. By the same reasoning, if we want students to understand music theory, they should have to create some music first.

Now this may not seem like such a radical idea, since many music schools do exactly this. But such a point is often devalued as we get to higher education, where music scholars are often clearly differentiated from musicians, and it is the former who teach the courses. Further, high school courses, and even elementary school courses, often perpetuate the biases of university level music professors, thus creating non-learning-by-doing courses in a subject area where the set of micro-scripts are as easily definable as is ever possible.

Many elementary schools are smarter than this and teach kids to play anyway. The same is not true, unfortunately, in subjects considered more central to a child's education. We don't let children just do physics. In fact, we hardly even know what that means. We do let students do math, because we know what that means, but we lose track of why we are doing it. One reason, I suspect, is that schools really like to teach micro-scripts when they can identify them. They are easy to measure and thus fit well into our test oriented society.

But what happens when a micro-script is hard to identify? We know we want students to be able to read and understand, but it isn't all that easy to tell when students actually have the requisite micro-scripts to do so, especially when the material they are reading doesn't interest them. But it is easy to tell if a student
can solve a quadratic equation, and it is a cognitive micro-script, so schools emphasize mathematics. The point is that while identifying relevant micro-scripts is indeed difficult, one should be wary of teaching any micro-script one can identify just because it is in fact something easy to teach. We need to teach micro-scripts, but they must be relevant micro-scripts. This means knowing the answer to what one can do with that micro-script. The things that one can do with algebra are far too limited for anyone to justify teaching it for practical reasons, so it is usually justified as a way to teach reasoning (although there might be better means available for doing so). It is a good idea, therefore, to know what micro-scripts one needs for what real purpose before one goes about designing a curriculum.

The Idea of Curriculum

Schools are full of curricula, that is, agreed upon sets of courses that constitute what the designers of curricula feel that their students must learn to be "qualified" in a given subject. The French curriculum covers certain aspects of French language, culture, and history as deemed appropriate by the designers of that curriculum. The mathematics curriculum covers certain material in the third grade, certain parts of geometry in high school and so on. When colleges say they require four years of mathematics, they mean that they require study in certain particular aspects of mathematics, to be studied over the course of a certain number of years, with certain tests at the end. There is some variation in these curricula from school to school, of course, but not all that much, especially when a standardized test looms at the end.

The idea of a curriculum is that a school has the right, indeed the obligation, to say what should be learned about a given subject. And therein lies the rub. There is a serious problem with the idea of a curriculum.

From the arguments so far stated, we know that a curriculum ought to be no more than a collection of micro-scripts to be acquired. Because real knowledge comes from doing, and micro-scripts are what are acquired in doing, then it follows that any curriculum, course, or teaching program should be no more than, and no less than, a set of exercises that allow students to acquire a micro-script in the natural way that micro-scripts are acquired, that is, by practice. Of course, there is the issue of motivation. No one will learn a micro-script, much less practice one, unless there is real motivation to drive what may be real work. Take for example, the micro-scripts mentioned earlier, programming your VCR and sending e-mail. Neither of these are intrinsically rewarding activities. Learning to do them comes from the results they bring. This means, to a course designer, that the results they bring need to be brought to the fore, serving as real motivation to acquire the micro-script.

Under this light, the idea of curriculum becomes very clear. Micro-scripts enable people to do things. To motivate a student to learn a micro-script, one of three things needs to be true. Either the student must find the result of the micro-script to be intrinsically rewarding, or the micro-script must be part of a package of micro-scripts which are intrinsically rewarding, or the micro-script must enable learning another micro-script.

Many micro-scripts can be grouped together to accomplish a goal even if no one of them would naturally stand alone. The classic restaurant script which I later reclassified as a restaurant MOP (see Dynamic Memory, Schank, 1982) is a collection of micro-scripts (such as ordering or paying). Driving a car is a collection of micro-scripts (such as engine starting, braking, or lane changing). Playing baseball is a collection of micro-scripts (such as fielding a ground ball to your left, hitting the curve ball, or sliding). No one of these things is ever done for its own sake. No one feels the need to pay a restaurant bill without its surrounding micro-scripts having taken place. No one decides to slide into a base (unless they are practicing) in the absence of the need to. Nevertheless, all these things take practice, and one can learn to do them so that one is quite skilled at various subtleties that might arise.
I have referred in other works to ordering and paying and scenes and said that MOPs package scenes. One should not confuse scenes with micro-scripts, although it is quite easy to do so. Remember that I am using the term micro-script in order to avoid using the wider term "skill." By micro-script I do indeed mean one aspect of the word skill and it is that aspect that is relevant when thinking about the difference between scenes and micro-scripts. There is a paying scene which has within it a paying micro-script which might be no more than the skill of knowing how to fill in the credit card slip properly. The scene has other properties (such as the presence of the waitress and the use of a little plastic tray) that have nothing to do with the micro-script at all. The micro-script refers to the set of actions one learns as part of one's role within a scene.

We do not often refer to these micro-script by themselves. While one might say that one knows how to make toast, change a tire, or program a VCR, it is less usual to say that you know how to start a car or pay the check. Nevertheless, these are all micro-scripts. The second category of micro-script, the one that one never brags about, is part of the packaged micro-scripts that one learns simply because it is part of the package. The package itself is worth taking about. So, one can say that one is good at playing baseball or that one is a good human resource manager, but there is no one micro-script associated with these so-called abilities. It becomes obvious, therefore, that they are not abilities at all. Rather they are names for packages of micro-scripts, no one of which may be worthy of comment.

Nevertheless, each micro-script, whether in a package or not, has the same properties. One needs to learn them by practicing them. When one decides to teach them, however, one must bear in mind their important differences. The ones that stand alone, that are intrinsically rewarding, can be taught by themselves. One can learn to make toast or program a VCR in the absence of any other activity or motivational issue. One learns it to learn it. This is simply not true of packaged micro-scripts. A sliding lesson may be fun for someone who is intrinsically rewarded by getting dirty, but very few people want to take a credit card signing lesson, and no one takes a braking lesson in the absence of an entire driving lesson. Micro-scripts that are part of packages must be taught within the context of those packages. We shall see why this matters later on.

Another situation arises when micro-scripts are learned in order to do something else. Now, clearly each micro-script in a package can be learned in order to do something beyond the micro-script, and so can micro-scripts outside of packages, and the packages themselves. That is, one can learn a micro-script that is intrinsically rewarding in order to learn another that is also intrinsically rewarding. Or one can learn a package that has a goal as part of a larger package that accomplishes a different goal. The idea that a micro-script is only useful in that it relates to a distant goal is the critical idea in an understanding of what should be meant by curriculum.

We might all agree, for example, that being able to calculate square footage of an area is a useful skill that any adult might need. Schools therefore assume that such skills should be taught, but they place such instruction in a course of mathematics. I am arguing that the concept of micro-script makes clear that there should not be any courses in mathematics in the early years of school. Rather, mathematics micro-scripts, of which the calculation of square footage is one, need to be taught in a meaningful curriculum. The reason that this must be so is that square footage calculation is not intrinsically rewarding, nor is it a part of a package of micro-scripts that depend upon each other like restaurants and driving. It is a quite independent micro-script that no one wants to learn for its own sake and thus presents a serious motivational problem.

One possibility in such a situation is to reconsider whether it is in fact important to learn the micro-script at all. But once one has decided that it is important, the curriculum designer would need to find a situation in which this micro-script must be learned in order to accomplish another goal that is rewarding. Thus, if the calculation of square footage is important to learn we might embed the learning of it within

http://cogprints.org/635/0/CBRMeetsLBD_for_Leake.html
the attempt to plan and build a house. This calculation would need to be made many times in a such a situation and would be learned in that way. If this situation is rewarding for the student then the student will indeed learn the relevant micro-scripts. If, on the other hand, no situation can be found that is rewarding for the student that naturally contains this micro-script it is reasonable to assume that this micro-script isn't all that important for the student to learn. Not every student will master every micro-script that we determine he should know.

The same is true in business. If we determine that reading a financial report, a package of micro-scripts, is important to know, we must find a context in which that knowledge matters. Giving the student a decision to make in which the various micro-scripts in reading a financial report come into play can make all the difference between a student really acquiring the relevant micro-scripts and his simple learning them in order to pass a test. One thing is important to remember here. It is not simply a question of finding the context in which the micro-scripts come into play, they must come into play quite often. Practice is a very important part of micro-script acquisition. Here again, this does not mean repetition of the same micro-script again and again as is done in drill and practice situations in school. It does mean finding repeated situations in the curriculum in which the same micro-script is of use so that the practice does not seem like practice. If you want someone to become a good driver, the issue is not having him drive in circles, but giving him a job which requires repeated driving in a non-artificial way.

The concept of a goal-based scenario, then, is that it is a means by which micro-scripts can be acquired where the micro-scripts (or packages of micro-scripts) themselves are not intrinsically rewarding, but where the situation has been set up such that every micro-script is acquired because the student can see that he will need that micro-script in order to accomplish a different goal that it enables. The student, in this scheme, must be aware of the progression of goals. He must want to accomplish the goal that drives the scenario itself, he must understand the subgoals that lead to the accomplishment of the final goal, and he must understand how each micro-script helps him accomplish the various subgoals necessary. Creating meaningful curricula means creating goal-based scenarios that comprise micro-scripts that have been determined to be important to learn.

**The Role of the Teacher**

In designing a curriculum, it is important to understand that the aim is to provide enough relevant experiences that allow for the acquisition of micro-scripts and for thinking about difficulties that do not result in practiced, script-based solutions. Further, it is important to provide some guidance through those experiences so that the student can know the difference. That is, the student needs to know when more practice is required and when an exception has occurred and more thought is required. It is not important that a student figure out everything for himself. A teacher can suggest new data to consider, new experiences to try, and, when asked, can answer questions by providing facts that cannot be readily inferred or attained through repeated experience.

The role of the teacher is to be an exposer of knowledge. Learning by doing entails trying things out, formulating hypotheses and testing them. But, a student cannot do this in a vacuum. The teacher should be there to guide us to the right experiences. The teacher should also be there to answer a student's questions, or at least, to listen to his questions and perhaps suggest ways that he could discover the answer himself. Curiosity comes from trying things out, from failing on occasion, from explaining why, and from trying again. This is what any goal based scenario must entail.

How do we know, under such a scheme, that the student knows all that he needs to know about a given situation? We don't. But we shouldn't care that much either. A good teacher should have as his goal exposing his student to enough situations that the student will become curious enough to take his learning into his own hands. In other words, the role of the teacher in a goal-based scenario is to open up
interesting problems and provide tools for solving them when asked by the student to do so. The accomplishment of the goal should be its own reward. The curriculum must be oriented towards, and satisfied with, the idea that a student will learn what they need to in order to accomplish goals. Hopefully they will have become curious and acquired both oddball cases and routine micro-scripts along the way.

If we abandon the idea of easy measurement of achievement, then we can begin to talk about exciting learners with open-ended problems and we can begin to create educational goals such as learning to think for oneself. Of course, such things are difficult to measure, but one cannot help but feel that we'll know it when we see it. Under this view, the problems of how we teach and how education is delivered become far more important than one might initially imagine. Actual content may not be the issue at all since we are really trying to impart the idea that one can deal with new arenas of knowledge if one knows how to learn, how to find out about what is known, and how to abandon old ideas when they are worn out. This means teaching ways of developing good questions rather than good answers.

To understand something about why goal-based scenarios matter, let's take a subject which could be taught in either the traditional way or in a more reasonable way, and play with the idea. Consider wine, for instance. I happen to know something about wine, which is an adult subject, that is, one not normally formally taught except to adults who have specifically requested such training and have typically paid money for it after work.

Let's go to wine school. Not a real wine school, but a wine school where the instruction is done in a way similar to that done in the schools or in many formal training programs.

We would start our instruction in wine by handing out four texts. One would be a geography text, teaching about where Burgundy is and where the wine growing regions of the United States are, talking about Virginia, New York, and Texas wineries, for example. The second would be an agricultural text. It would teach about the various grapes, where which is grown and why, discussing soil conditions, climate issues, optimal grape pricking times, and so on. The third would be a text about the wine making process. Fermentation, storage, blending, and such would be included, as well as a discussion of the wine business, including who owns which chateaus and so on. The fourth would be a history text, answering such questions as: What kind of wine did the Romans drink? Who invented the cork stopper? How were issues of proper storage discovered? Why do the British prefer to drink Bordeaux? Which wine growing regions of France were there in Roman times?

After instruction in these various areas, we would begin testing. What was the best year for Bordeaux in the last 30 years and why? Who owns Chateau Margaux? When did Mouton-Rothschild achieve first growth status? What grapes are grown in Oregon and why? What was the first French-American joint venture in wine growing? Can you identify the Chateauneuf du Pape region of the Rhone valley on a map?

What is wrong with this picture? Nothing, I think. It is the way schools teach most subjects. Schools teach information that can be tested. How will they know if you have learned anything if they can't test you? So, they must teach something testable. The tests drive the curriculum, and people lose sight of the original purpose. Notice that no micro-script (save those of memorization or reading) would really be involved at all in such a course. The goals of the student, which presumably had something to do with drinking rather than the acquisition of facts, were ignored. In general, I don't think that such a school would stay in business long. Students would vote with their feet. If students in school or training programs could vote with their feet in the analogous situations, they most certainly would.

The school that would stay in business would not involve lectures about wine. Teaching about wine means drinking wine, not memorizing facts about wine. Drinking with some help from someone who
knows more than you do means that you will learn something. Being able to compare one wine to another, having many different experiences to generalize from, means being able to create new cases (a particularly great wine would be remembered, for example) and new generalizations (seeing a common property that all wines from a certain place or year had in contrast to others from different places or years, for example).

Over time, a learner becomes curious about a wider range of issues. Learning entails, among other things, knowing what questions to ask. This means having gotten enough cases or micro-scripts that one can begin to wonder about them, seeking out new cases and refinements on micro-scripts such that new knowledge can be acquired. It is only in this context that the acquisition of facts is of any interest at all. To put this another way, facts can only be acquired in a way that they will be useful if those facts are sought after by the student for reasons of satisfaction of curiosity.

It took me a long time of wine drinking before I began to wonder about Rhone wines, or the British preference for Bordeaux (they used to own it.) I know about when Chateau Margaux changed hands because the quality has changed dramatically (down and then back up) the last two times that that occurred and I really like Chateau Margaux and need to know which years to avoid. I visited the famous Chateau Margaux and really appreciated the place and the wine I tasted there, but would not have if I hadn't liked the wine in the first place. A shrine isn't a shrine unless it means something to you. I know where Bordeaux is now because I had to find it on a map in order to get to Chateau Margaux. I drank Bordeaux for years without really knowing anymore about the region of Bordeaux than that it was in the southwest of France somewhere. All these facts would have been meaningless and easily forgotten had I simply been told them at the wrong time. The right time was when I wanted to know them, a time that could only have been determined by me and not a teacher.

Processes

Apart from any micro-scripts that we may wish to impart to a student, all students, in virtually all contexts, need to be able to engage in certain processes, no matter what their particular lives are like. If there is a sine qua non of education it must be these universal processes, not a set of particular facts. It is our contention that there are three processes that are more important than any others and that any curriculum must teach them. However, it is critical that they be taught indirectly, embedded in scenarios that are otherwise intended to teach micro-scripts and cases. The three processes are communications, human relations, and reasoning.

Every student, indeed every adult member of society, needs to be constantly learning how to communicate, how to get along with and understand others, and how to think. These processes are learned quite naturally when students are part of teams attempting to accomplish goals. What does it mean to learn these processes? Clearly, learning a process is different than acquiring a micro-script. A micro-script can be easily described as a set of steps and those steps can be practiced so that they become routine and require little or no thought to execute. Since micro-scripts are prescriptions for action we can meaningfully talk about their execution. The same is not true of processes.

We cannot say that someone knows how to do human relations. We can say they know how to communicate or how to reason, but it is very difficult to specify what we mean when we say such things. Clearly we are not talking about micro-scripts here. It would be very difficult to specify a set of procedures that form a package called "communication." Being able to get along with others or think about a new problem may have some executable procedures but it also seems to entail a great many more fuzzy concepts, such as being nice or trying unusual solutions, that are a great deal more difficult to quantifiy.
The word process here sheds little light on these phenomena in the same way that "skill" shed little light on what it was that we wanted people to know how to do. As with "skill" the word "process" can encompass too much. There are many phenomena that can be called processes. There are political processes, economic processes, scientific processes, and so on. What these ideas have in common is that they refer to complex sets of forces that come into play that require more of their participants than a simple knowledge of how to execute certain procedures. The phenomena they represent are complex and often not given to clear procedures that can be guaranteed to work. There is one way to send e-mail and program the VCR. There are known solutions to braking a car, riding a bike, or making toast. But for what we have been labeling processes there are often no good answers or many good answers. What answers there are are not executable procedures but rules of them, general strategies to try that may or may not work under the particular circumstances that have arisen. For this reason, it might be better to describe the substance of what we want people to learn about these phenomena as participation strategies.

Thus, we can restate what is learned in a goal based scenario as micro-scripts, cases, and participation strategies in various processes that are contained within the scenario. An ideal goal-based scenario would involve many people participating as part of a team, a complex environment in which to work, and a need to report the results. Such a scenario would cause participants to have to develop strategies for getting along with other team members, reasoning about the complex domain, and communicating the results.

Learning by doing, when one is talking about processes, means inventing for oneself strategies that work within the processes that one is involved in. When we asked what was learned in learning by doing earlier we recognized that the same mental structures we had always used were active here as well and that our old idea of scripts and packages of scripts was entirely relevant to learning by doing. In effect, learning by doing modifies existing memory structures at the lowest level described in Schank (1982).

Now we must ask where participation strategies for processes fit into this scheme. The answer is again to be found in Schank (1982). This becomes clear when one considers what a participation strategy actually looks like. Let's consider a few. Some good ones for human relations might be:

if you want someone to like you, ask for their help
if you are in charge of someone, be firm but treat them as an equal

Some good ones for reasoning might be:

in order to attack a new problem, try to see it is an instance of an old problem
in order to find a solution, hypothesize a world in which the current problem wouldn't exist

Some good ones for communication might be:

never say everything you know in one speech
always write in an easy to read, unpretentious style

One thing that should be obvious here is that these rules are most certainly not always right. Their opposites could also be right under certain circumstances. Further, they are accumulated by experience, by actually trying to engage in processes. Thus, they have all the characteristics of what were referred to as thematic organization packets (TOPs) in Schank (1982) and have been referred to as indices in several subsequent books (Schank, 1986, and Schank, 1991 in particular). These strategies are developed from particular cases. Cases provide data for generating abstractions, store exception episodes to warn of problems with existing knowledge structures, and provide a starting point for future comparisons.
(Schank, 1982).

Thus, no matter what else a course is intended to teach, if it has a format that includes using a group, it will also cause human relation strategies to be developed individually, by each participant, that, like TOPS are domain independent. If the course includes open-ended problem solving, it will teach strategies having to do with reasoning simply by force of having to engage in these strategies. If the results of any of this needs to be communicated, strategies for communication will be developed. These three processes, and how to engage in them, should not be explicitly taught. They will be learned by the very best method of all: by having students experience the processes for themselves.

Within the context of a group that is working within a scenario, the issue of human relations comes up quite naturally and must be worked out. Communications would be part of working within the group as well as part of communicating the work of the group to outsiders. Any scenario should have to have enough unsolved problems in it that reasoning would need to take place on a regular basis. The idea is never to explicitly teach these processes within a course, but simply to engage in them during the course of action included in the scenario. However, explicit instruction by experts ought to be available, from specialists, when difficulties arise, handled on an as needed basis.

Though the three processes listed above are critical for any learning situation and are also critical to learn in and of themselves, it is imperative that they not be taught directly. For some processes this is not a problem since they have never been taught directly, thus there is no existing bad stuff to undo. With other processes we are not so lucky. It is common enough for students to be taught principles and theories as a substitute for actually engaging in a process. We see this with the Pythagorean theorem, for example. It is taught simply because it is a principle of mathematics, a mathematical generalization, that students can easily grasp. It is not taught to enable students to do anything. Similarly, students learn facts about language, as opposed to improving how they use language. These ideas are of great importance to schools, since they are much easier to test than the more subjective issue of how well a student engages in a process.

Even when principles are worth knowing, despite the fact that they usually have no practical use, they are extremely difficult to learn without having, in some sense, discovered them oneself. Parents lament that they wish their children could learn from their own experiences, but there is a very good reason why children cannot learn from their parent's experiences. As we learn we generalize from our experiences. Only when these generalizations are grounded in actual cases will our memory of a bad or good result reinforce the rule that has been learned.

We really want to teach students reasoning. But there is a big difference between letting them create their own theories and, when these theories seem to fail, allowing them to consider other "official" theories in order to see if they work, and teaching those official theories directly. In the former case the student's own thinking provides a motivation to learn more. In the latter case, the official theories are objects of learning in themselves. The argument here is that it is simply not important to learn the official theories unless one wants to learn to do physics. But, with children, the goal must be to teach reasoning, creativity, argument, and such, not physics. Every goal-based scenario constructed to teach various skills, must, first and foremost, teach communication, human relations, and reasoning.

The reason learning by doing works is that it strikes at the heart of the basic memory processes that humans rely upon. Human memory is based in scripts and the generalization of scripts. We learn how to do things and then learn how what we have learned is wrong and right. We learn when our rules apply and when they must be modified. We learn when our rules can be generalized and when exceptional cases must noted. We learn when our rules are domain bound or when they can be used independent of domain. We learn all this by doing. In other words, we learn all this by constantly having new
experiences and attempting to integrate those experiences, or more accurately the memory of those experiences, into our existing memory structures. This integration process relies upon new data. This data is provided by experience. When new data are simply told to us, we don't know where in memory to put them because we don't really understand the use of that data. When we experience the data ourselves, we also experience, at the same time, other sights, sensations, feelings, remembrances of goals achieved, goals hoped for, and so on. In other words, we have enough context to help us to know how to characterize what we have learned well enough to find a place for it in memory and we begin the generalization and exception process.

It follows, then, that what we learn when we learn by doing will be details of how to accomplish something in a particular domain (a micro-script); strategies that are independent of domain (process participation strategies); and the cases that stand alone as exceptions awaiting possible future integration into the memory system. Learning by doing works because it impacts all these important memory issues.

**Learning by Doing Versus Learning by Cognizing**

Learning by doing allows for the natural acquisition of micro-scripts that supply a learner with a set of individual or packaged executable procedures that, if practiced, will be of use for as long as necessary. Also, rules of thumb about how to function in the course of various complex processes are acquired while engaging in these processes. We have mentioned, and will discuss in detail later on, the acquisition of cases that serve as exceptions to executable procedures and strategies for behavior while engaging in various processes.

All this leaves open the question of knowledge. Is this all there is to knowing? Is this all there is to useful knowing? If it is the case that the above items are all that can be learned by doing, is there some other method by which other types of knowledge is acquired? Or is the picture of what is acquired in learning by doing still incomplete?

To begin to understand this issue better, let's consider some kinds of knowledge that do not fit easily into the three categories mentioned above, namely, executable procedures, participation strategies, and exceptional cases. To make this easier to think about, below is a list of what might normally be considered to be some knowledge that an intelligent, literate, adult might have that does not readily fit into any of these categories:

- Richard Daley is the mayor of Chicago, following the path set for him by his father.
- Michael Jordan may well be the best basketball player who has ever lived.
- It is the freshness of the fish that matters most in determining the quality of sushi.
- 1970 was a great year for Bordeaux and the wines of that year are still drinking well.
- Kurt Vonnegut was an author esteemed by the children of the 60's who still seems relevant today.
- George Bush used the Gulf War as a political instrument for his own re-election but it didn't seem to help.
- In 1841 the U.S. had three different Presidents.
- The Balkans have been a hotbed of trouble ever since the Ottoman Empire caused one ethnic group
to be divided into two religions.

If you want to get ahead in life, follow your natural instincts and ignore the advice of your compatriots.

One way to get rich is to never spend a dime.

If you want people to like you ask for their advice.

When looking at knowledge of this kind, two issues are: When would one acquire this knowledge? and When would one use this knowledge? One could stretch the definitions of the three types of knowledge acquired in learning by doing to include some of the information listed above, but by and large they would be real stretches. One could argue that these are cases or rules of thumb or procedures, but they seem to be much more like the kinds of static knowledge that people can call up as needed. And therein lies the key to understanding what this type of knowledge is about.

It is important to make a distinction in any discussion of knowledge between that which is implicit and that which is explicit. The types of knowledge that we have been discussing in the context of learning by doing are, for the most part, quite implicit. Most people cannot tell you how to send e-mail or program their VCRs or how to tie a tie or change a tire. It is a lot easier to show you because the memory for such procedures is in the procedures themselves. We do not know how to talk about this kind of knowledge because that knowledge is not encoded in memory apart from the procedure for executing it.

Similarly, while we can tell a good story that indicates an exceptional case that we know, we cannot say exactly why that case has come to mind. The indices that are used are not always accessible. We know we were reminded of it by something that we just heard, and we may be able to make vague references to some of what reminded us of what we knew, but, although the case itself is explicit memory, what we know about the case that makes it relevant is often implicit and difficult for us to actually state. This is why people often tell stories and leave out the point. The point is typically implicitly encoded.

And, in the same way, participation strategies are often nearly impossible to explicitly state. We rarely know how we behave or why we behave that way. We treat people the way we do, communicate the way we do, and reason the way we do, without thinking about it very much at all. When we do try to make conscious our behavior in such situations, we often have a poor picture of what we actually are doing and how others perceive what we are doing. Often we are the last people to be able to say how we thought of something or why we said something or why we treated someone the way we did. In general, participation strategies are entirely implicit in memory.

But the information listed above is quite explicit in memory. We know that we know that kind of stuff, and can call it up at will. But how did we learn it and why would we want to know it? Let's start with the first example:

Richard Daley is the mayor of Chicago, following the path set for him by his father.

It is fairly obvious how one might come to know such a fact. As I write this, I am in Chicago, and simply by virtue of being here, I am aware of who the mayor is. Further, most Americans were aware of Mayor Daley's father when he was mayor because Chicago and the first Richard Daley played a significant role in the politics of the 60's. I feel quite certain I did not acquire either of these facts in a classroom. No one taught them to me, yet it seems convoluted to attempt to make an argument that I learned them by doing.

What exactly would I have been doing when I learned them? It seems obvious to me that two good
choices are either watching television or reading the newspaper. In a broad sense, I suppose, one could argue that watching and reading are something one can do and so I learned these facts by doing as well. However, it seems to me that we miss the real issues entirely by adopting such a stance. The real issue has to do with the way that such material is absorbed into memory. If the way such material is absorbed does not actually matter, then it would follow that the current strategy of teaching facts by having students memorize them would be one that is perfectly plausible. Since I clearly do not believe this to be the case, it behooves me to explain why the method of absorption matters and what that method might have been.

Consider the hypothesis that reading and watching television are, in fact, two ways in which information can be absorbed into memory. I am writing this in the morning, following my normal routine of spending an hour reading the Chicago Tribune and the New York Times. I read a long story on the front page of the Tribune about a small child who died. I do not now recall the name of the child or much about the circumstances of her death. That I remember this article at all is simply a recency effect; it will soon be gone from my memory. There was more than one story on the firing of the manager of the New York Mets and the hiring of a new one in both papers. I read all of them because I am a fan of the Mets. At this moment I could tell you a great deal about this event because I have been following it and I care about it. I do not particularly remember the actual articles that I read, but I can safely say that I have absorbed many of the details of them into my memory. How long they will stay there is quite unclear. The Mets have hired and fired managers before, and while I can probably name most of them, my memory is faulty and the details are likely to be wrong.

I also read in the Times today an account of a murder being tried in Louisiana involving a Japanese student who was looking for a Halloween party and unfortunately knocked on the wrong door. I had seen an interview with some of the murder's neighbors a day or two ago on TV and I was struck with their equating the right to shoot someone who knocks on your door with the American way of life. I have heard about the murder and the current trial on and off since it happened and was interested today in the defense attorney's account of the events that portrayed the Japanese student as acting oddly. It is clear that I have learned something from the collection of articles and stories that I have seen.

In fact, we can learn from what seems to be passive absorption, even if we don't understand exactly how we can or can't do so. The key issue is that we remember what matters to us. In order to understand why we learn what we learn, and how we learn it, we must understand that motivation is a phenomenally important part of the puzzle.

This is not just an issue of simply motivating learners to want to learn something. The motivation of which I speak is internally generated. The kind of motivation relevant here comes from knowledge goals, not externally generated goals (like grades or cookies). In order to make explicit knowledge your own you must have understood the need for that knowledge at the time of its appearance. In other words, explicit awareness of one's knowledge goals is one key to the absorption of explicit knowledge. It is by no means the only relevant aspect of the absorption of knowledge however.

**Acquiring Explicit Functional Knowledge**

Let me introduce here the concept of Explicit Functional Knowledge (EFK), which is knowledge that we know we can use. To put this another way, if you find out the answer to something you have always wanted to know, it is unlikely that you will forget that knowledge. On the other hand, if I tell you something that you did not want to know, that you can find no obvious need to know, it is unlikely that that knowledge will remain with you for very long.

The idea behind EFK is that, parallel to the physical learning by doing that drives the learning of the three
types of knowledge mentioned earlier, there is a cognitive learning by doing that is going on as well. The doing here has nothing to do with physical actions. Rather, it is centered on the mind's desire to build up a functional knowledge base. The creation of this knowledge base is what drives curiosity and is what makes us human. We shall dub this process learning by cognizing.

To better understand learning by cognizing, we must reconsider learning by doing. Learning by doing has, as its core premise, the idea that goals drive learning. When someone wants to accomplish something, they are forced to pay attention to the detailed actions that accomplish the goal. If they want to go somewhere by car, they must learn many details of driving. We have termed these micro-scripts. We know that not all micro-scripts are physical. There is a cognitive dimension to the micro-scripts that we learn. Nevertheless, the goals are physical -- to go someplace, to operate a piece of equipment, to behave properly in a situation so as to get someone to do something that you want.

Sometimes, however, goals are completely cognitive. Or to put this another way, the goal is to know something. Whereas it seems obvious that higher order animals can learn micro-scripts because they too have physical goals, it is less obvious that animals other than humans have knowledge goals. In any case, humans do seem to have such goals. And they often do not seem to be in any way in service of a physical goal. When a small child asks why the sky is blue, he is not hoping to use that knowledge to help him to do something. When I want to know who the new manager is for the New York Mets, I will indeed use that information, but my use is mostly cognitive. I will use that information to help me understand what the Mets are doing, or to converse with other baseball fans about the Mets. The notion of use here is purely cognitive and differs from that of the term use in learning by doing.

Nevertheless, the analogy is direct. Learning by doing works because the natural physical goals that people strive to achieve cause a need to acquire micro-scripts in order to achieve them. These micro-scripts are reinforced by practice and combine together to allow us to become adept at complex physical activities. Similarly, learning by cognizing works because the natural cognitive goals that people strive to achieve cause a need to acquire knowledge in order to achieve them. This knowledge is reinforced by repeated use and combines together to allow us to become adept at complex cognitive activities.

The activities to which I am referring here revolve around thinking and communicating one's thinking. I cannot think about how Chicago is being run if I do not know anything about its government. I can only understand how good a basketball player Michael Jordan was by watching him and comparing him to others. In order to do this I have to care about basketball, or athletic prowess, or excellence or something like that. Caring about such things is a mental activity grounded in the need to know more. Or, to put this another way, learning by cognizing entails asking and answering questions about the observed world in order to come to conclusions about it. Having a knowledge goal means having a question and seeking its answer either by observation or by asking someone who might know.

There can be many reasons to want to know something. One reason might be to supply a cognitive piece to a micro-script to enable you to be able to do something. Another might be to supply a piece of knowledge that will enable you to be able to know something. EFK is of two basic types, therefore. If we need to know something in order to do something, we are talking about physical EFK. If we need to know something in order to know something else, we are talking about cognitive EFK.

The reason to make this distinction and to put it in this way is related to teaching. It has always been easy for schools to identify knowledge that they wish students to have and then to begin a program to impart that knowledge by telling it to them and asking them to tell it back on a test. Similarly, we can make students learn to do certain micro-scripts properly, without giving them any understanding of why they might need such a micro-script, causing them to forget the new knowledge as soon as a test is finished.
When one is talking about learning by doing, the proscription is clear: never teach anyone to do anything that they didn't want to learn to do in the first place. If micro-scripts are acquired in the service of real goals that students actually have, they will not be forgotten.

The same is true of learning by cognizing. We cannot acquire new knowledge unless we truly wanted that knowledge. As in learning by doing, the issue is that goals have to be real. We cannot tell a student something and expect them to remember it, unless they wanted to know it in the first place. Now, it is clear that this is wrong if we take a literal view of remembering. We can force students to memorize information for long periods of time, especially if we give them mnemonics such as alphabetical cues or rhymes. All this does, however, is enable them to tell that information to themselves each time so that they can hear it again. It does not enable functional recall of that knowledge.

Recalling information functionally means being able to recall it at the precise moment that it might be of use, and this entails having learned it with respect to its use in the first place. To ensure that this happens easily the knowledge to be acquired must be learned in terms of its potential use. This is fairly difficult to achieve in school for the rather simple reason that much of what schools want students to know has no actual use. Even when that information does have use, the schools have often long since forgotten what it was. To see what I mean here, let's consider the functionality of the knowledge that I wrote down earlier and see how it can be broken down into the following classes:

Useful for understanding a domain:

Richard Daley is the mayor of Chicago, following the path set for him by his father.

Michael Jordan may well be the best basketball player who has ever lived.

The Balkans have been a hotbed of trouble ever since the Ottoman Empire caused one ethnic group to be divided into two religions.

Useful for making day to day decisions:

It is the freshness of the fish that matters most in determining the quality of sushi.

1970 was a great year for Bordeaux and the wines of that year are still drinking well.

Useful for understanding life:

Kurt Vonnegut was an author esteemed by the children of the 60's who still seems relevant today.

George Bush used the Gulf War as a political instrument for his own re-election but it didn't seem to help.

If you want to get ahead in life, follow your natural instincts and ignore the advice of your compatriots.

One way to get rich is to never spend a dime.

If you want people to like you ask for their advice.
Trivia:

In 1841 the U.S. had three different Presidents.

We shall refer to these knowledge types as domain knowledge, decision-relevant knowledge, life knowledge, and trivia. When attempting to impart knowledge to students, the rules of thumb for how to best do this relate to the knowledge type we are hoping to impart. As with learning by doing and for the same reasons, learning by cognizing is best done within the context of a goal-based scenario. Let's consider these types one at a time.

**Domain Knowledge**

A person wanting to participate in a domain of expertise, city government, for instance, must know something about the subject at hand. This much seems obvious. But when it comes to translating this rule of thumb into an understanding of what should go on in a classroom, it is easy to get confused. Why not simply teach people about the domains they need to be conversant with? Why not simply tell them what we want them to know about city government? The answer is: Because they will learn the information better if they can actually use it. This means we must ask ourselves what uses we anticipate for any domain knowledge we believe students should know.

This question is not always so easy to answer. In our example, a citizen would need to know how to deal with the government on various occasions. To do this he might want to know who his representatives are in government and how he can petition them. Of course, he could always find this out when the occasion arose, again learning by doing. What exactly would be the difference between learning about governmental process in a GBS that allowed one to play roles in a scenario about government, and learning by cognizing with respect to the same situations?

One answer is that the distinction between learning by doing and learning by cognizing is a rather fine one and that they are really two sides of the same coin. One problem with this answer is that it is indeed possible to be an expert on something without ever having actually done anything at all. For example, I know a great deal about history, knowledge acquired entirely from reading and talking about it. I've never studied history formally, have never written any papers, or done anything (not that I know what that would mean for history) in history. But I do know a lot of stuff. Clearly, I have learned this stuff by cognizing, but what exactly does that mean? How can we make that natural process take place in a more formal educational setting?

The answer seems to be that reading and discussing can be all that is actually done and something good can come out of it. I say this with some trepidation since it is this view that is behind all the problems in today's educational system. We all know that reading and discussion works to some extent, and since it is so easy to implement we settle for a school system based on that. So I hesitate to say that it has its place after all. What is its place then?

One of the things that works in school, sometimes, is the attempt to get students to "do the reading" for the next day. In the usual implementation of this idea, a reading is assigned and students know that the class the following day will be based upon that reading. They know that they may be called upon to say something about what they have read during that discussion. For some students this serves as sufficient motivation for reading the material. They do not want to be embarrassed in front of the class. Many students live in fear of being called upon by the teacher, having to answer a question about what they should have read. For some this fear is sufficient cause to do the reading. For others, they devise ways to deal with their fear and avoid the reading altogether.
One would be hard pressed to call the goal of "learning the information for reasons of not being embarrassed" a genuine knowledge goal. But what practical difference does it make? Either way the student reads, discusses, and learns new material, or does he? The claim here is that while knowledge goals can be induced they cannot be required. When I learn about what is happening with my favorite sports team, it is possible to imagine that the scene is much the same as with an assigned reading. I know there is going to be some discussion soon about what is going on with my team and I don't want to be embarrassed by not knowing the latest information. Many people go the latest movies for this reason -- they know there will be discussions of them at parties and such and they don't want to be out of the conversation. Indeed fear of embarrassment can cause many people to learn about their government, literature, history, and many other subjects, simply because they do not want to be embarrassed. Recently, I heard Vince Coleman, a black player on the Mets, say he had never heard of Jackie Robinson. He apparently was not embarrassed by this, but most New York Met fans were.

For most people, avoiding this kind of intellectual embarrassment can serve as motivation in school and out, for wanting to know things. Why does this matter here? When one wonders where knowledge goals come from, one must remember that human beings are social animals. They need to interact with others and verbal interaction is an important part of the social scene. Nearly everyone fears doing badly in such situations, and so they do what they have to to avoid embarrassment. This indicates that there really is a knowledge goal that comes about because of fear of embarrassment. The question we need to address is: "Is there a more positive version of the same kind of knowledge goal?" When does someone want to acquire knowledge for reasons other than fear of embarrassment?

We talked earlier of explicit functional knowledge that is of value in achieving a goal. We know that there is stuff we need to know about how to do things, the knowing of which will help us get what we want. Physical EFK is the knowledge we need to do physical things. But what is avoiding embarrassment? It doesn't seem to have much to do with functional knowledge. What is the function? Avoiding embarrassment isn't much of a goal, nor does it seem to make much sense to talk about the knowledge necessary to do that since that knowledge could be of any sort in any place or time. Nevertheless, people do learn for this reason. The question is, how long do they retain information acquired in order to avoid embarrassment?

The answer to this must depend upon the issue of subsequent use. We have argued against the idea that memorization can be a way to acquire new knowledge. Obviously, we know a person can acquire knowledge in this way. That knowledge will remain with that person for some amount of time, depending on how thoroughly they were drilled. The problem is that knowledge learned in this way is usually only accessible in the way it was learned. Thus, it is not of great use in real life because it was not acquired in relation to any actual activity that might occur.

The story is different with knowledge acquired for the purpose of discussion of that knowledge. No matter whether that knowledge was acquired in order to avoid embarrassment, if it is indeed used in subsequent discussions, then those discussions would certainly reinforce that knowledge and begin to cause new knowledge from the discussion to be associated with it. In other words, we can learn by cognizing and discussion is one way of cognizing. The method used by the schools would be just fine if reading-based discussion allowed continual themes to be followed, allowed time for genuine reflection, encouraged the formation and explication of divergent opinions, and ensured that the initial subject matter was of interest. Let me explain why this matters.

1. **Continual theme:** One thing that differs between my acquiring the latest information on the New York Mets and a student learning about ancient Greece by reading Homer is that I am continually interested in the Mets. I always want to know about them and am not boning up for a particular exam. Thus, I do think about them, have thought about them, and will think about them. The knowledge I acquire about them is
EFK, where the function is thinking about and perhaps conversing about the Mets. When a student who reads Homer does so because he is enrolled in a course in classic literature, he is, unless he is planning on being a scholar of the field, being poorly educated. Here again the problem is traditional courses as opposed to GBSs.

It is very important that any course of study focus on the attainment of a goal that is realistic, achievable, and germane to the interests of the students involved. The GBSs we have mentioned so far have tended to be physical in the sense that the goal was a performance goal that usually involved a physical component. Clearly, there need be no physical component to a GBS. There can be purely cognitive GBSs. Such GBSs would entail the pursuit of a goal that involved understanding a thematically coherent body of material and being able to discuss and argue for some propositions entailed within that material that is germane to one's own goals. Courses like this already exist. But sometimes they are actually quite difficult to differentiate from courses that are more or less parodies of what we have been saying here.

There are, quite typically, many courses in any school curriculum that superficially might look to be in line with what we have suggested for a cognitive GBS. For example, a literature course that has as its unifying theme that all the authors to be read were ancient Greeks, might ostensibly be portrayed as a cognitive GBS. One could claim that the goal of the course was understanding and being able to argue for some thesis or other that stemmed from one or more of the books to be read. The difference between such a literature course and a cognitive GBS revolves around the reasons that the works were being read in the first place. A cognitive GBS would first allow the student to decide what goal he was trying to pursue for which reading these books might be helpful. For example, something a student was trying to understand about life or about history might be the goal. Then the material to be read would be chosen by the student such that that material was germane to the student's goal. The task of the student in reading the material would be to gather what the student needed from the material to help him make a decision, understand a complex issue, or deal with whatever the student's actual goal was. For example, if a student had to make a decision about how the Greek government of a certain period were to be run, he might read the literature of the period in order to understand the issues and make an appropriate decision. In such a case, we would expect the organizing theme of the material to be read to be the issues covered by the material, rather than the fact that all the authors were Greek. Thus, it is the goal of the student that is the organizing theme in a cognitive GBS, rather than the course organizational themes current today in most curricula that group material around some concept of "literacy." Typically such courses concern themselves with attempts to make the student "literate" in some area (like the classics) rather than attempting to get the student to know something he actually may have wanted to know. In other words, if the motivation for reading were not avoiding embarrassment at one's lack of knowledge in a given area, but the honest attempt to know more about a subject matter that concerns you, the results could be quite worthwhile.

This means that the theme of any cognitive GBS would revolve around an issue that was of concern to the students in the GBS, and was likely to continue to be of concern after the GBS was over. We can discuss Greek authors all you like, but if what we discuss is not relevant to the issues with which I am concerned, and if what we discuss never occurs again in my life, and if what we discuss varies wildly from discussion to discussion, I will forget what we have talked about. If, on the other hand, we are discussing issues that concern me, and will continue to concern me, and that build with each additional reading, providing more evidence for varying points of view, I will remember what we have read and discussed.

There are teachers who conduct classes in this way and there are courses that are constructed in this way, typically in English and history departments in some of our better high schools. They are to be commended for doing it right. In general however, even these courses tend to end in the dreaded exam. In a cognitive GBS, the final measure must still be performance, in this case performance in being able to adopt and defend a point of view, citing evidence for one's position. There is nothing radical here. This
method is quite typically used in graduate schools, for example. Domain knowledge is learned in this way. The function of such knowledge is to enable one to think better about a subject of interest. This is the only way such knowledge should be learned, since it doesn't matter what one knows, it matters how one can put together a coherent argument for a point of view.

2. **Genuine reflection:** Any purely cognitive GBS must revolve around the act of reflection. When I listen to stories about Mayor Daley I am considering issues of government that affect me. I might wonder who to vote for; that might be one reason to listen to the mayor talk. But I also might want to have an opinion on a political subject. When a new tax bill is passed and all the people I know are talking about it, I want to throw in my two cents. Part of this may be the embarrassment factor again, but part of it also is a concern for how the new taxes will affect me. I might want to call my accountant and ask his advice, or I might simply get angry and attempt to better understand the political alliances that exist in the country. I might view it all as a giant soap opera that is very entertaining, or as a puzzle to be solved about economics.

No matter why we choose to follow the political issues that are reported daily in the media, the physical performance goal of voting is not all that compelling a reason to spend much cognitive time on these issues. We follow these issues because they are interesting to think about for a variety of reasons. The key point is that we do think about them. Thus, any cognitive GBS needs to allow time for thinking, for working out one's own arguments, for gathering one's own information, and for forming new generalizations. The EFK acquired during such a period of reflection is acquired mostly through reasoning processes. We can hear about Serbian actions in Bosnia, but we must come to some conclusion about them before we can engage in the next important steps in a cognitive GBS.

3. **Divergent opinion:** When reflection has occurred and a conclusion has been reached, it is time to engage in discussion with others. Discussion with others is a key aspect of learning by cognizing. It is very easy to come to conclusions that don't hold water when reasoning on one's own and it is thus very important to test one's conclusions with others and to attempt to poke holes in the arguments of others who have reached opposite conclusions. Again, some schools and courses do allow students to do these things and they are to be commended for that. Unfortunately, there is often a feeling, even in the most enlightened courses, that there is in fact a right answer and that the student needs to be led by the teachers to the place where this right answer can be properly viewed.

The reason that this is problematic is not only that there probably isn't a right answer, but, more important, that a course shouldn't be focusing on the transmission of answers as its goal. The goal of cognitive GBS is not to teach the facts of the domain of interest but to teach reasoning within that domain of interest. The knowledge itself doesn't matter since that knowledge will be acquired quite naturally in daily routines if the learner is both capable of reasoning in that domain of knowledge and has acquired a basic understanding of that domain. That basic understanding should not come from spoon feeding answers or memorization of facts, but from participating in continued conversations based upon reflections that the learner has made on his own. These could only have happened in the first place if the learner was personally interested in the subject and was ready to reflect upon it. Thus, a cognitive GBS must have a discussion period, unbiased by assumptions of what constitutes the correct argument, that allows each student to voice the conclusions reached during the reflection period and to attack those reached by others.

4. **Subject matter of interest:** One real issue in the design of cognitive GBSs that examine a domain of knowledge is the selection of that domain. We cannot simply allow domains to be chosen because they interest the school board, or the college board, or even the teacher. Inherent in a cognitive GBS is the idea that the student had the interest that would drive the domain being taught prior to entering any course. To put this another way, to learn by cognizing, one must be motivated to think about the subject in the first
place. A course in the history of Bosnia might have little attendance in the ghetto, but a course in dealing with violence, which could easily have Bosnia as one of the places under study, might have a great deal of relevance because the students are likely to have already been thinking about that subject.

Since the kinds of facts that make educators proud can be learned within a multiplicity of contexts, the trick in any cognitive GBS is to find a domain of interest that truly excites a student and then introduces cases that are applicable to that domain that contain the material that the teacher feels must be known. Thus, if we want students to know about Columbus, we can design a cognitive GBS that is about exploration, intended to interest students who want to see new worlds, in which they can discuss how best to do that. Within that context accounts of Columbus' voyages can be read. Students would pick up EFK about problems in exploration that would be grounded in a variety of cases of interest to those who feel that knowing about Columbus is somehow part of being an American. Nevertheless, and more important, the students would learn to think about exploration by discussing issues of which they have become aware via reading with their peers.

Day-to-Day Decision Making

It seems obvious that the way to teach the EFK that is part of day-to-day decision making is to allow students the opportunity to make decisions. This argues for the creation of environments in which students make many decisions that they would not ordinarily get to make. In particular, they need to be allowed to make contrastive decisions, that is to choose one thing one day and then make alternative choices the next, in order to learn the detailed level of nuance that is part of good decision making.

An example I cited earlier was in knowing how to select the right year of a wine to order. The trick to doing this is rooted in bad experiences. If everything turns out well, it is difficult to learn much from a decision one has made. To learn to drink wine, and to wind up with EFK about specific years in Bordeaux, one must acquire many expectations and many expectation failures, each allowing one to discriminate better. In order to make proper day-to-day decisions one must know what to expect as the outcome of each decision. To see this in the case of wine, imagine a small baby at its mother's breast. It may not know what to expect the first time it starts to suck, but after a number of trials at getting and receiving milk from its mother, the baby will be quite surprised if one day it gets chocolate milk. A baby would cry in this situation, not because it wouldn't like chocolate milk, one would suppose it would, but because of expectation violation. Children learn to adapt to all kinds of things by noting expectation failure and adjusting to it. A baby may cry the first time it is exposed to something new, when it had expectations to the contrary, but the baby will quickly adapt.

Let's imagine that instead of chocolate milk the baby suddenly finds itself drinking Chateau Mouton-Rothschild 1966. No one will find Mouton-Rothschild to be a great wine if it is the first wine they have ever drunk. Before you can discriminate great wine, you have to have first drunk wine. Very few of us drink our first glass of wine and rave about the experience. Wine is, after all, not what you expected. Few of us like our first taste of wine or beer or anything alcoholic, for that matter. We all know that we have to learn to develop a taste for such things, but what does it mean to "develop a taste?" The first time we have a new experience, we only have prior experiences to work with. If we want to learn important discriminations in a taste, for instance, it is helpful if those discriminations are rather on the fine side. If the discriminations are rather gross, then little will be learned from the connoisseur's point of view. If everything happens the way you expected it to happen, you may well be happy, but you won't learn a thing.

Many young people get their first taste of alcohol in college. They drink beer indiscriminately, taking whatever is offered. They often don't wonder if they liked the stuff, they are not drinking it because of the taste. What should such a student expect? What is the beer going to taste like? What can we predict about
what the student might be thinking before he tastes his first beer and what would you predict that he
might think afterwards? These are very important questions for understanding EFK because knowledge is
only built upon prior knowledge.

The novice beer drinker could only have had one of two basic expectations. Since expectations come
from prior generalizations, we can only expect what we already have experienced. We have to have a
basis of comparison, and this comes from the prior experience that we have chosen as the best
expectation we can muster at the time. One might guess, for example, that this student would expect that
either beer tasted like soda, the thing it most resembles physically in the experience of a student, or it that
it tastes like some other alcoholic experience, such as wine drunk at a religious ceremony.

Some of the expectations that such a student might have would be quite reasonable. For example, he
might expect a liquid, for example, perhaps a non-poisonous, possibly slightly nourishing liquid,
probably a refreshing-on-a-hot-day kind of liquid. When I drank my first beer I remember being surprised
that it was bitter and wasn't sweet. What kind of criticism is it of beer to say that it isn't sweet? All
alcohol had been sweet before in my experience, so I expected sweet.

Every time we experience an expectation failure, we need to explain it so that it doesn't keep happening.
You can't go through your life always expecting there to be a parking lot on the corner of Fourth and
Maple. The day they start construction on a new office building on that corner, you must decide whether
this is temporary, like a carnival - maybe it will go away - and if it isn't, you begin to update your
expectations. No elaborate explanation is needed; in fact, we can explain it simply by saying to ourselves
that, yes, buildings do tend to get built where parking lots once were. But when they tear down a
beautiful old house to make way for a parking lot, a slightly more elaborate explanation must be
constructed, one that talks about the insensitivity of our times, perhaps, or maybe one about the money
needed to repair a grand old structure is just too much for anyone. But when expectations fail horribly,
when beer just doesn't taste anything like Coca-Cola, we have no explanations that are satisfactory. What
can you say? Beer just isn't Coke, and it isn't sweet wine. When this happens, we create a new category.

Once that is done, we are on our way to becoming an expert. The next time someone serves us a beer, we
can announce proudly that Miller just doesn't have the flavor of Budweiser. In fact, pronouncements like
that, made by amateurs after having had only two beers in their life, are usually quite accurate. You
remember your first beer and can easily distinguish the taste of the second from the first. After having
drunk hundreds of beers of many different sorts, it becomes harder and harder to distinguish one from the
other. You just have too much information. Unless, of course, you are paying attention, careful attention.
You have to care about what you are going to learn in order to learn anything at all.

Now imagine such a new expert beer drinker, tasting his first glass of champagne. He should expect
something beer-like. Champagne even looks like beer. Now suppose that the champagne drinker likes
champagne a great deal and drinks a lot of it, getting drunk and then later getting sick. What can the
student learn from this experience? One serious problem in learning to make day-to-day decisions is
understanding the results. Deciding which generalization to make, and thus which new expectation to
generate, when one is dealing in a complex environment, requires knowing more than you actually can
know on your own.

Suppose that we go to eat in a fine restaurant that serves Thai food. You have never eaten Thai food
before, you like the meal, but the next day you are sick. Should you avoid Thai food in the future or just
that restaurant or just squid, which you ate there for the first time? Or should you never go out to eat with
the people who took you to that restaurant? In real life, we have no easy answers to such questions. In
science, we can run an experiment and control the variables. You can eat at another Thai restaurant, you
can go back to the same one and avoid the squid, and you can also go out to another restaurant that is not
Thai with the same company. But you are really unlikely to do all this, and even if you did, it would prove nothing. Suppose you got sick at the non-Thai restaurant. Does that really mean that the company made you sick? And suppose that you ate the squid, and it was okay. Does that mean it was okay the first time, too? Being scientific in real life is very difficult, and, in fact, none of us tries to be. We just make the generalizations that we want to make anyway.

It takes some time to make an expert on anything. To make a wine expert out of our novice beer drinker one would have to expose him to some wine of any sort and then, gradually, keep adding new information. We still can't give him Chateau Mouton-Rothschild because although he might notice the difference between some table wine and the Mouton, he wouldn't know what he was noticing. Our beer drinker, even one who now likes wine, too, wouldn't notice anything about the Mouton other than that he liked it. Changes in expectations cannot happen overnight. In order to get ready to appreciate the Mouton he needs to create complex knowledge structures that pertain to wine. Contained within such structures are the detailed expectations about smell, color, and various aspects of taste that one must compare and contrast in order to come up with a new idea, a modification of the existing expectations within the knowledge structure. New ideas are inherently modifications of old ideas.

Being able to add new information without regard for the old information it replaces might seem appealing on the assumption that we have empty spaces in the mind that would somehow be filled up by the new stuff. But how would we ever find the new information we have just added? For information to be useful you must know how to find it.

Imagine adding a new book to your library. You might as well not own it if you place it somewhere and forget where. In a small enough library, you could count on stumbling upon it, but as the library got larger, it would be necessary to have an effective indexing system that would allow you to find something on the basis of some scheme connected to important information about what is contained in the book, such as its author or its subject matter. Similarly, a new fact must be placed somewhere in the mind. People are not usually aware that they place new facts, experiences, ideas, and such someplace in memory, but in a metaphorical sense, they do. There may not be actual spots where one can find George Washington, but there has to be an indexing scheme that allows one to hear "President, wore wig, had wooden teeth, chopped down cherry tree" and to know instantly who we are talking about. But how does this work? Labels such as "wooden teeth" are indices used by the mind to retrieve information.

In order to appreciate and detect the differences in Mouton Rothschild one must have a place to put that information. That place would need to stand in relation to other places that store information about wine and would be in terms of features of the wine that were be gathered over time by lots of tasting. The effect of this tasting is to gather together a set of features that are of use in day-to-day decision making that are grounded in actual experience. The value of all feature collection is to be able to say, when tasting a 1959 Mouton, that it is better than the '61 but not as good as the '59 Latour. Of course, you might not care enough about wine to say this, nor have enough knowledge to say it, but if you both cared and had the relevant experiences, you would want to be able to say it. The only way to do this is to be continually re-examining and re-using the features that you have previously used. To do this, you must have myriad expectations and be able to deal with the failure of those expectations. When expectations fail, you must be able to explain why. This is the basis of learning. If you want to know how 1959 Mouton-Rothschild tastes, therefore, drinking a bottle of it isn't all you need to do. You need to work up to it with lesser wines, taste both younger and older wines, taste wines of the same year of chateaus of equivalent quality, and taste other Moutons. If you fail to do this, you will taste the wine, but you won't learn a whole lot from the experience.

In order to get good at making decisions then, students need to make a great many of them. A cognitive GBS must allow students the opportunity to make numerous decisions and to discuss those decisions with
other students. The purpose of the discussion is to encourage the collection of features and ways of
talking about those features that help one discriminate between choices. Students must not only be
allowed to choose, they must also reflect on why they chose the way they did. To do this they must be
able to defend their choices and to do this they need to be able to articulate the features of a situation that
caused them to make the decisions they did

**Understanding Life**

Teaching the EFK that is part of understanding life is rather complicated. One problem is that unlike
domains of knowledge discussed above, there is little agreement on the facts. Another problem is that
unlike day to day decision making, there is no program of ordered decisions that can be gone through to
arrive at nuances of knowledge. For example, let's return to the two adages cited above:

*If you want to get ahead in life, follow your natural instincts and ignore the advice of your compatriots.*

One way to get rich is to never spend a dime.

They are both neither true nor false, and neither can be learned in any ordinary sense of learning.
Nevertheless, people feel that they "know" such things and that they were learned in "the school of hard
knocks."

It is fairly obvious that generalizations made over the course of a lifetime about strategies for success are
not likely to be best taught in a short course that proposes to simulate life conditions. Any such course
would be naturally slanted towards the generalizations that the teacher wanted made and would thus fail
to teach the key issue. The issue with respect to such generalizations is not knowing them but making
them. You can have opinions on what makes for a happy life, or healthy children, or great wealth, or any
other subject which has been reduced to myriad proverbs, and I may have a different opinion. There are
no right answers in this regard. There are only beliefs that individuals have and beliefs that various
subcultures have. What is important is learning to make these generalizations in the first place, or to put
this another way, to observe life and learn from it.

Put this way, it seems clear that the teaching issue here can be addressed by having students reason about
situations and discuss their conclusions with others, defending their points of view. The discussion would
need to revolve around the rationale behind those generalizations, not around the generalizations that
were formed by a student. The lessons are in the reasoning processes themselves, not in the biases and
belief systems of the participants. As it turns out, a good venue for doing this is the reading of literature.
But I say this with some trepidation.

The problem is that literature courses invariably are taught with respect to issues of writing, appreciation
of classical authors, detection of themes of various time periods, and deconstruction of the text, among
other things. I am suggesting that literature (and for that matter, movies) has value in the presentation of
life situations and the possibility for discussion of what the right course of action might be in those
situations. In other words, in a course in "life" one needs to discuss issues that come up in life. The best
way to do this is to experience life vicariously in a variety of formats and situations and then have the
teacher, who would be a "reasoning teacher" in this case, not a literature teacher, help students formulate
points of view about proper courses of action and about life themes. This process happens quite naturally
out of school all the time. When teenagers discuss movies they often dwell on life themes, but without
guidance and in the non-intellectual stance often taken by teenagers, they might dwell on the baser issues
and not learn as much about life as they might with the help of a teacher.

The same course of action pertains to business. There are fewer business movies and less business

http://cogprints.org/635/0/CBRMeetsLBD_for_Leake.html
literature, but there are some examples of these genres. Even so, there are classic business cases that students often consider for reasons different than we are discussing here. What we are suggesting is that general business themes are best taught by seeing examples rather than by preaching. Thus, when a company wishes to teach its employees that honesty is the best policy in business, they tend to preach it. But teaching is better than preaching. Teaching in this case means allowing students to read about or see depictions of sample situations that illustrate possible courses of action and then allowing them to discuss the possibilities. To some extent this is done in business ethics courses today, but often these revolve not around reasoning the right course of action but learning the fine points of the law.

**Learning from Experience: Case Acquisition**

We learn micro-scripts when we learn by doing; we learn participation strategies when we participate in a process; we learn explicit functional knowledge when we learn by cognizing; and in each of these three types of learning we learn cases. While it may seem that knowledge, strategies, and micro-scripts are critical aspects of what we know, and they surely are, they do not have the overwhelming importance in the formation of unique individuals with distinct personalities, opinions, and reasoning abilities as does the acquisition of a case base.

When people are confronted with new situations they tend to attempt to see them as old situations, ones they have dealt with previously, so that they can copy behavior that has worked for them in the past. Typically, this sort of case based reasoning tends to be a version of the old concept of a script. When one has been in a restaurant many times before, one needn't ask existential questions about what to do next or why each role player is doing what he is doing. Scripts save processing time and energy. We do what we have done before. The difference between cases and scripts is really just one of the overarching generality and ubiquity of the script. Everyone has more or less the same McDonald's script because the world over one McDonald's is like another. We can assume that our knowledge about how to operate in them is not individualized in any interesting way.

I cannot assume that everybody has the same Lutece or Taillevant scripts, however. Most people have not been to these places. However, if they did eat there, their behavior would only differ from each other in small ways. The fancy restaurant script can be inferred rather easily, and most people can adapt their prior restaurant scripts to help out. Thus, when a particular script is unavailable, the usual strategy is to find the closest possible script and use it.

The distinction between cases and scripts is not that great. The reason for this is that when a new situation is encountered, and the best possible old script is used to help out, the understander will still recognize that a new situation has been encountered. So, when our first time diner at Taillevant has to resort to using the script that he had for the best restaurant in his home town to help him understand how to behave, either one of two things will happen. Either he will find that certain stuff works (e.g., "You will be handed a wine list and will be expected to order wine which will be poured out for the orderer to taste first") or he won't. When his rules fail (when he sends back the chocolates that arrived with the coffee saying he didn't order them) he will begin to acquire a new case.

People acquire new cases because the old script they were using didn't work all that well. We would expect our first time diner at Taillevant to remember and tell the story of his dining experience. Further, we would expect that, if he should find himself at Taillevant again, he would not make the same errors he made the first time. He would have learned from experience. Learning from experience manifests itself as the acquisition of a new case which has been added to memory.

Two questions that can be asked at this point are: Where in memory is that case added? and What form does the case take in memory? These questions matter because their answers will tell us how learning...
from experience actually takes place and what kinds of learning from experience can take place.

When a script is being formed in memory, it owes its existence to repetition and continued use. No script is formed when a given behavior is done only once, or in any case done quite rarely. Further, even if there is a great deal of repetition, lack of continued use would kill the script. (How many people could go back to sixth grade and recall the classroom routine that was at one time a script for them?) Since repetition and continued use matter so greatly in script formation, it seems obvious that at the time of the initial encounter with a new experience, memory could not possibly tell the difference between a script and a case.

Thus it stands to reason that scripts and cases are the same thing as far as processing of new information is concerned. To put this another way, human memory is full of processing structures. These structures tell us what to expect next from other people who are acting in a situation and what to do next in response to those actions. We have described in Schank (1982) how MOPs are formed as containers for aspects of such processing structures such that larger structures can be put together from smaller structures. Thus, knowledge of how to act in a fancy restaurant comes from what we know about paying, ordering, tasting wine, and so on, some of which are particular to fancy restaurants and some of which come from what we know about contracting for services. The MOP is an organizer of scenes which contain the processing rules for particular situations.

But where do cases fit in this scheme? In Schank (1982) we said that cases were found as wholes when they were labeled (or indexed) by TOPs which were explanations of situations that were couched in the language of goals and plans (see also Schank (1986)). Also, we indicated that cases were sometimes stored as exceptions to expectations within scenes in a MOP. Thus, cases are to be found in two places in memory in the scheme presented in Schank (1982). First, they are inside scenes, stored as exceptions, waiting for confirmation that their exception was normal and that they should be generalized into new scenes or new parts of scenes. Second, they are labeled by TOPs, stored in terms of certain goal interactions, and planning situations that might occur.

What does this tell us about learning? Obviously, learning takes place when an existing memory structure needs to be modified. We learn because some processing structure got it wrong, that is, an actor did not do what was expected of him, or an action we did turned out badly (or unexpectedly well).

If we learn by modifying memory structures, then it stands to reason that we cannot learn anything much if we do not have processing structures to modify. In other words, we can only learn a new case when the old case we were using for processing turned out not to work. Since expectations need to fail in order to acquire a new case, we need expectations in the first place or we won't learn much. Since expectations only exist inside scenes in MOPs and inside planning strategies in TOPs, and these are derived from previous cases, a clear educational strategy emerges.

Any educational scheme must focus on creating expectations in the mind of the learner and then presenting cases which cause those expectations to be modified. Since the expectations that are critical here are those contained in scenes in MOPs and in planning strategies in TOPs, it is clear what must be done in any learning situation. In order to learn a new case, a similar case must already exist in memory. Further, that case must make a prediction about what will happen, which turns out to be wrong. The new case can then be understood in terms of a partial match to the old case and in terms of explanations that need to be created by the learner to account for the differences between cases. In other words, there is an art in presenting new cases to a student. New cases must follow in a particular way from previously presented cases. They must modify expectations built up by the prior case. There can be no new cases without prior partially matched cases.
The reason for this comes from the two questions cited above. Where do we put a new case? The answer is that new cases are stored in relation to the aspect of the old case that failed. Since a new case needs to be stored in memory in order for it to be learned, we would hope that it would be stored someplace where it could be found some other time. This can only happen when cases are stored in terms of expectations that are activated by situations. If a case is stored independent of an expectation linked to a situation, nothing would cause it to come to mind during active processing.

The second question above was: What form does a new case take? The answer is that it simply copies most aspects of the old case from which it was derived and adds an exception that is true under certain circumstances, and it notes those circumstances. Thus, it has the effect of causing detailed discriminations in expectations to be made that allow a learner to detect nuances of difference in a complex situation.

The lesson for education here, then, is that one can only learn from experience if the experience one is having is strongly related to an experience one has already had. Since so much of education fails to understand this key point, and since allowing students to learn from experience is so critical to education, we shall now explain carefully exactly under what circumstances learning new cases from experience can work and under which circumstances it will not work.

While educators often understand the significance of presenting cases to their students, they often fail to understand the significance of the ordering and timing of the cases they present. So, business and law schools which use case methods of teaching fail to recognize the errors they make in case selection, case size, case ordering, and other factors that severely affect students' abilities to absorb the material. The goal, after all, is that students remember the cases, storing them in a way that assures their retrieval at a relevant time later in life. In order for this to happen, particular attention must be paid to the memory issues that mitigate their absorption.

The key error that most case-organized courses make is the preference for temporal ordering over thematic ordering. Temporal ordering of cases occurs when cases are presented in a serial order determined by the time in history when the case actually occurred. This is the worst possible ordering of cases that could exist because it totally ignores the issues of partial matching of prior cases that enables new cases to be stored in terms of the expectation failures of old cases since no expectation failures occur.

Creating properly organized courses based on cases depends on making sure that each case sets up the next. That is, every case needs to provide its understander with new expectations, some of which fail in subsequent cases. It is easy to misunderstand the concept of cases setting up cases. Why couldn't the case of what happened in 1810 set up the case of what happened in 1815? Isn't that one case setting up another? Of course it is in the temporal sense, but it might not at all be a set up in the thematic sense. The issue is whether the material in the second case builds on the expectations set up in the prior case by confirming some and violating others. This distinction, between cases that build on each other and those that merely follow each other, is central to the goal of having a student will remember not only the cases but also the principles those cases exemplify.

There are many possible orderings of cases and decisions on what makes cases appropriate besides temporal ordering that are of concern here. In general, any syntactic ordering or selection criteria (e.g., one from this type and one from that type, or all the cases that involve fire engines) will make for a course that violates the principles that underlie memory's ability to absorb new information. The ordering and selection must be made according to the following maxims:

1. No case before its time
2. Any new case must violate expectations from prior cases

3. Cases should relate to actions

4. Cases should have the potential to change behavior

We will now consider these maxims one at a time.

1. No case before its time

It is tempting to tell children stories that are of general interest. Thus, one can tell of George Washington
chopping down the cherry tree or of Paul Revere's ride because these are stories of the culture to which
children can relate. But when we consider that we are trying to do more than entertain, such stories need
 to be more than simply appealing to children. They also must be germane. The question is, of course,
germane to what?

Perhaps the best way to illustrate the issue here is with reference to the story "The Boy Who Cried Wolf." Typically, parents tell this story when a child has complained about some actions on the part of another
child when it turns out that there really wasn't much of a problem and the complainer had exaggerated or
just plain lied. This story is not such a fascinating story, and probably is told by parents at just the time
that they perceive that it is needed.

This pattern of just in time story telling is one that parents and teachers know to be the right thing to do in
ordinary life situations, but it is violated all the time in educational settings. This happens because
someone simply wants to tell a story for some reason, or more commonly, because that story has been
mandated to be told by some curriculum committee as some specified time in the school year. When this
happens two bad things occur.

First, the listener is often bored. Frequently, listeners find themselves distracted when they have no need
for what they are hearing. One must be ready to hear a story, to receive a lesson, or to read a book. The
same message told before its time is often completely ignored by a person who might revel in that story at
some later time (or might have loved it at some earlier time.) If we want listeners to remember what they
are being told, they must want to hear what they are being told. "Want" means in this case, the presence
of an active expectation, question, or curiosity about some life strategies that happens to be addressed by
the new story (or case).

The second problem is that the listener, having no clear need for the story, is left to determine the point of
the story for himself. This means that a listener is left thinking about why George didn't like trees or
wanted to eat cherry pie, or why Paul Revere didn't use his car or what the roads were like in those days.
While it is fine for listeners to speculate on aspects of a case that they find interesting, the intended
"lesson" of the story fails to come across and, more important, the entire story is unlikely to be
remembered at all unless the listener does a remarkably good job of creating his own idiosyncratic lesson.

This same problem occurs in business situations when a classic case is told to an audience that could not
possibly appreciate its point. Left to memorize the point, the trainees have no clue what to do with this
memorized point and they fail to link it to actual behaviors that they have had on the job. Sometimes they
cannot do this because the company that is training them is giving them training prior to their doing the
job, which considering what I have been saying here is absolutely ludicrous from a memory and
expectation point of view. How can they learn something that relates in no way to any expectation that
they have ever formed? But even when expectations have been formed and when a trainee has worked on
the job, the new cases that he hears about often relate to situations in some future job for which he has no

http://cogprints.org/635/0/CBRMeetsLBD_for_Leake.html
expectations. The trainee is thus left with cases and no place to put them, which means he will soon forget them.

2. Any new case must violate expectations from prior cases

The particulars of what case is best presented when are important to work out. The right thing to ask about the right time to tell the cherry tree story is, "After what case should the cherry tree case be presented?" One possibility, a very good one indeed, is that this (and all other cases) are presented only after the listener has taken some action that shows he is in need of the case (lying, in this example). This point shall be elaborated further in the next maxim. Here we address the issue of what to do when the only medium available is the presentation of cases.

The ordering of cases in a continuous presentation of cases requires that each case address some expectation in a prior case. Put this way, the cherry tree case would have to be presented after a case about lying and getting away with it if it were part of a course on honesty in relationships. Or it could be presented after the case of Cain and Abel if it were part of a course on managing hostility in children. I am actually not trying to make a joke here at all, but rather to bring up a significant issue. There is no way to say when the cherry tree case ought to be presented in the absence of an understanding of what kind of course it was a part of. What is absolutely wrong is that it be used as a case in American history since it tells us nothing whatever about American history. It might be part of a course in Washington's character. This could be useful in setting up expectations about his honesty that might be built upon or violated in a subsequent story about his adult behavior, but I have never heard such a story and certainly have never heard of it being told for that reason.

This bears on the ideas brought up earlier of the thematic organization of cases in a course. Cases cannot be easily remembered if they are not part of some organized set of expectations about a certain class of behaviors. It may be appealing to tell Paul Revere and George Washington stories to children who may well respond to them as children respond to any well told story. But if we want children to remember what they have been told and put that story to use in some way, they need to be told with some coherent themes in mind, building each new point on an expectation set up by a prior case.

3. Cases should relate to actions

Of course, the best teaching relates to actual behaviors, not passive listening. This is what learning by doing is all about. Not all learning can be learning by doing, but when possible this must be the first method of teaching. This does not mean, however, that cases must only be actually experienced to be learned. We can absorb cases that are told to us if they are told at the right time. The question is, "What is the right time?"

Expectations are created by both cases and by behaviors. When you see a man enter a store with a gun in his hand, you expect a robbery. This is somewhat different from reading about the same situation. You still expect a robbery, but you are not afraid and are not wondering what you should do next. The prior situation is, of course, far more memorable. Nevertheless, one can tell a case in either situation. Ideally, in a teaching situation, we want to set up the robbery with the student as a player in the scene so that it feels real. The more real it feels the more memorable it will be. Then, any teaching we wish to do involving a new case can be understood in terms of the case that has been set up in a realistic way. The listener is ready to hear about the second case after experiencing the first. In some sense, the second case will be remembered as part of the first, so the more memorable the first, the more likely that the upcoming case will be remembered as well.

4. Cases should have the potential to change behavior
This maxim is, of course, quite critical. Learning is about behavior change after all. Thus, what we need to do is remember that when a case is told (after a doing experience, for example) we want the listener to have to act upon the lesson of the new case immediately. That is, if the case being told is how someone died in a robbery attempt because they threatened the robber, then we want the next experience to cause the learner to have to make a decision about how to deal with the robber. Or, to put this back to cherry trees, if there isn't a situation presented where the learner needs to choose between lying and telling the truth the lesson will be lost.

It follows from this that cases must be followed by actions of some sort. If the actions are purely cognitive, and all a listener needs to do is say what he would do, we run the risk of having students parrot right answers independent of real visceral decision making. Students can learn to say the right answers but can they learn to do them? This can only be found by alternating cases with actions in some way.

**Conclusion**

Learning by doing works because it teaches implicitly rather than explicitly. Things that are learned implicitly need only be experienced in the proper way at the proper time. In order to make classrooms into learning-by-doing experiences we need to allow students to be in situations that are germane to their interests.

What students learn when they learn by doing often remains implicit. Micro-scripts, participation strategies, explicit functional knowledge, and lessons from cases are often the kind of knowledge that people don't really know they have. The knowledge comes up when they need it and people can sometimes explicitly state what they know. Educators are often confused by the fact that people can explicitly state what they know. In fact, they are so confused by this that they pervert the education system so that it will highlight the explicit stating of what one knows rather than highlight the behavior that would indicate the presence of implicit knowledge. We must turn this state of affairs around if we are to ever really change education.

**References**


