Learning to Learn

What's the only edged instrument that gets sharper with use?

The same one that solves every problem you're ever going to solve. Here are a few ways to keep yours honed keen.

The car finally rolls out the door and down the road, days late. Ate your lunch? Ha! It was one of those killers – time and money killers that come along every once in a while, the kind that make you think better about a career driving trucks or wielding a spatula. For several days you dreaded arriving at work just to see it still hulking dead in the workbay. It was a nightmare problem, of course, and one that will never fool you again, that's for sure! Of course, you'll probably never see that same problem again, either. So the real question is how you can learn something from this experience to help you when the next nightmare car rolls into the shop? How can you turn this last time and money loss into some sort of gain, at least a learning gain for the future?

Can you expand what you learn from these kinds of hair-pulling problems to help you not only with the unlikely case of a repeat of the same automotive glitch, but to learn as much as you can about the best ways to approach unpredictable and difficult technical problems across the board, wasting minimal time and coming up with the correct diagnosis at least most of the time? There is no magic recipe, of course. Every carmaker has a few nightmare cars in a secret back lot, bought back from purchasers, cars that the service engineers couldn't fix, either. You've already seen how often (almost always, actually) trouble-trees lead nowhere useful, missing the real problem because they left out the fundamental point: understanding how the system works. But what *can* lead to a solution?

Every problem-solving diagnosis is learning for the diagnostician, even when you don't succeed. And the shop is a fantastic classroom in which you are paid to learn. With a car in your bay and your tools at hand, you are Sherlock Holmes with a wrench, Einstein with an oscilloscope, an investigative scientist and a theorist. The work is not always (not even often) easy, but it wasn't for them, either. It takes a level of concentration and a capacity to shoulder frustration aside that few other jobs require. Frequently it's also true neither the customer nor your shopowner will understand the diagnostic work you've done. But the results will be apparent, with or without their understanding.

Learning to Learn

This is the first of several articles in which we'll explore several ways to observe what you've done right and wrong in a given procedure, and even more important, what successful conceptual tactics you've followed to get where you did, so you can cultivate them again. The object is to look back over the more difficult diagnostic jobs with a 'cold eye,' an eye that can distinguish between a mere lucky guess (luck you can't count on again) and a reasonable hypothesis that turned out right (reasoning you *may* be able to use the next time). If the last green car in the shop needed a main relay, this doesn't have the foggiest connection to whether the next green car will need that part or not. But if the last no-start in the shop got gas at a specific station just before the engine died and here on the hook comes another with a load of the same fuel from the same place, there may be a connection.

These are some of the major elements of a learning-to-learn process. The first one, since we're not talking about beginners here, is the body of knowledge we already have, our existing knowledge. Except when we're bragging to friends, we're always inclined to underestimate just how extensive this is. Even when faced with the most intractable diagnostic problem, however, we really understand much more of what is going on than we don't understand. Otherwise, we wouldn't have any idea what the machine was supposed to do; we wouldn't even be able to make guesses ('toot the horn to check the battery,' 'check the gauge for gas') about any possible failures. We need a certain fairly high level of background knowledge just to know the system *isn't* working – namely, we know what it should be doing when things work together properly.

So our first and often best effort to fit the problem into diagnostic categories comes from our background existing knowledge. The engine won't start? What do any of us do for such cases? We check for cranking, spark, fuel and compression. We do these (usually in that order, too!) because we know both from theory and from experience that most no-starts will yield to these avenues of diagnosis. We know every engine requires certain qualities of cranking, spark, fuel and compression if it's to run at all.

The problem with our existing knowledge, then, is not so much that it's limited. Of course it's limited — everybody's knowledge is limited! The problem is that we don't access the right parts of that knowledge when facing the problem, parts that will illuminate it as much as we can and show us (by the 'dark' patches we don't understand) what we still need to learn.

'Volts'

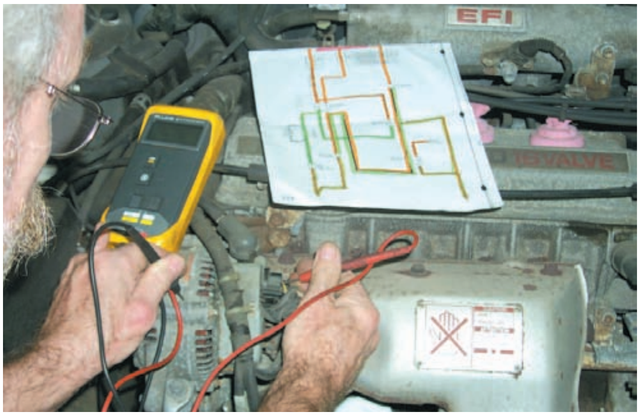
'Amps'

'Ohms'

Ohms Law: *You already understood it, even before you first heard of it.*

Let's take the electrical principle we know as Ohm's Law. Everyone groans when you mention it because we start immediately thinking of the famous equation and its mathematically equivalent notations. But that's just an orthographic formulation of Ohm's Law; it's not the law of nature itself. Suppose you knew nothing about the flow of electricity in circuits, but you did have the ordinary background knowledge all of us pick up as we grow up.

In particular, we know about garden hoses, controlling their flow by putting a thumb over the tip or kinking the hose, affecting and how much and far they squirt. We don't know any equations about garden hoses, or at least we don't need to. But here are some things we do know: If you want to fill a bucket as fast as possible, that is, draw the most water in the least time, you just put the hose in the bucket and keep your thumb off the end altogether. Water pressure in the hose is next to zero (except for the unavoidable fluid friction resulting from the hydraulic drag from pushing water through the rubber), so the force is at a minimum while the quantity is at a maximum.



Planning out your course of diagnosis will not magically find problems faster, but it will eliminate useless wild-goose chases from guessing and hoping. When you plan the sequence of tests you'll run, you base your procedure on an accurate understanding of what conditions are required for the system to work correctly. By tracing that essential path, you'll certainly find the subsystem that's failed. Then pinpoint tests will zero in on the fault.

Now suppose we want to squirt the water through the air as far as possible: We cover the end with a thumb and restrict the flow as much as possible short of cutting flow off altogether. This increases the pressure of the water in the hose (and against the water side of the thumb); it reduces the volume delivered to a minimum; and it maximizes the delivery speed and thus the squirted range. Similarly, if we kink the hose, the amount of flow will decrease, and there will be a higher pressure on the upstream side of the kink.

Ah, you might think, everybody knows that. We learned it as kids, horsing around in the yard. Big deal! Well, that's Ohm's Law, by waterflow analogy. You don't get the quantitative calculations, but you could with the right sorts of gauges and flowmeters. The pressure of the water and the distance it will squirt, corresponds to volts; the quantity of flow, in gallons-per-minute, corresponds to amps; the tightness of the kink pinching off some or most of the flow corresponds to ohms (resistance). Turns out, you see, the basics of electric circuit flow was something you and almost everyone already understood long before we heard of Mr. Ohm.

The equation, first put forth by Ohm, depends on the concept of the interrelated parts – volts, amps and ohms. And that correlates exactly to the analogy of water flow through a hose. The electrical equation works out so elegantly because Ohm got there first and defined volts, amps and ohms in terms of one another, so they calculate together handily – one volt drives one amp through one ohm. Gallons, pounds and inches were quantitative concepts long before and completely independent of the invention of hoses, so calculating with them is much harder. Similarly we could, for instance, calibrate speedometers in furlongs-per-fortnight, but we're already used to miles and kilometers and hours, so it would just be inconvenient, not useful, to change the units of measurement.

If you've ever worked at a shop that specialized in German cars, you may remember how their internal technical literature often describes fuel economy not in "miles (or kilometers) per gallon" but in "liters per 100 kilometers." The simple and powerful concept of fuel economy is the same under either description, but in the one case, we're talking about how far you can drive on a fixed quantity of fuel and in the other about how much fuel you need to drive a fixed distance. Even though the numbers for these two measurements correlate 'backwards' (you'll need *fewer* liters-per-100-kilometers in a car that gets *more* miles-per-gallon), this is the same concept of range or fuel economy in each case. Any difficulties attach not to the concept but to the notation.

Writing Your Own Diagnostic Script

So using this background knowledge, here is a practical way to optimize your diagnostic effort this time and improve it later: As soon as you suspect you have a car with a more complex problem than usual, take a moment to jot down what you think is the best sequence of tests to perform to identify the fault quickly. You're not locked into your notes, of course. If in the course of your tests a lead turns up that seems more fruitful to pursue than the next one on your list, follow that one instead, just noting it down. It is surprising how much difference it makes to have a written plan of action at your side, giving you a sense of what you've done and what you still have to do.

When the car is finally complete, properly diagnosed and repaired, go over your list and evaluate the steps you took. What this will do is to improve your skill at planning these diagnostic sequences in the future. You don't just eliminate tests that didn't solve the problem: checking for spark on a no-start is still a good idea even if you solve half a dozen no-starts with no spark problems among them. Other tests, like taking a fuel sample and letting it settle in a beaker, do sometimes lead to a solution but are hardly among your first tools out of the box unless you live somewhere with really bad gasoline.

What you're doing with these procedures is sharpening two skills at once: your basic automotive diagnostic tools, hardware and software (tools and brains); and your ability to determine what kinds of tests you need to run in which order, what you might call your strategic diagnostics. We'll talk more about those in future articles in this series. ■

— By Joe Woods
based on concepts from Jorge Menchu