Teaching Troubleshooting and Problem Solving in EET

William F. Reeve
Purdue University

A recent survey of more than 100 books in the local university library, dealing with troubleshooting, revealed that the overwhelming majority address electrical or electronic problems. Relatively few of them deal with problems in a mechanical, a chemical, a biological or any other system. Most of them approach troubleshooting as a *specific task* activity. That is, the goal is to troubleshoot an amplifier, a video cassette player or recorder, an electric motor, an analog circuit, a digital circuit, etc. A typical text repeats a large amount of basic fundamentals and provides tips on how to *fix* the item in question. These books describe various methods or strategies employed in troubleshooting, such as signal injection, signal tracing, the strategy of "split in half," bridging, substitution, applying heat, applying cold, etc., and indicate the normal failure mode for specific devices and components. All but a few of the tests start at the unit level, progress to the board level, and end the process at the component level.

Since its inception in the mid 1960s, the Electrical Engineering Technology Department of Purdue University has had a sophomore-level course with "hands-on experience in electronic troubleshooting from the system level to the component level" as part of the EET curriculum[1-4]. In the mid 1980s, the faculty and staff developed an instrument called ALFRED, for Amplitude Linear Frequency Related Educational Device, that is essentially a one octave music synthesizer. It has served as a useful tool to teach troubleshooting for more than a decade. Hundreds of students have developed their troubleshooting skills to the point where they are able to locate and repair multiple faults at the component level in a complex electronic system[5].

Tomal and Widmer state that, "troubleshooting is the process of problem solving"[6]. Problem solving in the broader sense involves the process of developing a systematic logical approach to the identification and solution of a problem, something that Fogler and LeBlanc refer to as a heuristic[7]. The steps of identifying the problem, devising a hypothesis for its cause, postulating a test strategy that will identify the source of the problem, implementing tests to determine if the hypothesis is correct, evaluating the results of the tests, and taking corrective measures in such a way that the problem does not recur are part of this heuristic. The nature and complexity of the problem, how often it occurs, and the resources influence the specific details and solutions on hand. The problem often goes beyond the point of *fixing* the immediate fault on a single unit to asking questions about the underlying causes for failures when several units are involved and proposing solutions that will prevent their recurrence. This aspect of problem solving is seldom stressed formally in troubleshooting texts, although the underlying principles may still be mentioned.

In an effort to address problems that arise in the manufacturing environment, lectures on problem solving that employ graphical analysis techniques, such as flowcharts, check sheets, run charts, Pareto charts, cause & effect (fishbone) diagrams, histograms, scatter diagrams and control charts have been presented in the troubleshooting course (EET 276) since 1997[5]. They provide methods of data analysis that relate to the solution of production problems where issues of reliability and quality control are concerned[8].

Homework assignments that use several of the graphical techniques mentioned above, along with a laboratory activity that focuses on the frequency and kind of failures found in the ALFRED units throughout the semester, provide opportunities to perform fault analysis. Open or shorted passive components, missing or bent pins on active devices or ICs, bad sockets, cold solder connections, solder bridges between traces or pins of an IC, open jumpers, improperly inserted devices, and incorrect devices illustrate the types of faults placed in the units. During the lab session each team of students compiles the data from several *repair forms,* completes a check sheet and constructs a Pareto chart to identify the more important faults. The results from all of the teams are compiled and the students actively participate in the dialog that ensues to suggest several possible causes for the *failures* observed. Those who have had industrial experience frequently provide anecdotes that enhance this learning activity. The following list contains a sample of the questions that typically are raised:

1. Is this a new problem, a recurring one, or one that was thought to have been solved but has returned?
2. If this is a new problem, what has changed recently that might be a contributing factor to the problem?
3. If this is an old problem, what was done previously to correct the problem?
4. Are there problems associated with process reliability, with parts reliability or with people reliability?
5. If this is a process reliability problem, what has changed recently? Have control settings drifted out of tolerance?
6. If this is a parts reliability problem, were the faulty components obtained from the usual vendor or a different one? Has the quality and reliability of the parts from the usual vendor declined?
7. Do weaknesses with the basic design contribute to the frequency of failures?

These questions merely illustrate the kind of questions that could be raised. In an industrial setting the answers to them would likely raise additional ones. Eventually, enough answers would be found that one or more solutions could be implemented and the problem corrected.

Finally, some observations by the author about the troubleshooting process as it relates to current technology. With the exception of the cathode-ray tube (CRT), it is a rare book written in the past decade that contains troubleshooting tips for vacuum tube circuits. The advent of miniaturization brought on by solid-state electronics and printed circuit boards has pushed them into obscurity (This point is made with an apology to the audiophile who still prefers the sounds produced by a pentode). The trend continues with the proliferation of application specific integrated circuits (ASICs), surface mount devices (SMDs), and more densely populated multi-layered boards. Another popular trend is the continuing adoption of computer interfaces by the instrumentation industry that link instruments to computers via PCI, USB, and IEEE 1394 (Firewire) buses[9]. Many of the troubleshooting techniques previously employed are complicated by or are found inappropriate with the new devices and heavily populated boards. Therefore, the challenge we face as educators is to develop meaningful learning experiences for our students that will prepare them to deal with the problems created by the newer technologies.

Bibliography

1. Dennis, D.S. & Aubrey, R.A., A New Approach to the Art of Teaching Electronic Troubleshooting in Electrical Engineering Technology, *1992 ASEE Annual Conference Proceedings*, pp 1947-50.
2. Naylor, W.R. & Dennis, D.S., *Troubleshooting Featuring ALFRED II*, Learning Systems, Lafayette, IN, 1993.
3. Aubrey, R.A., Dennis, D.S. & O'Connor, T., Adaptive Instructional Tools and Techniques Used in Teaching Electronic Troubleshooting, *1994 ASEE Annual Conference Proceedings*, pp 2655-59.
4. Aubrey, R.A. & Brelage, T., A Temperature and Voltage Monitor Board for the Electrical Engineering Technology Laboratory, *1995 ASEE Annual Conference Proceedings*, pp 484-87.
5. Reeve, W.F., Graphical Analysis Applications in an Electrical Engineering Technology Laboratory, *1997 ASEE Annual Conference Proceedings*.
6. Tomal, D. & Widmer, N., *Electronic Troubleshooting, Second Edition***,** McGraw-Hill, 1999.
7. Fogler, H.S. & LeBlanc, S.E., *Strategies for Creative Problem Solving*, Prentice Hall, 1995.
8. Rowland, R., Simple Process Control, *SMT (Surface Mount Technology)*, February, 1999, pp.32-4.
9. Lecklider, T. & Vitale, P., Taking the Measure of the Instrumentation Industry, *EE – Evaluation Engineering*, December, 1998, pp.38-47.

WILLIAM F. REEVE

William Frank Reeve is currently an Associate Professor in the Electrical Engineering Technology Department of Purdue University. He had a varied career in industry, the military, and in education. He received the Bachelor of Science and Master of Science degrees in physics from the University of Louisville. He conducted research on ionic vacuum pumps and quadrupole mass spectrometers in industry, investigated physical properties of salt-ice, snow, and single-crystal ice while serving in the U.S. Army, and taught chemistry and physics in high school for three years prior to joining the faculty of Purdue University. In addition to his duties at Purdue, he has conducted numerous workshops on electrical safety in hospitals, coordinated and taught week-long courses for Landis & Gyr, Inc., and Otis Elevator Company, served as an IEEE evaluator for TAC of ABET, and served on the editorial board of the **Journal of Engineering Technology**.