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Tapping the Hidden Potential for Quality Improvement and Cost Reduction in PCB Manufacturing

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Abstract
Automation, change and complexity have become the normal working environment in the PCB market. With this change has come the realization that high tech manufacturing, technological innovation and the fast paced world of the Electronics Interconnection Industry are intimately connected to rapid learning. In fact the very survival of companies involved in the design and fabrication of PCB's, their competitiveness, their ability to innovate and remain cost effective is directly linked to the speed and quality at which technical information is assimilated and applied by their workforces.

The Research
Over the last 10 years, research has been conducted on the subject of employee proficiency and specifically, the proficiency levels being achieved in high tech manufacturing through the use of traditional methods of training as well as the most modern performance improvement methodologies.

This research disclosed a number of interesting factors regarding proficiency levels:

- Not a single organization was found to be using valid measures of whether or not operators, technicians, engineers and other employees were fully proficient.
- Scores of 100% on standard "certification" tests were no guarantee of on the job proficiency.
- Operations Managers, Organizational Development Administrators and Technical Training Departments did not know how to measure full employee proficiency.

From this research it was realized the industry was missing a benchmark or standard, defining what full proficiency is.

We developed this standard, which was named 100% Proficiency®, and the processes to achieve it. But first, the concept of full proficiency had to be defined:

That definition is:

When an employee, operator, technician, engineer -

a. Has all of the knowledge necessary to do their job.
b. They are fast and 100% error free and
c. They are able to use good judgment within the scope of their job (operate with minimal supervision; are able to solve problems; are able to *think* things through).

With this definition in hand, well over 100 companies were surveyed.

The results of our research are as follows:

- We found that no organization has a workforce that is uniformly 100% proficient.
- The organizations we surveyed estimated that their employees were 40% - 60% proficient on average.
- 70% was the highest estimate given and this was considered leading edge.
- The lack in employee proficiency was found in all manufacturing areas: operators, technicians, engineers and supervisors; as well as in support areas such as Material Control, Warehouse and Shipping, Customer Service, Buyer/Planner – Procurement; and with specialized training such as Quality Systems, TPM, TQM and SPC; and also in the Information Technology area including software applications, ERP Systems and software conversions .

The Problem
At this point in the research Operations/Manufacturing Managers were asked: "So what?" In other words, what effect is this gap in proficiency creating? What problems is this causing? The following answers were found: (See Figure 1.)

- The "proficiency gap" (the gap between the 40% - 60% average and 100%) is considered responsible for such things as employee errors, scrap, re-work, customer dissatisfaction, the high cost of quality, lowered productivity, fire fighting, equipment downtime, shipping delays, customer returns and even employee turnover.
- The "proficiency gap" creates hidden costs, costs that are not directly measured and so are hidden from management view, which amount to millions and millions of dollars in loss each fiscal year.
- No organizations were found to have a process in place to bring their employees up to 100% proficiency, to remedy the effects of the "proficiency gap".

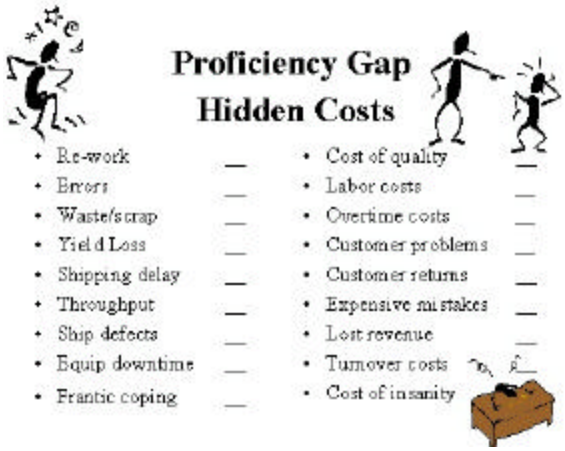

Figure 1 – Proficiency Gap

Examples of these costs are as follows:

One high tech manufacturing company was losing over $1,000,000 per quarter due to human error in the Buyer/Planner area specifically from write-offs of untraceable return to vendor parts and supplies (RTVs). The human errors in the process were also generating a backlog of aging RTVs, stacking up inventory in the plant and adding extra direct labor hours for inspection, verification and resolution of problems associated with RTVs.

Another company's employee errors at First Test Yield were producing factory re-work and 25% more headcount than otherwise necessary to get the job done, adding to manufacturing costs and the cost of quality and producing a 94% Final Audit Yield which was well below World Class Standards of 98% for the industry. Employees were not using identical production processes and were not following proven processes uniformly which was creating variation and quality problems. Quality problems increased direct labor time, lowered productivity and increased the cost of goods sold. And as a result, customer dissatisfaction created a major issue for management.

A company involved in Aerospace applications manufacturing was bleeding approximately $50,000 a day in productivity loss due to employee lack of proficiency and was losing 2.4 million dollars a year in re-work and cost of quality. Operators were 60% proficient on their job functions, did not follow work procedures exactly and entered in variations and "creative" interpretations of process specifications.

Reported field failures due to the proficiency gap at one company amounted to 8% and errors discovered by customers were measured at 2.5% of all units shipped. And another company was found to be losing over a million dollars a year in mis-processing, which was causing expensive scrap. Re-work, cost of quality, loss in productivity and yield as well as scrap may be due to 3 factors: processes, equipment or human error. The factor that was focused on in each of these examples was human error and the common denominator was a lack of proficiency.

Additional metrics that were used to discover that current training methods were ineffective include:

Employee errors	Speed of implementation of TQM
Efficiency	Speed of implementation of TPM
Defects	Units per Operator Hour (UPHs)
Rework	Customer satisfaction
Scrap	Yield loss
Yield or Throughput	LRRs – Lot Rejection Rate
On-time shipping deadlines	DPPMs (Defective parts per million)
Customer returns	Operator to machine ratio
Equipment up time	# of lots scrapped
Cost of quality	Idle time
Productivity	Mixed devices/mixed lots
Labor costs	CARs (Customer Action Reports)
Head count	ITRs (Internal Trouble Reports)
Equipment set-up time	Mean time to assists (Equipment)
Training time (ramp-up time)	Equipment troubleshooting time
Employee satisfaction and morale	Equipment repair time
Cycle time	Unplanned equipment downtime
Manufacturing costs	Scrap due to equipment
Capacity	Sustainability of Quality Systems
Capital Expenditures on new equipment due to employee productivity	
OEE – Overall Equipment Efficiency	Mean time between equipment failures
Turnover	

The Root Cause

The questions of why and how this situation came about were asked. Tracing back the history of industrial training, astoundingly it was found that all high tech manufacturing organizations are using a training methodology developed back in the 1940's :

a combination of classroom and on-the-job training; also known as "buddy training", or "the buddy system", "show & tell", "look over the shoulder" or "line training". Originally developed for low-tech assembly, this training methodology relies heavily on verbal explanation, repetition of instructions and constant on-the-job correction rather than on precision understanding and exact execution of written specifications or work procedures.

In many cases the "buddies" are not themselves 100% proficient on the job functions they are teaching the trainee, are not trained as effective trainers to achieve a standard of 100%, and are not trained to uphold a consistent standard. In other instances under this system, trainers are found to be "content experts" but again not trained as effective trainers enabling the transfer of knowledge to occur at a proficiency level higher than 70%.

On the other side of the coin, the trainees do not have the inherent skills, nor have they been trained to learn, at a level of full proficiency and self-reliance which empowers them to study a work procedure, fully comprehend it and put it into precise application.

An additional important discovery that was made was that training was not held accountable for financial "Return on Investment" or metric improvement and therefore, not held accountable for human error, significant inconsistencies in product quality, reduced efficiency and significant manufacturing costs.

Research has found that this outdated 1940's training method is a bottleneck; it places a substantial constraint on productivity and organizational performance and can be likened to the use of a manual typewriter to produce a financial report, compared to the use of a computer and spreadsheet program. If you need copies of the report – you would have to use carbon paper and correct a mistake with white out. The inefficiency of such a system is clearly evident. Another analogy would be the use of a rotary telephone and manual switchboard in comparison to the efficiency of a fully automated digital phone system with call waiting, voice mail, electronic switching, hold, conference and transfer capability. Picture using 1940's technology anywhere in your business!

Verbal training, classroom training, on-the-job (buddy system) verbal training and explanation at best produces 70% proficiency in the trainee with a very low retention rate. This has been further substantiated by the Gartner Research Group out of Stamford, Connecticut, which found that the average retention rate (what employees remember) 30 days after employing traditional training methods was 10%.

Remedial Measures

The remedial actions found to correct the "proficiency gap" were as follows: (See Figure 2.)

- Measure Training on 6 Levels.
- Link training to organization metrics by doing a front-end analysis to deploy training and affect metric improvement where substantial financial loss and/or customer satisfaction and customer retention is at stake.
- Design training to achieve a standard of 100% proficiency which makes positive changes to the organization's culture and internalizes the concept that full proficiency starts in training and not out on the floor.
- Train the trainers to achieve 100% proficiency and not be satisfied with anything less that 100%.
- Train the trainers, supervisors and trainees to uphold the 100% standard.
- Make training accountable for metric improvement, results in productivity increases, quality improvement, cycle time, costs, revenue, etc.
- Make training achieve a financial Return on Investment.

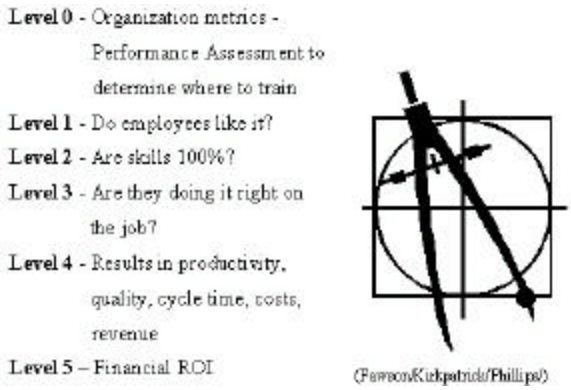

Figure 2 – Training Evaluation

Performance Improvement – The New System

In order to achieve a level of 100% proficiency a new performance improvement system had to be developed (Figure 3). Verbal training is unworkable, results in low retention and no better than 70% proficiency levels. The original research on the subject of data assimilation and retention was done by L. Ron Hubbard in the 1960's and published as a 12- lecture series. The following best practices are based on his work and are now being used throughout high tech manufacturing with tremendous metric improvement, financial Return on Investment and quality results.

- Management support and commitment to a 100% proficient workforce.
- Performance based training needs assessment.
- Work procedures that comply with a standard of 100% proficiency.
- Instructional design modules called “check sheets” which conform to 100% proficiency standards.
- Learning How to Learn training for employees teaching them how to understand and follow work procedures precisely and thereby achieve quality consistency and uniformity.
- Coaching skills for line trainers, which teach them how to achieve a standard of 100% proficiency and maintain it.
- Supervisor training so that knowledge transfer on the job is verified and maintained to a standard of 100%.
- Evaluation of training based on business results, speed of ramp, productivity, yield, reduced costs.
- Significant financial Return on Investment.
- Annual re-certification and quality control systems for sustainability.

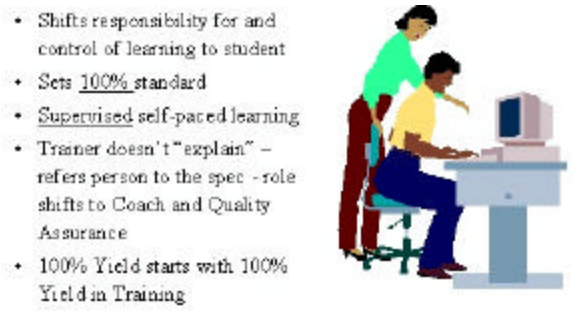

Figure 3 – Performance Improvement System Best Practices

Application and Results

Figures 4 through 9 is a sampling of results obtained by implementing the best practices covered in this report:

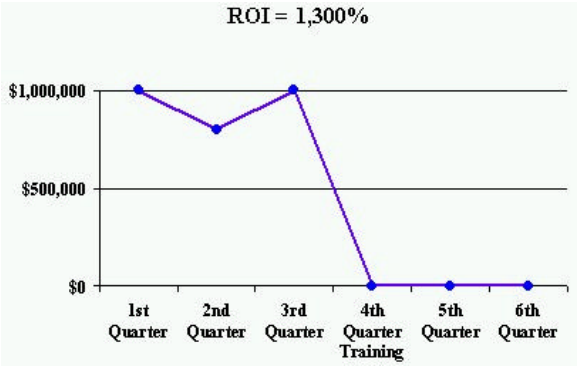

Figure 4 – Buyer/Planner Financial Loss Reduction

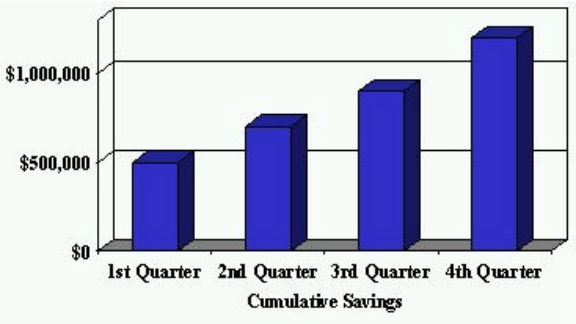

Figure 5 – Semiconductor Mfg. Company: Savings Reduction in Scrap Due to Misprocessing

Figure 6 – Quality Improvement Assembly Final Audit Yield

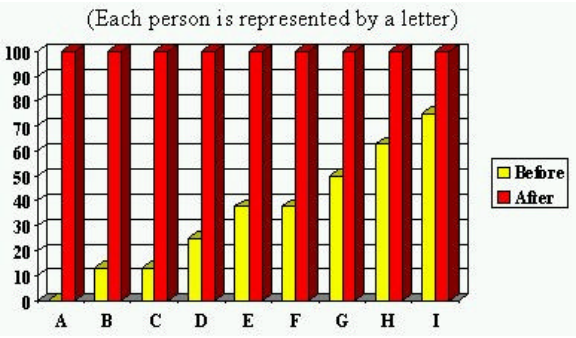

Figure 7 - Comprehension Scores - Comprehension of Specs Before & After Learning How To Learn

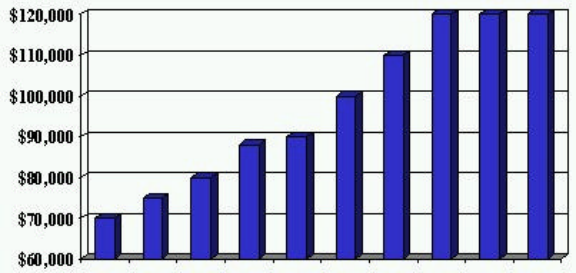

Figure 8 – Aerospace Manufacturing - Dollar Volume Increase of Daily Production in one Department

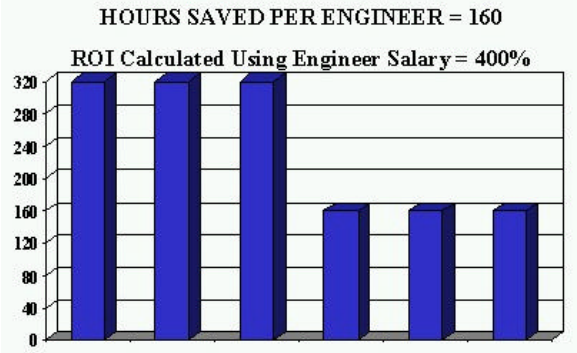

Figure 9 - Reduced Ramp Time

"Make It Better, Faster and Cheaper" cannot be achieved by using a low-tech method of training from the 1940's. The speed of technological change in the PCB industry demands a state-of-the-art Performance Improvement System that significantly decreases manufacturing costs associated with employee errors. Tapping the hidden potential for quality improvement and cost reduction can materially impact your company's ability to gain new customers while satisfying and retaining existing customers. Workforce proficiency can no longer be ignored and training cannot be relegated to the status of a necessary evil. Training which is driven by management and strategically utilized as a metric performance improvement system aligned to business goals is a competitive advantage you can no longer ignore.