# CONCURRENT EDUCATION: A LEARNING APPROACH TO SERVE ELECTRONIC PRODUCT MANUFACTURING

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**ABSTRACT**
A world class workforce is an important element in a comprehensive, multi-disciplined strategy leading to manufacturing excellence.

This paper makes the case that education is the fundamental issue associated with this workforce through its potential to be the enabling agent of important technical, managing, judgment and interpersonal "tools" which are required for manufacturing excellence.

The technical tools include: Product Design for Manufacturing and Assembly (DFMA), Design of Experiments (DOE), Statistical Process Control (SPC) and Continuous Flow Manufacturing (CFM).

The often overlooked judgment and managing "tools" include: problem-solving for problems without closed-form solutions (stochastic and statistics), failure analysis, cost/benefit studies, risk/reward analysis, project management, material management, and Total Quality Management (TQM).

In addition, the need for education in interpersonal and "soft skill" subjects such as conflict resolution, consensus decision making, influence techniques, leadership, and working in teams is identified as another critical success factor for a world class workforce.

This paper presents the theory of Concurrent Education: a strategy in which education and real world experience are provided to the student, concurrently, using a for-profit business as the learning environment.

A subset of Concurrent Education, Concurrent Electronic Manufacturing Education (CEME), is offered as a more efficient and effective learning approach for acquiring the tools required for electronic product assembly excellence, when compared to our traditional post-secondary educational system. This is based on the observation that the complexity and rate of change in the associated assembly processes and techniques have outpaced the ability of existing schools to supply qualified personnel to this industry.

The paper addresses the fact that to close the gap between academic preparation and industry need, our industrial sector has been obliged to fund the required additional education.

Sending employees to off-site seminars or establishing in-house training programs are direct costs that have been incurred. Absorbing the costs associated with the inefficiencies of long, on-the-job learning curves has been an indirect and often hidden cost. Regardless, the result is a competitive disadvantage to industry.

Within the existing system, co-op and intern programs have provided the student limited

insight and training, but not the properly balanced, intensive, real time theory/experience learning environment necessary to give the graduate the ability to "hit the ground running."

Since a customer will purchase those products, which have had the most value, added at the least possible price, our competitive position in the global marketplace is strongly linked to our ability to minimize product manufacturing cost. The human resource variable is the most expensive controllable part of the cost and value equation. Education is the key to this variable.

With a state-of-the-art, real world environment as the classroom, it is suggested that entry-level employees will actually be agents of change in the organization where they are employed, rather than just more people "to bring up to speed."

Finally, a blueprint for a new concept in electronic manufacturing education is presented. The teaching hospital is used as an analogy. A for-profit contract manufacturing business is suggested as an ideal "classroom" to provide the concurrent, real world experience needed for effective and efficient learning in the technical, judgment, managing and interpersonal skill groups.

## CONCURRENT EDUCATION: THE PREMISE

Simply stated, Concurrent Education is a learning approach that uses a for-profit business as the classroom over the student's entire post-secondary education, leading to an Associate's, Bachelor's, Master's or combination of these degrees. Specialized skills required for the existing workforce are addressed through the use of certification programs. These programs serve remedial, as well as continuing education needs which are crucial in some rapidly changing fields of study.

The area of educational interest determines which type of business will provide the best learning environment. This does not obviate the need for classical education in subjects not directly related to the area of interest, but does provide the necessary relevant backdrop for the specialized education the student is interested in receiving.

This approach affords the student a real time correspondence between the academic curriculum and the real world. This correspondence is especially useful for many technical subjects, and for most subjects that fall within the judgment and interpersonal categories.

In addition, new courses of study can be continually and quickly created in response to the changing technology, taking advantage of the co-located "business laboratory," which, because of its for-profit nature, has a vested interest in providing a state-of-the-art capability to its customers.

This paper addresses Concurrent Education's application to the manufacturing industry, and specifically, high tech electronics manufacturing, but it should not be thought of as being limited to this discipline.

Concurrent Education's pay back is greatest for fields of study whose corresponding businesses are complex, capital intensive, and in a constant state of change. Electronic product manufacturing is such a field – 18th Century English Literature is not.

Applying this educational approach to the electronic product manufacturing industry results in a Concurrent Education subset, called Concurrent Electronic Manufacturing Education or CEME.

So, the school uses the business as a means for students to develop state-of-the-art skills in a world class, real world environment. This will permit the students to enter the workforce and immediately contribute to the company that employs them. They will not only contribute in the context of the status quo, but they also will help change the company with the leading-edge knowledge attained in school. Wordsworth, the great 18th century English poet said: “The child is father to the man.” In Concurrent Education we might be so bold as to suggest that: The student is father (or mother) to the company.

Therefore, having defined Concurrent Education and a subset, Concurrent Electronic Manufacturing Education, we begin with a premise: A key ingredient needed to successfully compete on the electronic product manufacturing global playing field is a world class workforce. This may seem self-evident.

However, it may not be as evident that a world class workforce depends on the effectiveness of its entry level personnel. This effectiveness can be measured in three ways:

1. How well-versed are the new members of the workforce in the things their companies are doing right?
2. Can the students identify the weaknesses of their companies?
3. Are there leading-edge technologies that the new employee is able to bring from their educational experience into industry?

Entry level personnel should be a stimulus to a company’s need to refresh its policies, procedures and approaches with new ideas, not a burden whose principal mission is to “get us up to speed.”

Today, most agree that continuous improvement is a critical success factor for a company’s long term growth and stability. With the proper education the new graduate could become an important agent for that improvement.

## WHEN THE SUN REVOLVED AROUND THE EARTH: AN ASTRONOMICAL PARADIGM

For over 1300 years there was no debate. No discussion. It was just the way it was. The earth could not move. Why? Because of the “fact” that the universe must have a center. Since things would tend to fall to this center, and objects thrown up from the surface of the earth fell back (only being stopped by the impenetrable nature of the Earth’s surface), clearly, the Earth’s center and the Universe’s center were the same. This was even consistent with the spherical nature of the earth (a “fact” well entrenched by the 17th Century) since no matter where on earth you were, objects falling freely struck the surface at a right angle. The heavenly bodies moving around the earth were held up in the heavens by invisible glass spheres. Epicycles (circular orbits whose centers traveled on other circular orbits) caused the retrograde motion of the “wandering stars.” It all made sense.

This description of Ptolemy’s universe was based on Aristotle’s work that provided him with a series of “givens.”

As better empirical methods became available after Aristotle, observations and measurements were made to fit the existing foundation of thought. So the epicycles that defined the observable motions of some of the heavenly objects were a result of the axiom of earth's centrality. In other words, this one accepted "fact" set in motion a series of beliefs which supported the accepted "fact" which itself did not require proving!

Today we call this sort of presupposition a paradigm. Looking through our eyes it is hard to understand how one could believe something that today seems so clearly false – we have our own set of paradigms that guide our thinking.

How things are perceived is largely a function and a commentary on the times in which they are thought. The foundation for this thought is a set of prevailing axioms that are "self-evident", not requiring proof. These axioms create the "box" in which we operate.

Of course, the conclusions drawn from deductive reasoning, in the absence of empirical evidence, totally rely on their axiomatic foundation for support. This is the way Ptolemy was led to his Universe. However, if the foundation should crumble, the conclusions that were built on it come tumbling to the ground.

In 1931, the brilliant mathematician, Kurt Gödel, formally proved that one could never establish a set of "givens" for a system, which could absolutely insure the validity (i.e., total consistency) of the conclusions derived deductively from the set of conditions.[1]

The point is: We should be leery of conditions that seem self-evident. And to challenge a foundation of thought or paradigm requires, in most cases, "stepping out of the box." This is usually not a comfortable process.

In industry we have an easier time of it. That is, in trying to test the validity of our assumptions, we can look at our results. If our results are less than satisfactory, we ask why. But, as a rule, we don't like to challenge our belief systems – remember, as Galileo found out, that is usually uncomfortable – so we exhaust all the possibilities for poor results "in the box," first.

Just as Newton's laws of motion were "correct" at low velocities, the way we think about technical education was correct in an age where products and technologies had much longer lifetimes and we were the only manufacturing game in town, serving the primary consumer in town – us. In 1950, the United States was responsible for 50% of the world's GNP! Our educational system serving our industry was doing just fine, thank you very much.

The aspect of education that makes it a supplier to industry causes us to consider its role in the difficulties we have had in manufacturing competition worldwide. Working "in the box," we attack this situation with co-op arrangements, intern programs and development of alliances between industry and academia, attempting to deal with rapidly changing technologies and the changing nature of the manufacturing workforce that this condition has prompted.

How well has our manufacturing industry been served by the products of today's educational system, and the "in the box" responses we have developed as a coping strategy to deal with our industry's changing nature?

Talk to American industry and their answer is, in general, “not very well.”

Let us look at our educational “box.”

**OUR EDUCATIONAL PARADIGM: THE SEPARATION OF OUR SCHOOL SYSTEM AND THE INDUSTRIES FOR WHICH THEY EDUCATE**

One legacy of our educational history is the notion that we educate in one environment and employ the educated in another. It is on this paradigm, the box we have operated in, that our current system is built. In a static world of lesson plans that can be used over a ten or twenty year period, this model works. In the high tech world of automated, continually changing electronic product assembly, with fierce global competition, it does not. Joseph Hill wrote the following:

> “…educators, either as willing or unwilling participants, are embroiled in a revolution of the rapidly developing new age. And as highly important participants, it is essential that educators realize that man controls the device of automation…(and) is capable of controlling the revolution.
>
> To bring about this control, however, it is necessary for educators to adopt a philosophy of education that:
>
> (1) allows the establishment of a self-adjusting system of education that is compatible with the needs of contemporary society
>
> (2) avoids the pitfalls of educators being engulfed and swept along by the pervasive current of the false dynamism which is created by the employment of the artifacts and operations of automation … without regard for the long-range objectives.”[2]

Mr. Hill wrote this in 1966!

If we interpret one of the “needs of contemporary society” referred to in (1), today, as providing a world class workforce for the electronics manufacturing industry, the challenge becomes how to make our educational system “self-adjusting” in a complex, rapidly changing technology. CEME would propose that educating in a for-profit manufacturing environment has built into it the needed bias toward change to successfully respond to industry’s ever-changing requirements. Further, students educated in the environment will go forth into industry expecting, even demanding, continual improvement (a broad-based change strategy) from the companies who employ them.

Ironically then, by today’s standards, those companies whose management, for example, do not reflect Deming’s 14 points for management excellence[3] in their operation will be at a disadvantage, competing for top students who have attained a thorough working knowledge of this philosophy from the environment in which they were educated!

In the interpersonal skill group we currently educate in a setting where, for the most part, the student acts independently, competing with fellow students for grades. The measure of success becomes the magnitude of their grade point average. These students are then thrust into an industry that, now more than ever before, because of its complexity, requires strong teamwork. CEME provides exposure to both interpersonal skill theory and practice simultaneously by coordinating the students’ classroom activity to their participation in business activities.

In electronic manufacturing it appears to be time to challenge the paradigm that keeps education and industry in separate communities.

## THE DIVERGENCE OF EDUCATIONAL PREPARATION AND INDUSTRIAL NEED

We cannot avoid the issue of vocational training, liberal education and professional education. This can easily become a semantic mish-mash if we do not confront this head on now.

Mortimer Adler, in 1951, drew the following distinction: Vocation training is learning for the sake of earning. Liberal education is learning for the sake of learning.[4] Most people in 1994 would agree that most post-secondary education today is focused, in some way, on providing a basis for earning a living after leaving school.

In *Schools of the Future,* written in 1985, Marvin Cetron Dispels the myth that teaching job training in schools is a waste of time since "jobs in the future will be changing so frequently because of technological advances."[5]

What is the ideal background of manufacturing employees – those responsible for the process development, maintenance, production, and quality of the assembled product?

The author believes that our electronics manufacturing industry is on a course where a smaller professional workforce consisting of personnel with 2 and 4 year degrees is replacing the traditional vocational workforce. The number of manufacturing employees is decreasing as more and more human labor is taken out of the recurring assembly processes, while the required skill levels of those remaining is increasing. These professionals are being held responsible, not only for process development, but for production as well.

This is a consequence of a number of factors:

1. Automation – the removal of servile or hand labor continues as sophisticated electromechanical equipment, outfitted with optical recognition, replaces the traditional, labor intensive processes.

Automation itself is a consequence of not only wanting to do things faster, but also because it provides the only practical way to handle very small parts and fine lead pitches.[6]

2. A reduced workforce is putting extreme pressure on reversing the Henry Ford division of labor manufacturing strategy – employees are being driven into wearing more and more "hats."

Time and motion studies for manual assembly are fading, as emphasis is placed on assuring equipment up-time and product quality through developing robust automated manufacturing processes and utilizing Statistical Process Control.

There is little relevance in our industry for traditional vocational training as manufacturing technology continues to get more and more complex.

If one accepts the evolution of manufacturing labor toward the need for problem-solving and judgment, then the term "vocational education" wanes and is replaced by professional education.

If the deficiency in the education of our workforce only involved existing employees, one could make the case that changes in technology alone have caused the need for continual education.

However, an even more basic issue arises from two facts:

1. The deficiencies are observed whether the employee is experienced or entry level.

2. In most cases, much of the educational content required for industry is not part of our traditional institutes' curriculum.

A result of this divergence of preparation and need is the additional education that industry is compelled to provide. Large companies have been able to absorb the costs necessary to establish their own internal training centers. Small companies have used seminars and consultants.

However, responding to the lack of judgment and interpersonal skills is usually way down the priority list as we scramble to get the new product into manufacturing and out the door.

A college administrator was recently asked why her school could not be more responsive to the needs of industry. Her reply, in terms of the electronic manufacturing business, was as follows:

When a curriculum change is suggested requiring a significant capital investment (e.g., surface mount assembly), the following tasks must be accomplished:

- a committee is formed to evaluate the available surface mount equipment,
- a syllabus must be written,
- a proposal must be generated to request funding,
  - the funding and course proposals are submitted for approval,
  - the proposals undergo the approval cycle,
  - the equipment is ordered,
  - an instructor must be educated on the equipment's operation,
  - lesson plans must be developed which define the course in detail,
  - the course is offered through the course catalog,
  - the equipment is received and installed,
  - teaching the course begins

This is a two to three year process! During this period the equipment that was selected is likely to be obsolete.

Even when major capital purchases are not required, changes in an existing curriculum are slow in coming. The sense of urgency in business caused by the desire to stay in business provides a compelling reason to adopt "change" as a standard operating procedure.

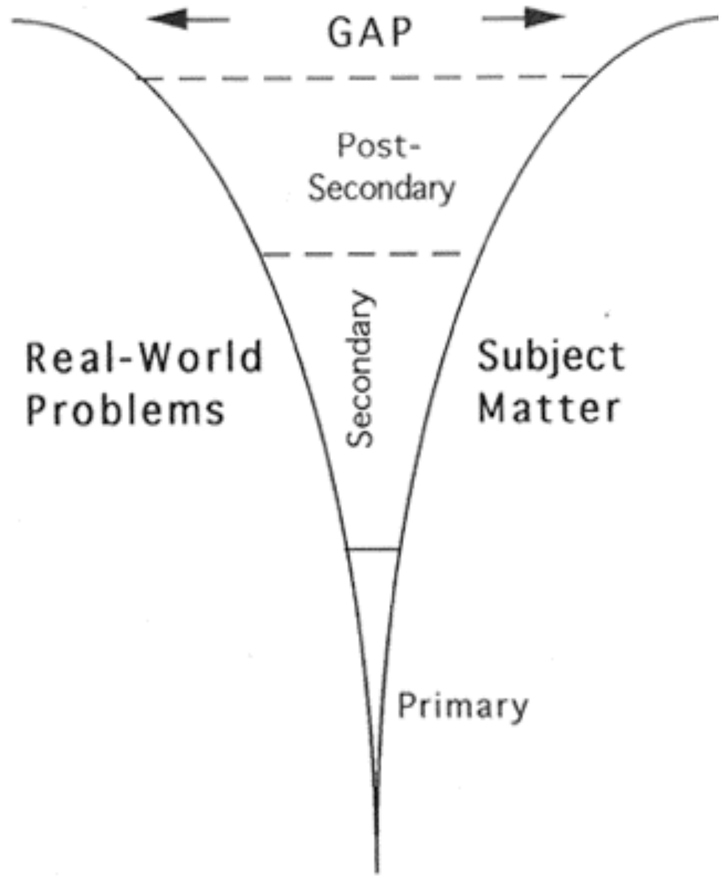
CEME takes advantage of this inherent motivational force in a business to drive the curriculum of the co-located educational institute.

But, identifying the course material required to provide the students with the “most relevant bang for their buck,” and adding it to a curriculum, is only half the problem. The other half is determining what is the most effective and efficient way to provide the instruction - in other words, the delivery system.

It is recognized that using real world problems that are wrapped around the corresponding theory helps in the educational process. Putting these problems in a real world setting makes the educational experience more effective. If we go back to the beginning of our formal education, we see that this is a fairly easy task: “If Jane has two apples and she gives one to John, how many apples does Jane have left?”

As we progress up the ladder from primary into secondary education, more complex and abstract subjects present themselves. The task to create a correspondence between the subject matter (whether relevant or not) and the real world becomes more difficult – the dreaded “word problems” in first year Algebra come to mind!

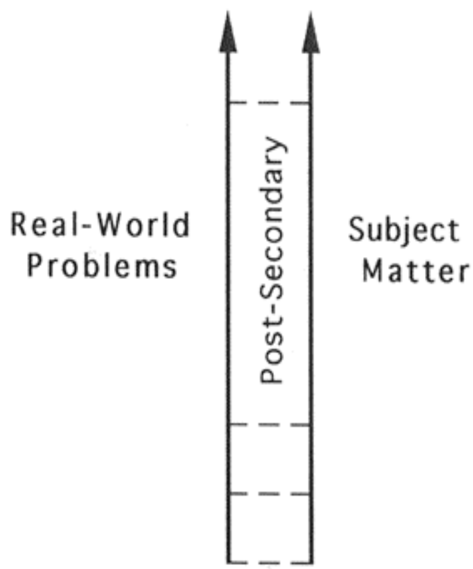
But even for subjects that are not abstract, we start to lose the ability to correlate the subject matter with real world problems as we graduate in complexity (Figure 1).




Gap Between a Subject's Complexity or Abstractness, and the Ability to Create a Correspondence with Real-World Problems — As a Function of Education Level

Figure 1

Facts, and problems using cookbook algorithms for solution, remain in the center of our educational stage, however, because of the sterile and antiseptic nature of our learning environment. CEME greatly narrows the divergence by using the co-located business as a means to provide a correlation between the course material and the real world problems (Figure 2).



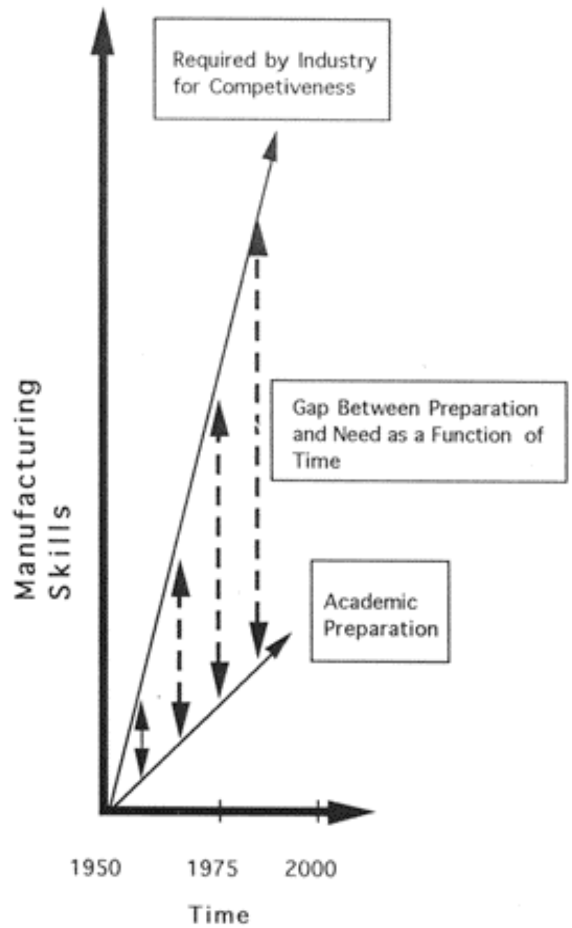

CEME Post-Secondary Education Gap Between a Subject's Complexity or Abstractness, and the Ability to Create a Correspondence with Real-World Problems

Figure 2

Now we add a rapidly changing technology requiring continuously changing skills and our current system has responded in a fashion represented by Figure 3. How fast are things changing? In 1985, the half-life of the skills an engineer learned in college was 5 years![7]

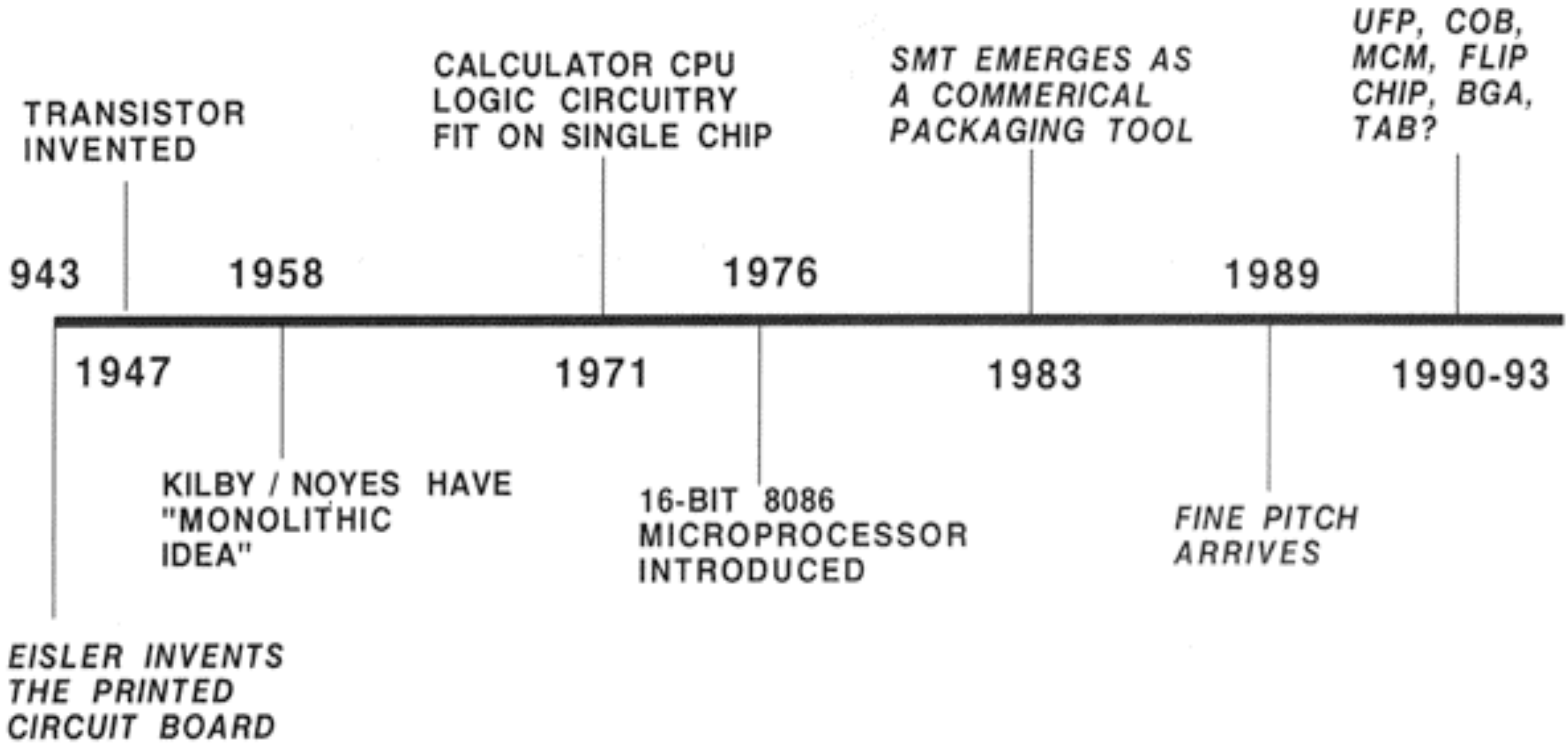
Figure 4 presents some significant electronic and "packaging" (italicized) milestones starting with the inventions of the transistor and printed circuit board in 1947 and 1943, respectively. Notice the accelerating rate of "packaging" changes within the last few years!

CEME responds to this changing technology in a parallel fashion (Figure 5).



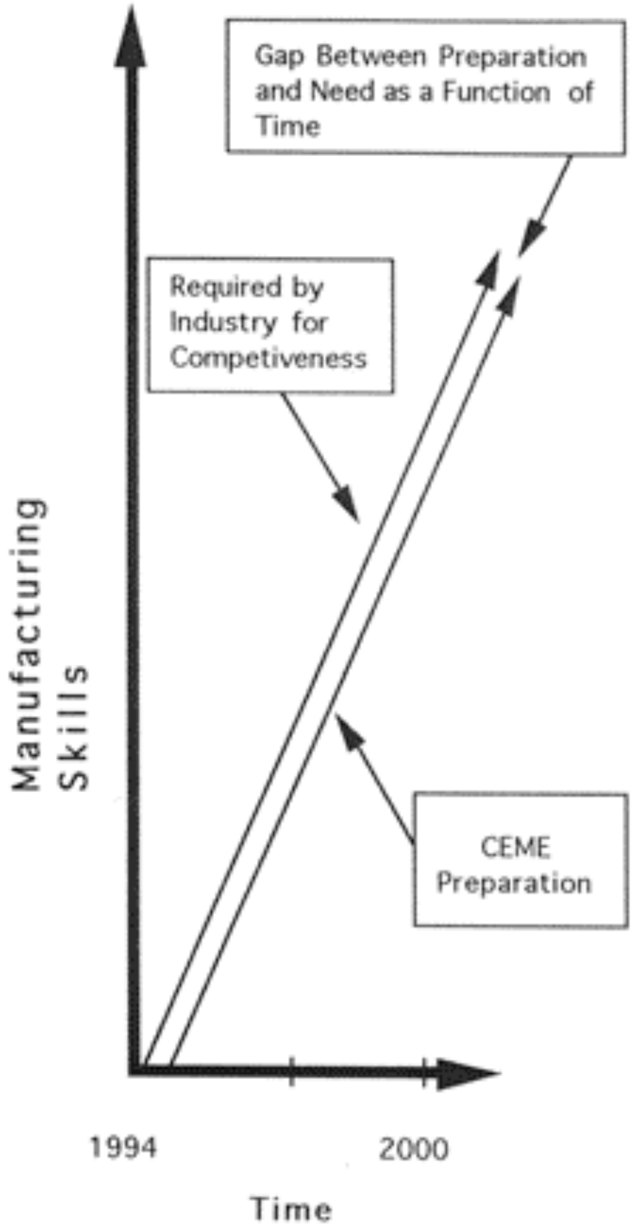

The Divergence Between Academic Preparation And Industry Need

Figure 3




SOME ELECTRONIC MILESTONES

Figure 4




The Responsiveness of CEME To The Changing Needs of Industry

Figure 5

**THE STATE OF OUR MANUFACTURING AFFAIRS – POSITIONING FOR A GLOBAL ECONOMY**

In the United States companies spend about 65% of their R&D resources on developing new products. The remaining 35% is used for new process technology development.

In Japan the numbers are just the opposite: 65% of its resources are assigned to process development, 35% to new product development. As Lester Thurow points out, it'' not hard to understand why we can invent the VCR, but we do not build any.[8]

The neglect toward process development has caused products that are developed domestically to be built offshore.

We used to talk about the facts we learned in college. We recognized that when we got into industry, even though we didn't remember the equation for calculating the stress in a cantilevered beam, our education taught us where to look it up! Knowledge of the specific facts wasn't as important as knowing where to look them up.

Our knowledge of the facts and cookbook algorithms to apply the facts is even less important to day as computer software does much of this for us. What has become more important is the ability to use good judgment. One can define judgment as the process we use to make decisions when confronted with problems that don't have closed-form solutions – i.e., those that don't have an definite answer that is attainable, usually because the variables involved are statistical in nature, or more unknowns than independent equations exist, or both.

Most of the problems we were confronted with in school were of the closed-form type. "For homework solve the odd-numbered problems at the end of the chapter – the correct answers can be found in the back of the book."

We probably can agree, most of the difficult problems we come up against in industry, certainly in manufacturing, are not of this type.

A 63/37 eutectic solder paste will melt at 183º Centigrade. It did 10 years ago, and will do so 10 years from now. So, what do we do when the circuit board comes out of the reflow furnace with paste that has not reflowed properly? Or, how do we develop a robust process that is resistant to the variables in our manufacturing environment? How do we reduce the variability? Should we burn-in the assembly – at what temperature, for how long? What is the payback for this added cost? What electrical test approach should we use for this product – component level, board level, unit level, MDT, ICT, Functional? What are the cost implications? Our students should be taught the strategies needed to solve these problems, and many others.

The worldwide assembly of electronics is about a $40 billion per year industry. In 1980, the United States held a 40% share. Today our share has decreased to 29% (about $11 billion) and continues to fall. Japan has 31% of the market, the rest of Asia 25%, and Europe 15%.[9]

This trend can be turned around. Automation can be a great equalizer in softening the effect of significant labor rate differences. So can all the other "tools" aforementioned, but we need a world class workforce for implementation. And we will not have a world class workforce without a world class educational system.

**WHO SHOULD PAY FOR A WORLD CLASS WORKFORCE?**

Should industry be called upon to underwrite the cost of effectively educating their entry level workforce? If they are, they will continue to be at a competitive disadvantage.

Today, a post-secondary education is being paid for either directly by the student or through loans, grants, employer reimbursements, and scholarships.

The issue is how to make this education more relevant to the industry it is serving. Accomplishing this will remove the burden presently carried by industry to supplement the educational system.

The need for continuing education to deal with the rapidly changing technology is a shared responsibility between employee and employer. Participation in associations like SMTA, and reading technical books and journals are ways for the employee to stay current. Fostering these types of activities through encouragement, making time available, and helping to pay the associated costs are the responsibility of the employer.

**A NEW EDUCATIONAL ARCHITECTURE**

The dilemma of establishing the best educational blueprint reduces to two principal issues: cost and quality. The question becomes what system will provide the most efficient and effective framework to meet the needs of an electronic manufacturing industry?

Most would agree that any measurement system employed will result in a need for changing our existing approach to manufacturing education. Many will also agree that a key to that change is introducing the student to industry during the period of education.

If there is any current opportunity for real world exposure during the student's schooling it is through co-op or intern programs – relationships that have formed between education and industry.

These initiatives are in the right direction and spirit and may be called "weakly" concurrent. A limited number of students are at best able to take advantage of these programs. Developing a fraction of a world class workforce will create pockets of manufacturing excellence – this is what we have now. The manufacturing sector will not expand with pockets of excellence. True manufacturing market growth needs a world class workforce, which is larger than the current industry demand. This will create the opportunity for broad growth. A smaller block of excellence compared to demand will cause our market to shrink.

However, the most effective and efficient approach is to strongly link the student's classroom activities with real world problems. As well as physically locating the school in a real world environment, CEME uses the same personnel to provide their knowledge and leadership – whether the student is participating in the business or sitting in the classroom. This dual responsibility helps provide a strong correspondence between the manufacturing business and the classroom.

The notion of supplementing the educational experience with real world experience before a person is considered qualified to work in a particular field, is not a new one in some professions. A graduate of medical school, for example, is not a doctor until he or she has successfully completed an intern program at a teaching hospital.

The teaching hospital provides a real world environment where the remaining skills, those that can't be taught effectively in a classroom, can be developed under the watchful eyes of experienced professionals.

With human beings, however, we don't want to risk a concurrent learning of the facts and usage of the facts. So, the facts and certain skills are taught first in medical school using something other than living humans as learning tools.

Skills needing real world problems to develop the required expertise, such as those that are judgment-related (medical diagnosis, for example) and of the interpersonal type (bedside manner, for example), are perfected in the teaching hospital – a real hospital with real patients where interns perfect their skills. Teaching hospitals are also places where research is done to improve the medical profession.

This is the intent of CEME. However, circuit boards don't warrant the same concerns that humans do. As much as a solder bridge, once discovered, might dismay us, its ramifications are less severe than a gall bladder that was removed by mistake. So, we can concurrently teach skills in an electronics manufacturing center while assembling real products – but like the teaching hospital, always under the watchful eye of experienced professionals.

**What is the Best Business to Use For The Electronic Product Manufacturing Classroom?**

The one that presents itself as the strongest contender is contract assembly. Why? A criterion for selection is identifying the business environment that will expose the student to the broadest array of products and processes. Contract assembly does this by virtue of building products in a wide variety of product areas: computers, communications, medical, consumer, military, industrial controls, etc.

**What Form Will The Education Take?**
Four general types of study should be offered: programs leading to A.S., B.S., M.S. degrees in electronic product manufacturing (recall the prediction that this workforce will move more and more into the professional sector), and certification programs, primarily for existing members of industry. These programs can be customized for specific company needs, as well as providing a basic assortment of courses focused on specific skills.

**The "Time" Problem:**
As James Braham lamented in 1991, "How do you cram leadership courses into a curriculum already so crowded that a bachelor's degree general requires at least 4 years to attain?"[10]

And, in electronic product manufacturing education, we are suggesting the addition of a lot more than just leadership education. Where does the extra time come from?

The Korean school year is 250 days; the school year in Japan is 240 days. What is the length of the school year in the United States? 180 days! Of course, in college you could choose to take courses in the summer.

CEME addresses this issue by using a standard business year for education. This adds 70 days, or almost 40%, to the school year.

These extra class days are not optional in the Concurrent Education system, but required to give the student the time needed to fulfill their real world project team responsibilities.

**What Is The Organizational Structure Of The Contract Manufacturing Business?**
The traditional functional department structure is abandoned. The business is composed of only two groups:

1. Project Teams which manage the contract manufacturing customers' programs,

2. A leadership group which serves the project teams by providing direction and guidance. The leadership group also acts as an "enabler," providing the tools and removing roadblocks to help the project teams be successful.

**What Is The Makeup Of A Typical Project Team?**
A project team consists of a blend of staff and students. Within a given team all the necessary skills exist to successfully manage the project.

<u>A Partial List of Subject Matter to be Added to the Curriculum in a CEME Environment</u>

<u>Technical</u>

- Circuit board process development
    - Component placement process related
        - Fine pitch, COB, MCM, BGA, TAB
    - Solder process related
- Equipment Operation
- Robotics
- Optical recognition
- Electrical test strategies
- Product reliability analysis and test
    - Electrostatic discharge
- Facilities engineering
- DFMA
    - Circuit board layout
    - Higher level assemblies

- Design of experiments
- Process validation
- Statistical Process Control
    - Data acquisition systems
- Continuous flow manufacturing
- Component engineering
- Material science
    - Solder rheology
    - Solder joint integrity
    - Substrates
- Joining
    - Adhesives
- Cleaning methods

Managing

- Project management
- Total Quality Management
- Material management
- Time management

Judgment

- Quoting and estimating
- Stochastics
- Failure analysis
- Risk/reward analysis
- Cost/benefit analysis
- Decision making
    - Weighted averaging

Interpersonal

- Conflict resolution
- Consensus decision making
- Influence techniques
- Leadership
- Working in teams

One could interpret this proposal as skewing away from classical topics toward a curriculum that is heavily biased in technical subjects at the expense of the humanities, etc. It does not. The subjects listed above must be integrated into a program that includes a balance of liberal arts subjects as well.

**INITIAL CONDITIONS: THE EDUCATION PIPELINE**

If we agree that post-secondary manufacturing education should produce individuals trained in leading-edge technologies with a solid base in theory and a demonstrated real world ability, gained through real world experience, then what should be the qualifications of those entering the post-secondary segment of the educational pipeline? We cannot expect excellence in industry if any link or section in the educational pipeline is mediocre. It is important that the students starting CEME have a solid primary and secondary education.

The recommendation for the firmest foundation on which to build CEME is the Paideia system.[11] This educational method is focused on the following goals, subject matter and skill development:

Acquisition of Organized Knowledge

- Language, Literature and the Fine Arts
- Mathematics and Natural Science
- History, Geography, and Social Studies

Development of Intellectual Skills – Skills of Learning

- Reading, Writing, Speaking, Listening
- Calculating, problem-solving, observing, measuring, estimating
- Exercising critical judgment

Enlarged Understanding of Ideas and Values

- Discussion of books (not textbooks) and other works of art and involvement in artistic activities, e.g., music, drama, visual arts.

## SUMMARY

The needs of our electronic product manufacturing industry have outgrown the ability of our traditional educational approach to provide for them. It is no longer effective to educate in one community and send the educated to a different community to work. The complexity and rate of change in the technology require a new way to deliver efficient and effective education.

For many types of industries, teaching and providing the student with real world experience, concurrently, is a more effective and efficient method of preparation.

A relevant "classroom" which can act as a vehicle to provide education a real world setting is the contract manufacturing business. This for-profit environment will provide the student with an opportunity to gain the required skills necessary for an industry in constant change. As the business changes to accommodate the changing technology, the students' exposure to these changes is immediate, as reflected in corresponding curriculum and work-related changes.

Concurrent Education is a learning approach to help better serve the needs of our electronic product manufacturing industry.

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