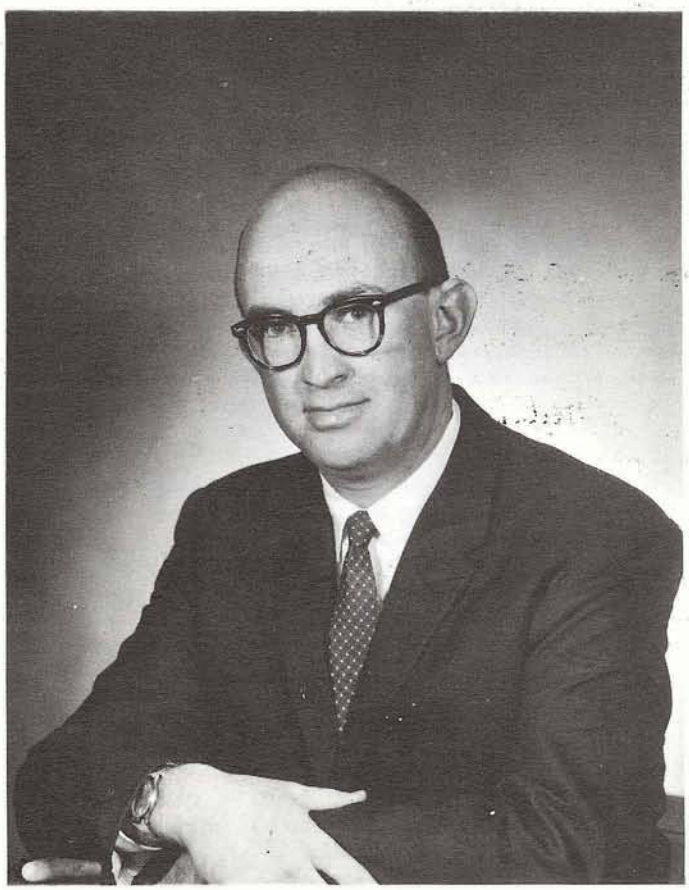
computers and automation

INNOVATION IN TEACHING – WHY INDUSTRY LEADS THE WAY



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INNOVATION IN TEACHING — WHY INDUSTRY LEADS THE WAY

"If in a company 500 technicians must at present spend four weeks per year in school to keep themselves up to date, and if a new education method can cut that time to two weeks, a reasonable estimate of the saving to the company is $300,000. To generate a similar amount of net profit, most companies would have to sell at least $3,000,000 more of their products and services."

In California, about 1961, an electronics firm introduced a new teaching method and reduced its engineering training program from six months to three months. Veteran company engineers soon asked to be allowed to enter it. They saw they were missing something.

In Nigeria, in 1964, a group of 50 Africans from six nations was seen studying 10 to 14 hours a day, month after month, using a new method.

In Belgium, in 1966, one instructor conducted two classes, covering two slightly different technical subjects in two different languages, simultaneously, using a new method.

In Canada, in 1966, a young man started conducting a six-week technical class for twelve students who had a better formal education than he. He'd never taught before, and he had less than a week to prepare. Most students finished the course in less than four weeks. The students thought the class was a great success. The teacher enjoyed every minute of it. He used a new method.

Not more than a handful of dedicated "industrial educators" (perhaps not even the man who started it all in California) are aware of the significance of this chain of events. This new teaching method is one of the innovations produced in industry education, and will be discussed more fully later.

The Lecture Method

But first, let's look at the conventional, centuries-old method of instruction — the technique most familiar to all of us — the "teacher-in-front-of-the-class" approach. Let's call it "the lecture method." (Although the term "lecture" has certain unpalatable connotations in industry education, it's still a fairly accurate description of what usually happens in classrooms, regardless of what's being taught.)

To start with, let's consider the assumptions that a teacher is required to make before he steps in front of a class and begins to "lecture":

1) The group is ready to learn.
2) The group is willing to begin where the teacher wants to begin.
3) Each student will learn at the same pace as the other students in the group, and will be able to keep up with the teacher's presentation.
4) Students will learn the material in the sequence in which the teacher presents it.

"Unrealistic," you may say. Right! Yet, no teacher can conduct a lecture class without assuming these conditions. The instructor's success with his class depends upon his ability to cover each topic in such a way that each individual is able to learn it — now, in the given sequence — in the time allotted for the class.

Result? A tremendous variety of successes or failures, depending upon many factors: the teacher's skill, patience, and knowledge of the subject, the number of students in the class, the similarity of their backgrounds, knowledge, intelligence, etc.

Your next question might well be, "If that's all true, how come the lecture method is still the most common method of instruction?"

I think the key reasons rest with the teachers themselves, and the emotions that motivate them to be teachers.

Teachers are smarter than most people, and they're strongly motivated to leave their mark on society by contributing their knowledge in the way that seems to affect the most people. They get their greatest satisfaction from seeing their students grow, change, and improve under their guidance. The vast majority of teachers thrive on their emotional role in the personal teacher-student relationship. Being human, they usually love to lecture. It seems the easiest way to prove that they know their subject. (Incidentally, for those who really know their subject, and who have been teaching it for a long time, lecturing requires very little pre-class preparation. That leaves time for study, research, student counseling, and other, less dedicated pursuits.)

Naturally, when someone comes along who advocates that teaching might be more effective by using other methods, most teachers react negatively.

Educational Systems

But the teachers are not the only ones to blame. Consider the entire public educational system. It still places emphasis on the very valid idea that a student must not be sent to

college, or out into the world, until he is mature enough to cope. (One obvious alternative, to teach a lot more in those thirteen years of preparation for college or leaving school, has been exploited considerably in the past decade, to be sure.) This objective is fine. But how do you evaluate a student's education with this intangible objective as a criterion?

Let's switch our thinking now to what we will call the industrial education system, the system of adult education usually provided by an employer. To avoid clouding the issue, I won't attempt to differentiate between education and training.

Industrial Education Methods

How is industrial education different? To the casual observer, the differences seem to be largely the subject matter and the age of the students. Plus the depressing fact that industrial teachers are often higher paid than the best paid teachers in our nation's public schools.

To the experienced educator, there are still greater differences. In industrial education, there is great emphasis on the quality of instruction. But the purpose of industrial education is "high quality, at the lowest possible cost, and with the greatest possible speed." And in industry you can usually measure your results.

Quality

Take the quality factor. Since most industrial education means teaching a specific skill, it's usually easier to determine if the student is able to do the work when he's finished. Either he can operate a lathe or he can't. Either he can use a desk calculator or he can't. Not all subjects being taught in industry are by any means as "yes or no" as those examples; but it's regularly easier to judge the effectiveness of industry teaching than it is to determine if a youngster is ready for college.

I am not saying that the industry educator does not face problems. Here are some factors that tend to complicate the quality judgment in industrial education programs:

1) Since education is frequently regarded as a "necessary evil" (that means it's not a direct revenue producer), it's hard to find a top executive who is willing to pay much more than lip service to the activity.
2) Not very many companies have an "Education Department". The function often rests with a particular department manager, or one of his designees, who regards education as an additional duty.
3) Even in some of the best organized industrial education departments in the world, it's not easy to find someone who's had formal training in schools of education. (Before you become too concerned about that fact, however, remember that only a small percentage of university teachers have had such training.)

Cost

What about the factor of cost? In public education, the taxpayer is at the mercy of the school officials (although they would have us believe it's the other way around). "Sure," you say, "but our town has turned down school budgets and bond issues." Let me express it this way. As I see it, the taxpayer is thoroughly boxed in. He wants his Johnny and Susie to have the best education possible. But the real problem is — he knows nothing about education. He is forced to rely, for the most part, on elected officials to represent him. If his local school board consists of people who are trained or experienced in school administration, his community is fortunate indeed.

In industry education, costs are also difficult to control, but there's one all-important difference. There's frequently a comparison available between the total cost of hiring people who have the required skills, and the total cost of educating people who don't. That comparison is continually being made, and it doesn't require any education expertise. It serves nicely, moreover, to keep the industrial educator honest.

Speed in Industrial Education

What about the factor of speed? It's clear that time is the greatest contributor to cost. Total teaching salaries, student salaries and classroom space are affected. But there are more subtle items also. What about student living and travel expenses if they must visit a distant location for training? That cost alone can easily become 50% of a company's total "per student" training costs. But by far the most subtle and important consequences of the speed factor may lie in its effect on the size and cost of a company's workforce. If in a company 500 technicians must at present spend four weeks per year in school to keep themselves up to date, and if a new education method can cut that time to two weeks, a reasonable estimate of the saving is $300,000 (see Chart 1). To generate a similar amount of net profit, most companies would have to sell at least $3,000,000 more of their products and services.

Speed in Public Education

Let's speak again of public education, for the moment. We've commented on the good job the schools have done since Sputnik in 1957 woke us up to the need for better education. But if you want to contemplate a really significant effect on teachers, students, and your annual school tax bill, how about having society accept the idea that a youngster is as adult today at 17 as he was 50 years ago at 18? It should follow then that he can enter college at 17. (Plenty of them are doing it right now.)

So why not bring the speed factor into public education? Let's eliminate one calendar year of school, but let's not do it by shortening the holidays, or by working longer hours, as recently announced by a Long Island school. Let's do it, as a well-known IBM executive is fond of saying, "By working smarter, not harder." If that sounds like a ridiculous idea, keep in mind that eliminating one entire school year constitutes an overall reduction of only about 8% in total school time required for our youngsters.

New Teaching Methods

Earlier, I commented that most teachers react negatively when it is suggested that there might be teaching methods which are superior to the lecture method. But, on the other hand, many top educators do realize the need for innovation. Dr. Mark Scurrah of the New York State Education Department Center on Innovation said in a recent speech, "We are terribly unimaginative as teachers. We seem to feel that talking is the only way to impart knowledge."

Why is it, then, that much more innovation occurs in industry education, especially since so few industry educators are trained as educators?

I believe that one important reason lies in "the system." (Don't forget the purpose of the industry education game: "High quality, at the lowest possible cost, with the greatest possible speed.") Every true educator is striving for quality, in public or industrial education. Cost and speed are simply more important in industry than in public education. Let me add two more examples that illustrate the importance of speed.

Chart 1

Company F's maintenance staff includes 520 technicians, who must spend 4 weeks per year in school to keep themselves up to date. How many technicians are required if this schooling can be cut to two weeks -- all other factors remaining equal? At present, 520 workers x 48 work weeks = 24,960 total work weeks. If each technician can work fifty weeks, instead of 48:

$$50 \overline{)\ 24.960}\ \ 499 \text{ technicians required}$$

The expense of keeping those 21 extra technicians on the payroll can easily look like this:

21 salaries @ $8,000	$168,000
2 supervisors @ $12,000	24,000
Fringe benefits @ 15%	28,800
Floor space for 23 people, 100 sq. ft. each @ $5.00 per sq. ft. per year	11,500
Tools, equipment, etc. @ $200 per technician	4,200
	$236,500
Miscellaneous overhead (10%)	22,650
	$259,150

And what about training costs:

Eliminate 500 students for 2 weeks each	1,000 weeks
Then -	
Eliminate 21 students for 4 weeks each	84 weeks
Savings =	1,084 weeks

A cost figure of $50.00 per student week would be very low for most training operations, not including travel and living expenses.

	1,084
	x$50
Training cost saving	$59,200
Payroll cost saving	259,150
Total Saving	$318,350

The Value of Saved Time

Company A has an 18-month training program for newly hired salesmen. The sheer length of that program may have a direct bearing on that company's efforts to hire top candidates. Few fresh college graduates, especially those holding advanced degrees, are interested in entering an 18-month training program if they can avoid it. Usually, it simply means more delay in starting to earn "the big money". A substantial reduction in the length of that program, provided quality is maintained, might do more than any other single thing to raise the quality of that newly hired sales trainee, and thus, eventually improve the quality of the entire sales force.

Company B produces a specialty electronic product. It has a highly trained staff of technicians to service and maintain its product. The engineering department has developed a greatly improved version, and it is estimated that, when they start shipping it, profits will increase by $1,000,000 in the first year. But before it can be released to customers, the technicians must be trained. All else being equal, if the training program can be cut by one week, it might mean as much as $20,000 added profit, since shipments can begin one week earlier. Not to mention the cost savings resulting from the reduction in the training program.

Nearly all large organizations can cite better examples than these which will show the dramatic impact of reducing the length of their training program. Why not develop a similar rationale regarding public education?

The Difficulty of Bringing Students Together

The second important factor spurring innovation in industry education lies in the simple idea that it's frequently extremely difficult to bring students together for a class. After all, they have jobs, family responsibilities, and other demands on their time. Then too, there's the continual problem of the company "crisis du jour", that arises to prevent a key person from attending a class. These complications lead to all sorts of interesting methods to make certain that students make it to class as scheduled. One company often gives a student a day or two off, prior to class. They tell him they want him to be "fresh and alert". The fact is, however, it's nearly a foolproof method to get him away from business problems that might prevent him from attending class.

A third factor in encouraging innovation in industry education is the sheer physical problem of assembling students. That may involve high expenses in student living and travel and more lost time due to travel.

Unlike public education, industry education is frequently a "crash program", for many reasons like Company B's problem of preparing to market a new or improved product. There's also the frequent requirement to take a segment of a company's staff and give it a "one-shot program."

- Example: A company manufactures radios. They switch from tubes to transistors. A new technology must be taught.
- Example: A company introduces electronic data processing. Every executive and manager, not to mention every employee in affected areas, must be given an orientation program.

In these cases, adequate classrooms are frequently not available, and instructors are almost never ready and waiting.

The Student Himself

A fourth factor is the student himself. He is frequently unprepared, unmotivated and uninterested (just like some youngsters of our acquaintance), but the adult student is usually much quicker to react vocally to poor instruction.

Also, to complicate things further, the older we are the slower we learn. Therefore, the teaching method must be more challenging. If you don't believe this, try a little research in a typical education department. Examine two or three classes where the students were ranked in performance. Compare those rankings with the "age ranking" of the students. The youngest will often be grouped at the top of the class, and the oldest at the bottom.

A fifth factor that contributes to the urge to innovate in industry education is the character of the education staff itself — the managers, developers and teachers — whose motives may be considerably different than public educators. Let's examine this factor carefully:

1. Few industry educators consider education as their "career." For most, it is another in a series of diverse assignments.

2. Industry teachers seldom spend more than 50% of their time in class, actually teaching. For some assignments, 20% is considered a "full-time" teaching load.
3. Only a small percentage of industry teachers have taken education courses at the university level. Even fewer are, or have been, certified to teach in primary or secondary schools.

Let's imagine what goes on in the case of a bright businessman who is selected for a teaching assignment in his company's education department. First, he is aware that most of his predecessors have stayed in education for a relatively short time, perhaps only two or three years. The good ones have then moved on to better jobs. He also realizes that he's never taught before, except perhaps as an incidental part of a former job. Finally, if he's ambitious and bright, he knows that he must do something extraordinary in order to assure recognition and commensurate reward. This last thought is common to nearly every known situation. But remember, the industry educator is in a system that allows him to exploit his opportunity to excel. In that sense, he's in a considerably different position than a public school teacher. He realizes that to excel in teaching is expected. Perhaps, therefore, he begins to seek new and better ways to teach.

Innovative Methods of Instruction

What methods can he choose? A whole host of new and different techniques have come into being in the past 15 years or so. Most famous for several years was Programmed Instruction (P.I.), developed by B. F. Skinner of Harvard. Today it is Computer Aided Instruction (CAI) that makes the headlines. In between were many variations on the theme, each with some applicability in the education scheme.

Through nearly all of these innovations in instruction are some common threads:

- The student can learn on his own, rather than in a group.
- The student sets his own pace.
- The material is carefully structured in order to minimize the time required for learning a given amount of information.
- The student is actively involved in the learning process — he's not just sitting there listening.
- The student is kept abreast of his progress, or lack of progress.

At this point, think of a "new" teaching technique you are familiar with, in terms of those five factors. Do they all apply to the technique you picked? Probably. (How about "the book" as a means of learning? It fits every factor, except possibly the last one.)

There's another characteristic I didn't list that is common to nearly all of these techniques (including "the book"). There's no personal interface with a human teacher.

Job Security of Teachers

It's not hard to understand why teachers might resist these new methods. Their resistance should ring a bell with lots of us. Let me explain why by asking you a question. What is the usual reaction when employees hear that their company's getting a computer? Any fleeting worries about job security? Of course! With some it's more than a fleeting worry.

When the job security of any group is threatened, for whatever the reason, there is a natural resistance from the group. Why should teachers react differently when a new concept seems to threaten their security? I think I can hear you saying, "But very few people lost their jobs because of computers. In fact, there are more jobs now than ever, and unemployment is very low."

Right. And new teaching techniques will undoubtedly, in time, produce the same results. A result that is common to nearly every innovation introduced since the first prehistoric man hooked up a crude wheel to a cart.

But let's think back to another fundamental point that goes beyond job security. Remember our earlier discussion about the motives that teachers have, and the satisfactions that they derive from being teachers? Guiding students in their growth. The personal student-teacher relationship. The love to lecture. Now we're arriving at what I believe is the true source of teacher resistance to new teaching methods.

The real effect of innovation in the Industrial Revolution and the Computer Revolution was job displacement, not job replacement. Stagecoach drivers learned to drive buses. Wood carvers learned to operate wood lathes. Clerks learned to program computers. Now the Teaching Revolution is upon us. What will the teachers do?

Did you nod in agreement when I said that teachers are smarter than most people? If so, you might now agree that if a teacher can continue to gain personal satisfaction from his work, he'll probably continue to teach. So, let's consider one more factor. Dedicated teachers are often frustrated by their inability to give adequate attention to each student, especially in these days of over-crowded schools. They would love to pull the under-achiever up by his bootstraps, and push bright ones on to greater heights. But the class is too big, and the teachers have more material to cover than ever before.

Learner-Controlled Instruction (LCI)

These same positive and negative factors existed in California, in Nigeria, in Belgium and Canada. And in each case, an industry educator decided to try something new, a technique which at first glance doesn't seem new at all. Dr. Robert Mager pioneered this technique at Varian Associates in California in the early 1960's. He called it Learner Controlled Curriculum. I introduced it in IBM in 1963 and labeled it Learner Controlled Instruction. Here's how LCI works:

Each student is given a detailed list of specific "learning objectives." He is given suggestions for reading, reference, observation, inquiry, practice, or experimentation. He is told precisely how he must demonstrate that he has learned the subject at various stages (if appropriate) and when he has finished. He is advised that he may direct specific questions to the instructor in private, and that he will receive a specific answer. He is informed that there will be no formal class session, and that he may begin to learn in any manner he chooses. Finally, the student is told that, when he has completed all requirements, he is free to return to his job. He is then directed to a quiet place to study and the instructor establishes himself in a convenient location.

Please read that paragraph again carefully. In it, the essential ingredients for the success of LCI are stated precisely. The same technique applies equally well, by the way, for groups of students.

Categories of Subjects to Be Learned

Before we go on, let me remind you that there are two broad categories of subjects that we learn in life. One broad group consists of specific skills — mathematics, engineering, the sciences, machine operation, and computer programming, to name a few. The other broad group generally centers around the idea of changing a person's attitude or outlook — music appreciation, salesmanship, and public speaking, for example. The technique I've described is remarkably well

suited to the "skills" group of subjects, but the "attitudes" group of subjects may be taught best by some form of active voice communication between teacher and student. A natural tendency is to consider most borderline subjects as unsuitable for LCI-type techniques. That may well be the same kind of error that was often made when determining if a certain task could be done by a computer. We're still amazing ourselves with the things computers can do.

Why a Student Likes LCI

Why does a student like LCI? That's easy. He studies when he feels like it, and he day-dreams when he feels like it. (The fact that he may leave whenever he finishes, is sufficient motivation for 99% of the students.) He can proceed at his own pace, in other words.

He can select his own best method of learning. He might choose to read, experiment, observe, ask questions, or, more likely, a combination of those methods.

The student can start his learning at whatever point he wishes. And he may choose any sequence of topics that he wishes (where appropriate). These two points are extremely significant, and they are based on the simple idea that no student is completely ignorant of a subject to be learned. Each student, in other words, has some point of departure that is unique to him. That puts him in the position of being the only person who knows at what point, and in what sequence, he should begin to fill in the gaps in his knowledge of the subject. These two points also are the key items that are not taken into consideration by any other "automated" teaching method with which I am familiar, although Computer Aided Instruction (CAI) has the potential to assist the student in this regard.

Computer Aided Instruction

Speaking of computers for the moment — let's ask the question, "Does the LCI technique exclude the use of automated instruction techniques"? Not at all. Variety is the spice of student life, too. An industrial education center in San Francisco is using computer terminals, video tape, programmed instruction, and audio tape in various combinations for various subjects. The student comes to regard these devices as simply another reference source. He may find himself turning to any one of them to watch, or listen to, a short description or explanation of a particular subject, in the same manner as he turns to a book or a reference manual. The important difference is that he chooses the medium, and that he has the instructor to turn to when he's stuck. Programmed instruction (PI) and CAI does not usually accommodate those two ideas. I look forward to the day when it does.

What is the reaction of the student to LCI? Nearly every student I've talked with dreads the day when he must return to "conventional" learning methods. Enough said.

Why a Teacher Likes LCI

What is the effect of LCI on the teacher?

From the start, the teacher never concerns himself with preparing his lecture. Rather, he is deeply involved in defining what is to be learned, in stating it clearly and logically, and in gathering materials that will contribute to the student's ability to learn. He soon discovers that a well-written definition of the learning objective leads him almost automatically to the point where tests, or other methods of verifying the student's knowledge, can be prepared relatively easily.

The teacher also discovers that his conceptual knowledge of the subject is more important than recalling precise details. I once taught a complex technical subject in LCI mode, which I hadn't studied or worked on for four years before walking into that class. But because my conceptual knowledge was sound, I could answer questions easily.

Still another effect on the teacher, of course, is the idea best expressed by a man who pointed out that LCI enabled him to concentrate his efforts on the individuals in the class who most needed the instruction. This deceptively simple point scores highest with teachers who scorn PI and CAI.

Selection of Teachers

There's another important effect, not only on the teacher, but on the selection of the teacher. When using LCI, the main prerequisites for teacher selection change considerably. The principal emphasis should be on locating someone with a high level of competence in his subject (I didn't say "education," I said "competence"). The LCI teacher does not lecture. Therefore, his ability to stand up in front of a class and articulate is simply not important. Every public and industry education administrator will appreciate the impact of that difference. His job of finding qualified teachers is different, and easier.

How can we summarize the choice of methods up till now available to a teacher? On one side of the teaching ledger is the lecture method. On the other side are Programmed Instruction and CAI. On the one side, the teacher feels that he is everything — on the other side he feels that he is nothing. In the middle lies Learner Controlled Instruction and other new methods, with much fertile ground for improvement.

The challenge of the next decade requires that all educators concentrate on researching and developing instructional methods that stress a closer personal relationship between student and teacher. If that goal is made clear, I believe nearly all teachers will join in the search, since they won't be worried about developing methods that essentially eliminate their lecturing jobs. Further, more competent persons may be attracted to the teaching profession, because the prerequisites will undoubtedly change.

Learner Controlled Instruction is only one innovative technique. There are many more, yet to be discovered, that serve the specific mutual interests of both student and teacher. The consequences of using such teaching methods could be a marvelous and revolutionary change for the better in education. ■

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