knowledge wave 2003

the leadership forum

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20 February 2003

Presentation to Knowledge Wave 2003 – the Leadership Forum
February 2003

"Presentation also available on Forum website - www.knowledgewave.org.nz"

KNOWING, UNDERSTANDING, TEACHING, AND COMPUTING

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INTRODUCTION

The other speakers here are an impressive group of highly *knowledgeable* people. That is, they know a lot about some field or group of fields, which they can and do inform *you* about. In that way, you acquire some *knowledge* about those fields. But of course, you don't finish up in the same state of knowledge as them. We might say that after hearing them you now *know more* about those fields than you did before; but they, by contrast, *understand* those fields. It's a distinction we make all the way through the process of education. We begin by learning something—we might learn that car engines lose power at high altitudes, and gain power in wet or cold weather: we end up, so our teachers hope, by understanding why this is so. If we develop real *depth of understanding* then we might be able to work out why the loss of power at altitude is less than the gain from the drop in temperature that occurs at that same altitude. I'm going to talk to you about that difference, the difference between knowledge and understanding, because what I'm hoping to get across to you is not a sense of the *content* of knowledge about some field or fields, but knowledge about *the nature of knowledge itself*--and the nature of understanding itself.

Now, that may sound a little on the abstract side, but I will quickly prove that's not so, because I'm going to show you a couple of highly practical results of the distinction. First, the difference between knowledge and understanding, far from being a matter of merely academic interest is a difference that keeps *you*, standing on your own two feet, from dying today--a fairly practical matter. Second, that same difference between knowledge and understanding provides you with one of the few straightforward ways to

make a million dollars--without laying out several million dollars as an investment--that are floating around in the ICT domain these days, also a rather practical matter.

KNOWLEDGE VS. UNDERSTANDING

The essential difference between knowledge and understanding is this. If you *know* something, say the date of your birthday, you have information stored in your brain that puts you in a position to answer a specific question, namely, What is your birthday?, or simple translations of that, e.g., On what date in the year were you born? If you *understand* something, e.g., why internal combustion engines lose power with altitude, then you are in a position to answer a wide range of questions about that specific topic, e.g., what's the loss in power for a doubling of altitude, and you are quite likely to be able to answer, or work out the answer, to questions about a number of related topics, e.g., will they lose power, or gain power, or not be affected, if it starts to rain in their environment . That's one practical reason why understanding is much more valuable than mere knowledge; it equips you to deal with unforeseen challenges that come up. In a world where the demands of a job have quickly moved from being something that are fairly stable across a lifetime tenure to something that changes radically every few years and sometimes faster. So understanding is a strong requirement for job preparation.

In some of the sloppy attacks on testing, one sees it said that testing only tests for knowledge; but that just shows ignorance. Good testing also tests understanding and that can be done perfectly well even using multiple-choice test items, although there are now some other test types that do a better job in some cases, e.g., the multiple-rating items. Of course, essay tests can easily test understanding but they are very expensive to mark, and even more expensive to mark in a consistent and valid way. The multiple-rating item is interesting because it can be machine-scored, just like the multiple-choice item. But that's just an aside to a general point which is that the *nature of understanding* is to be able to answer questions to which the answer has not been directly learnt. So it is impossible to develop reliable measures of understanding without testing.

However, this audience mostly comprises people that have somehow managed to obtain a job, and keep it for a while. My case for understanding as a key to survival does not rest on the need for it in order to get and keep jobs.

The underlying reason for the importance of understanding is much more urgent. It is this. Our sensory apparatus carries information down the optic and other nerves into the brain in an astonishing volume. Ignoring all senses except sight, rough estimates suggest that the optic nerve would fill the brain's straight information storage capacity for bits of information *within a day*. After that day, you would not be able to learn anything new. In particular, you would not be able to take in the fact that a bus is bearing down on you as you cross the street, and so you would be dead. The brain has evolved some commonsensical ways to cope with this everpresent threat of overload, and the success of these strategies is the secret for homo sapiens still being around. For example, it stores constancies, i.e., regular patterns, instead of individual events. This is an interactive process with the optical sensory system, and means that after I have quickly scanned this room, my repeated glances at the audience only register changes, whether they be movements or variations in facial expressions or murmur level. This cuts the intake load by more than 99% and is all that I normally need for survival. That's one of our perceptual strategies at the level of our animal faculties, shared with every creature to a greater or lesser extent.

As we move into areas of experience and survival where our brain becomes more important, the same lesson applies. The scientist looks for regularities, becomes famous if s/he finds a new one, and then works on explaining the deviations from the regularity. That famous sometime Otago kiwi, Sir Karl Popper, analyzed the scientific approach in terms of the search for exceptions, for counterexamples to generalizations. He oversimplified the process considerably, but an insight remains; good thinking consists partly in looking at what claims rule out rather than what they rule in. The exceptions don't prove the rule, nor do they, as Popper thought, disprove it; but if nothing can disprove the rule, the rule is trivial, it says nothing that we ever denied nor could deny, it adds nothing to our store of knowledge.

You can probably begin to see where understanding a.k.a. comprehension, fits into all this. Understanding is the thinking person's lifeline to survival. It's what protects you

from being blind-sided, not by a bus, but by that little dark mark on your arm where you used to get sunburned when you were a kid. Take a little trouble and learn how to understand the difference between freckles and basal cell or squamous cell abnormalities and melanomas, and you get early enough treatment to survive. Just observe without thinking, acquire knowledge but no understanding, and your chances go to hell.

Understanding what your body is telling you, like understanding what your car is telling you, or your business is telling you, is the path to survival. And it's quite likely none of that stuff was in your Year 12 textbooks. In other words, being a lifetime learner, not just acquiring knowledge, but acquiring understanding, pays off very handsomely indeed. A number of years ago, I was able to prove a kind of heuristic result along these lines, called (rather grandiosely) the Comprehension Theorem, that showed roughly that understanding is the most efficient way to store knowledge in the brain under the conditions of information overload that we know exist there. So we need to view understanding as a survival requirement that lifetime education, not just education while you're in school, must keep moving you to achieve.

So much for a superficial look at the basic cognitive science of understanding. Let's now turn to the business of how to *teach* for understanding, which is the great challenge for the teacher. Oh, yes, and that little item about how to make a million from getting serious about understanding. As you'll see, the two come together in an interesting way.

ELECTRONIC KNOWLEDGE & UNDERSTANDING

We can begin our look at how to make money from the electronic aspects of knowledge and understanding with a brisk overview of some of the details of the computerization of knowledge tools and domains. We all know what giant steps forward have been made in the acquisition of insight—the Eureka flash that marks the acquisition of understanding—and the mastery of skills by the development of mighty tools for data analysis like Mathematica, and for knowledge representation, from the humble PowerPoint to the use of virtual reality in the simulation training devices used by the Air Force and NASA and merchant marine training of tugboat captains. All of these are part of what we might call the apparatus of electronic epistemology, the computerization of the theory of

knowledge. The question we want to ask ourselves is, Are there still some niches in this geography for the New Zealand entrepreneur to fill in?

A. Knowledge engineering, the great skill of extracting from experts the principles of inference on which they are relying, largely unconsciously, in moving from data to their expert conclusions. This is the key to developing expert systems (a.k.a. artificial intelligence) that can match the accuracy of the expert, as has now been done in many areas, e.g., most notably medical diagnosis and most secretly, drilling for oil.

B. Artificial intelligence and expert systems

C. Knowledge management

D. Informatics (adapting Coiera's definition[1], this is "the study of how knowledge is created, shaped, shared and applied")

E. The conceptual foundations of computer science, still in need of considerable further work

F. Interface design, especially adaptive and graphical user interface (GUI) design, and web page design, still in a primitive state in matching form to function

G. Information strategy and policy (in organizations or disciplinary areas such as geology and medicine)

H. Information ownership (the legal issues around copyright, 'hiring to invent', etc.)

I. Information presentation, especiallyinformation architecture (1975) & 'informing science' (1999)

J. Evidence-based knowledge vs. expert-based beliefs (the current war/revolution in medicine, social engineering, and most recently education)

K. Search engine, browser, directory, and index design (this includes, for example: the use and abuse of metatags, other types of spider-deception, web intelligence,

accessing the invisible web, blog-mining, automatic cataloging, competing measures of use e.g., hits vs. click-throughs)

L. Web information uses; (e.g., data warehousing, web locating of common apps—Microsoft's latest dream for increasing its income), local government historical records (births, marriages, deaths), blogs, (i.e., weblogs)

M. Information literacy and computer literacy (problems of content as well as pedagogy, forms of delivery, etc.)

N. Computer-assisted instruction, testing, and learning

Since there is now a substantial number of books on most of the subjects in the above lists (in some cases amounting to small libraries), and indeed, in most cases, professional associations dedicated to their furtherance, we're not going to get much else done if we try to start with a survey of the state of the art under each of the above headings. However, we can skate lightly over most of them, and bypass the technical jargon and esoteric details, if we look for the underlying questions that generated them, which include some that they have not yet dealt with, at least not with any success. That means trying to think about such issues as the following:

1. How to improve the ***representation*** of knowledge in computers
2. How to improve ***access*** to that knowledge (the GUI issues)
3. How to improve ***teaching and learning*** the mental skills needed to access ***and assess*** that knowledge, not just in school but also in later life, and
4. How to improve the way we ***connect that knowledge to true understanding***, a more complex and sophisticated intellectual achievement than 'mere' knowledge. The goals of education are often said to be closely tied to an emphasis on understanding *rather than* mere knowledge: we can ask ourselves just what that means in terms of electronic storage and retrieval.

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[1] Enrico Coiera, ***Guide to Medical Informatics, the Internet and Telemedicine*** (Lon-

I'm also trying to narrow our focus in the direction of answering the following question of particular interest to us in New Zealand:

5. Apart from enlightening ourselves and the rest of the world about the topics above, a noble but somewhat unrewarding enterprise, are there any ways in which we can develop practical applications based on our analysis of these concepts that might enable us to take a leadership position in the market for computerized knowledge tools? The invention of the spreadsheet was an example of this kind of thinking, and it was rightly called a 'killer app' (i.e., a breakthrough computer application), not to mention an invention that generated a few billion dollars. The connection to education in this example was also extremely intimate, since the spreadsheet was invented by someone who was a graduate student at the time, as a way to simplify an enormous task that had been set as homework by an accounting instructor at MIT, the Massachusetts Institute of Technology. I won't guarantee to produce examples of quite the same market-shattering importance, though I think I can come close. For the most part, I'll just be trying to help us move in that direction. To do that in the long term will require attention to the educational aspects of this issue.

IMPARTING KNOWLEDGE & UNDERSTANDING: THE EDUCATIONAL ISSUES

The last two items, M and N, in the alphabeticized list are different from the others: they refer to *developing* the *human's* knowledge resources rather than developing the *electronic* ones. Unless we have a citizenry that can and will use the inventions and conceptions in the earlier part of the list, and, even more importantly, a citizenry that will invent new ones and new twists on many of the existing ones, then even our own breakthroughs in electronic knowledge won't benefit us, that is, this nation.

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don: Arnold, 1997)

Now, for many of us, serious study of most of these topics was not in the curriculum we were coveredin school or at the university. Yet they contain much that is of great importance to most of us in the information age. Hence one of the fairly urgent issues we need to look at in reviewing the national response to these huge new *and* fast-changing areas of knowledge that are so close to the cutting edge of both scientific and business developments today, is what to do about updating the knowledge of the citizenry in these areas. Citizens not only need to have at least a general understand of what they are voting to support (or not support) with some of their taxes, but they also need to know about these areas in order to get jobs in them, and, more importantly still for New Zealand, make significant contributions to the state of the art. Of course, there is the obvious need, already partly met, to provide appropriate courses in the senior years at school (or earlier) and at the university level (for both prospective professionals and interested adults), and a need for ongoing education and training efforts in the workplace. We should make a considerable effort to get much of this information online, not—as has so often been the case—by treating the task as something to be relegated to juniors with a tiny budget, but as something that is incredibly challenging, requiring the highest level of both art and science.

But it is necessary to do much more than this. Ted Hesburgh, then President of the University of Notre Dame, saw this long ago and puts it very well[2]:

> I do not believe that the global education problem is solvable by conventional means: the building of classrooms in remote areas, and the preparation of a vast array of teachers. Very affluent countries may continue to pursue education this way, but even we in America have, almost without realizing it, created a vast system of unconventional continuing education that today serves to educate more people than the conventional system, ranging from kindergarten to the university. We have certainly come to the time when we need to entertain some new and creative thoughts about the total enterprise of education, especially as

[2] In ***The Human Imperative***, page 65, Yale University Press, 1974

it affects the less developed countries, which will become comparatively less and less developed without some new system of education.

Now it is true that we have often tried some alternatives, usually electronic, but usually with dreary material and negligible impact. It's time to give this approach our best shot, whether or not the schools and universities argue against invading what they regard as their turf. To give just one example of many, it seems clear that we need to undertake a serious *public broadcast* educational campaign through the media on a scale that is unprecedented, but that will surely become increasingly important in the future, as e.g., medical and agricultural knowledge is transformed by genome engineering. We've seen the small scale efforts in the health area, for example in attacking smoking, and pushing for HIV prevention and care, but we need to do more than that, with a smaller budget, and do it much better. There are a number of other dimensions for this extension towards the learning society, and no country—certainly not the US—is ahead of us in this effort.

In general, then, we should pay some serious attention to the extension and sophistication of our *public educational* strategy for those not in school. That means extremely talented reporting on television, radio, and in the newspapers, reporting made cumulative rather than episodic and excessively repetitive, and made interesting enough to intrigue the average citizen; and it also means distribution in some less conventional ways that have not previously been seen as respectable parts of media campaigns—I'll come back to them later. These approaches are not expensive; not dirt cheap but much cheaper than ignorance and inaction. The model for us has to be the America's cup team; they showed that it's possible through intelligence, dedication, and hard work, to beat outfits that had many times the funding and access to all the most advanced technological resources.

But all of this is fringe stuff; important because we need to make a total push here. Let's focus on the key issues, well presented by John Hattie. We need to be *engaging* learners, *helping and rewarding* teachers, and *covering* the right stuff.

What I want to say is simple. There is a way to make sure that the lowest quartile of school learners catch up to the international standards (let's call that Solution A) and

there are two ways to engage all students in the subjects they need to learn (Solutions B & C), and it's a way that makes life for teachers more attractive and makes teachers more effective. There is also a Solution D to the problem of teacher retention, that is not very original, and not cheap; but almost certain to work.

Let's begin with the tried and true. Solution C was set out very well here last year; it's the solution that Australia has adopted, with vocational education tied to work qualifications, built up by employers and workers, that can be earned before or after leaving school and that provide a good entry to good jobs. You've heard about it, and you know that it has proved very popular and successful. I think it has to be part of a general solution.

Solution D is a conventional solution to getting teachers to stay, or at least to come back after the great OE, and it's not dirt cheap, though it will save money compared with what the present system is going to cost us in terms of replacing the teachers we're losing. Solution D requires us to instal a decent system of teacher evaluation on merit, which means ignoring the failure of the bad system that was tried earlier and using one of the two or three well-supported alternatives, AND kick in a student loan forgiveness system that atarts after the first 4 or 5 years of teaching, evaluated by the end as good teaching, with a 20% forgiveness across each of the next 5 years during which the teacher rates as good to very good. This is a whole lot cheaper than having to train and supervise a new person for each one lost, given that the training takes about ten years, and it should be tried as soon as possible. As an aside, let me add that while John Hattie thinks the US' National Board of Professional Teacher Standards is a good model, I am less forgiving of its faults and would advocate one of two others that have excellent credentials, the Duties-Based Model or the Outcomes-Based Model.

But put those fairly conventional solutions aside. I'm going to focus on Solutions A and B, the ones that have not been seriously tried anywhere, *although we know they work*.

In other words, you rightly say, there's a catch, isn't there? Yes indeed there is; one in each case. In each case, there is an unreasoned prejudice against adopting these solutions, pretty much like the only recently overcome prejudice against allowing married women to be school principals in Western Australia, or women of any kind to be com-

mercial airline pilots. Now, however, we have come pretty close to the end of the road with the alternative solutions and we have not got a fix yet. While it's OK to try the conventional solutions C and D, it's unlikely they will be enough, and in any case, we should not take the substantial risk that they will not be enough. It's time to face up to the prejudices and go with the other approaches, not only because it's our future citizens that are at stake, but, if you'll forgive the mercenary touch, because we have a chance here to get into the market first with solutions that will sell by the millions in a world that's willing to be convinced by their success here (as we can tell by the success of one or two not-really-too-successful packages like Reading Recovery).

So it's show time. What *are* Solutions A and B? They both examples of putting the computers that are sitting around in schools, scarcely earning their considerable keep, to better use. (Yes, it's fine to teach word processing and spreadsheet and Internet literacy to students, but that doesn't take very long, and after that it's a bit like using a boat as a swimming pool for the toddlers.)

Solution A, which will teach almost anything to almost anyone (e.g., Maori to pakeha or to Maori, reading to non-readers, Zen and the art of motorcycle maintenance, etc.), is what's referred to as "highly interactive computer assisted instruction", which means instruction calling for a meaningful response every 20 seconds or less. Forget drill and kill; this is not it. This can be introduced on three scales with corresponding levels of investment: (A1) is a print version, with near-zero investment over the printing costs, (A2) is a small scale approach using computers (ideal for NZ, investment in the mid-thousands because the work has almost all been done), and (A3) the large scale version (the Bork plan, outlined in his 200 book, Tutorial Distance Education, currently under consideration by the World Bank). You will of course have two big questions about this approach. (i) How do we know this will work? Details will be supplied when I present this, to the extent that I have time in the paper, and more details in response to questions from the panel.

Question (ii). What was the prejudice that kept this approach from being used before now, to save a few million kids from growing up illiterate? Simple; it got crosswise of the teacher unions, probably seen as a threat to jobs. But that's not our problem here, and in any case it's based on a grave mistake since it's a teacher supplement not a teacher re-

placement. Let's contrast the role of the teacher when supervising a class of students working on a good CAI program, with the present situation...

Unconventional Solution B, which will motivate almost anyone to learn almost anything, is equally simple and equally shocking to many sensibilities. It is to create educational games that are as much fun to play as any existing computer games, but which teach important material and skills. There's nothing very hard about doing this, if you go about it the right way. We have the evidence that it can be done in a few games like Where in the World is Carmen SanDiego?, and to a lesser extent, some of the slightly gamy instructional efforts like Reader Rabbit. But we're still up against the mentality that says school isn't supposed to be fun, that bans playing games on school computers, etc., and that gets in the way of doing this really flat out.

Let me explain to you what it means to go flat out towards making brilliant educational games. First, forget everything your banker ever told you about business plans, and everything your HR people told you about advertising for, interviewing, and hiring qualified candidates. You, perhaps in collusion with the Ministry of Education who aren't as stuffy as you might think, are simply going to run some competitions, and they are quite likely to be won by some geeky 14 year olds, who would give your HR department fits, except they'll never see them because they will never be on the payroll. The plan goes like this, beginning with the premise that nothing matters unless the game is *really* fun for kids to play. So you announce that there will be a competition with a lot of prizes, mostly donated by companies making some of the current hot games, but with a few cool things like motorbikes and small fast ski boats, also probably donated in return for lots of free advertising in the ads you are going to use anyway to get the word out, which represent most of your investment. The first competition is for 'proof of concept' that is, you will award prizes for the most exciting *ten minute piece* of a new game that teaches something valuable, using the standard basic hardware and software you'll find in the average school in NZ. The Ministry may help you identify a curriculum area where they would most appreciate some highly successful instructional material, or you may take teachers' or parents' or kids' advice on this; or both. A good case can be made for English, Maori, parts of science (or scientific method), and technology, just for a few examples.

Of course, entries may come from anywhere in the world. You are particularly keen to get small groups to enter from the best game designers in the world, and you know this will be a spare time project for most that do enter, though you are happy to encourage any of these small companies to have an official go—after all, it's their money and time they're investing. You're also very keen, as is the Ministry, to get some hot teams from NZ to enter, so you do a bit of traveling around to drum up trade of this kind, and the Ministry helps out with some people doing this in the course of their other duties. The games can be role playing games, action games, simulations, or any other kinds, yes, including shoot-'em-ups. We can have interesting discussions about the ethics of the gorier entries once we find out if they work better than any others; if they don't we have an easier way to handle the ethical issues, i.e., bypass them.

So you get 20 or 30 or 300 entries. Time to turn them over to the judges' panels. By now, you have guessed who the judges are going to be. Right: kids, and mainly but not entirely kids from the age group at which these games are aimed. Of course, there has to be a little organization of the kids, including some prior practice at judging (and making systematic suggestions to improve) existing educational games, and the running of at least two panels completely independently; no great problems there. And of course, some of these games should be aimed at adult learners, so for them there will be some adults on the judges panels.

Once we have identified out top four or five winners, we proceed to the second round. For this round, we pay those who undertake to proceed, albeit a rather modest amount, upon their completion of the next phase of the games, which is a one hour block of play (for the average player.) The main payment, however, is substantial, and is reserved for the first, second and third place winners. There will be some games that are played out at this point, games that set narrow sights in the first place, e.g., teaching the periodic table, or Pythagoras' Theorem. But, as entrants will have known from the beginning, some subjects take more than an hour to teach, even with the multiplier effect you get from games, and many entrants will have deliberately chosen those capable of major expansions to cover major fields of learning. And, as some of you may not know, good games will hook you from somewhere around 16 or 20 hours up to several hundred hours. Third round players have to make a big decision, which is to turn over the game

code at the end of the third round, which doesn't mean that they lose their advantage as game developers since they will have all the expertise that derives from their extensive practice in writing code. It just protects the ministry or the investor from catastrophe in case the group goes broke or breaks up. The third round provides funding for completing a working version of the game as covering the targeted subject, and marks the point at which preliminary, trial, marketing is undertaken. The time has now come, when we get this product, after we run it past our judges for quality assurance and refinements, for serious evaluation out in the schools, of at least the best two of the products we have managed to get developed. If successful, we can then consider extensions or sequels, as in Lord of the Rings or Harry Potter.

I won't go into all the further details. I've talked about some of the practical matters for two reasons. First, because I want to make it clear that there's something to be learnt here about the specific ways to deal with these novel approaches to our old problems. I am not, in short, arguing that one just produces breakthrough games as if they were can openers; success here does not run on the backs of old models of how to run new technology start-ups.

Second, I went into a few details because I want to generalize from this discussion to something about the curriculum for our schools and something about vocational training for our citizens.

I've been looking over the documents that define how we teach about technology in our curriculum in NZ. Now it's really important that we do have some coverage of this topic; there isn't any in US schools, for example. However, what we do have is notably defective in a number of ways, for example the failure to discuss the huge differences between science and technology in method as well as subject matter, the fact that technology antedated science by a million years although most people think that technology is pretty much applied science, the total dependence of our lives on technology although we'd hardly notice the elimination of all scientific research for decades, and so on.

the basic facts about of which I want to call attention to one that's relevant to our topic on this occasion, knowledge and understanding. If you want to educate a new generation of New Zealanders to provide a society that excels and continues to excel, especially

in the intensely competitive field of technology, then you'd better teach them how to evaluate this stuff. Product evaluation is the proof of concept in technology as elsewhere, and it is notoriously deficient in the training, even of engineers, let alone computer scientists or food scientists. You can imagine how pleased I was, therefore, to find a section on evaluation and asst in the Ministry document on Technology in the NZ curriculum. Silly me! It was only about how teachers are to evaluate and assess *students.* It's ironic that we have learnt the crucial nature of evaluation and assessment in education but that it should not have occurred to us that it might have a place in the subject we are studying!

How many times has each of us struggled with some new piece of technology and the inadequate instructions that came with it (if indeed any did). Of course, those bad instructions are usually written by the guys who designed the technology, on the excellent grounds that no-one else would know how to explain how it works. Of course those are just the wrong people for the job. Just as we used kids to evaluate the new educational games, we should use dumb consumers to evaluate instruction books and indeed the whole user interface of new gadgets. Obvious point; why not universally implemented? Partly, at least, because no-one bothers to teach engineers and inventors about serious evaluation of technology. It would save a lot of markets we lose now because the consumers can't understand how to use the product, it would save a lot of bad investments based on bad evaluation of potential products, and it would save a lot of potential repeat business if we did better evaluation before we complete the design of a product, its whole package (which includes the instructional manuals), and its marketing plan, i.e., if we trained the designers, the bankers, and the consumers to be better evaluators. Why are Toyotas and Hondas at the top of the reliability and durability analyses and Ford near the bottom? Because, in my oversimplified view, Toyota and Honda took product evaluation out of the hands of the engineers and put it in the hands of the production staff with strong input from systematically gathered consumer feedback, and forced the engineers to listen to the production workers discuss product quality, and actually respond to the consumer feedback, so that the cars were re-engineered for production and on-the-road quality. It's a revolution that cut GM and Ford in half, and they still haven't

learnt the lesson in it, which in my terms is, take evaluation seriously and the market will take care of itself.

You still think that industry does this pretty well? Let me tell you, if there's still time when I get to this point in the paper about the worst scandal in the history of computer technology, the productivity paradox... [details if time permits]

Product evaluation is s serious business, as you can tell from the road tests in automobile magazines or consumer product review magazines like Which? or Consumer Reports. It's something that needs to be taught in the schools, at least the rudiments of it, and it's probably one of the most cost-effective units we could put into the curriculum, if well designed; it could save every citizen hundreds of thousands of dollars and frustration during their lives. Well, the Ministry is about to begin a new review of the whole curriculum, so I though it might be worth a plug here, in case they get to see or hear these remarks at some point. After all, you wouldn't expect the new Professor of Evaluation to miss the chance to get something about evaluation into the new curriculum, would you?

For all of us, though, I hope that I've illustrated some ways in which some good solid critical thinking can still turn up ways to improve our educational system, our product development procedures, our investment plans, and our own personal life planning. I look forward to questions and challenges from the panel and the floor in that same spirit.

[6086 words]

Feb 11, 2003 – compressed draft