Rear-vision thinking - why it ought to stop

There are some golden opportunities ahead says
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Computers are in schools. This is an obvious premise. Gone are the halcyon days when we would discuss the advantages and disadvantages of computers in schools, the number of computers necessary to viably teach, which teachers are using them and whether they should be in labs or dispersed across classrooms. All fascinating questions, but it is time to move on.

We will have little success convincing our colleagues, students, principals, and Ministry officials if we persist in asking the above questions. We need to go beyond the conception of computers as tools and make contributions in fundamental ways. We need to say ‘no more’ the preponderance of papers that say “Here’s how I put a software package together” or “Here’s what I observed when we introduced computers into a class”. Such expositions may convince you and a few of your computer colleagues, but broader, more generalisable, and more research-based evaluations with clearly specified standards are required. We need to change the questions more adequately to reflect the use of computers in schools and, as researchers, be innovative rather than constantly looking through the rear vision mirror. We need to be more concerned about the different ways students can learn when using the computer, the pressures on students now and in the future when they use computers, the learning processes underlying present and future software, the power of various kinds of feedback, and the psychology of the interaction between students and computers.

The purpose of this paper is to defend three propositions.

Computers can enhance learning, but in general, they can only enhance learning as much as other techniques that teachers use.

To address the question as to whether computers are effective in enhancing learning, we need to concentrate on the points of comparison. Too often, researchers have assessed the effects on learning by comparing classes with and without computers. I suggest that this is an incorrect comparison. While such research is based on acceptable social science methodology that highlights the null hypothesis, it is also misleading as it makes a comparison with an unrealistic alternative. The more appropriate alternative is to compare the effects of computers with other typical effects of innovation.

The problem is how to ascertain “typical effects” given the myriad of effects on schools, different teachers, subjects, school administration systems, ages of students, and other moderators like gender, prior ability, etc. The determination of the typical effect cannot be answered with any one study. Rather, the power of a simple statistical revolution can be harnessed to summarise over 22,000 previous studies.

Let me start by introducing a continuum on which the effects of schooling can be summarised. On this continuum, the zero point means that there is no effect from introducing some teaching package, innovation, or effect on schooling. A negative indicates that the innovation etc. has a decreased effect on achievement, and a positive indicates that the innovation has an increased effect on achievement.

The aim is to place various innovations and effects of schooling along this line to identify the typical effects of schooling (and to identify the strengths, weaknesses and to allow for interactions). To do this, a scale is needed. The recommended scale is calibrated in effect-sizes. Cohen (1977) argued that an effect-size of 1.0 would be regarded as large, blatantly obvious, grossly perceptible, and he provided examples such as the difference between IQ of PhD graduates and high school students. It is extremely unlikely that we could find an educational innovation that systematically leads to an effect-size of 1.0. The difference between myself (at 5'11") and a person of 6'2" would equal an effect-size of 1.0. This would be easily detectable. The difference between myself and a person of 6'0" would be .34; difficult to detect, but would lead to some important differences such as size of clothes and length of walking stick. An effect-size of .34 would not, according to Cohen, be perceptible to the naked eye.

So, it is possible to devise a unidimensional continuum that can serve to place the various effects of schooling. The scale is expressed in standard deviation units such that 1.0 is unlikely although a very obvious change in achievement. This continuum provides the measurement basis to address the question of the typical effects of schooling. Altogether 22,155 effect-sizes were calculated from 7,827 studies, representing approximately 20-40 million students, and covering almost all methods of instruction, innovation etc. The key question is: “What is the typical effect of schooling?” The answer is .4.

Most innovations that we introduce in schools improve achievement by about .4 of a standard deviation. This is the benchmark figure. Most of what we do in classrooms should relate to improving education at least by .4 standard deviations, and preferably exceeding .4 standard deviations. This typical value is much more informative than the usual comparison figure of .0, and more meaningful than the ideals expected by some politicians, press writers and critics.

Let me now turn to the effect-size after introducing computers. It was possible to locate 557 studies that investigated the effects of introducing computers on students’ achievement. The average effect-size across these 557 studies was .31. Thus, compared to classes without computers, the use of computers was associated with advancing children’s achievement by approximately 3 months, improving the rate of learning by 15%, a correlation of .15, about 65% of the effects were positive (that is, improved achievement), thus 35% of the effects were zero or negative; and the average student achievement level after using computers exceeded 62% of the achievement levels of the students not using computers.

Of course, this is only an overall effect-size from introducing computers. There are many important moderators. For example, the effects decrease with age: primary students gain most (effect-size ≈ .48), secondary students have medium gains (.32) and college and university students gain least (.25). There are no differences in effect-sizes between males and females on achievement scores.

Thus, the effects of introducing computers in schools is close to the average effect of introducing most educational changes. So, those who wish to argue that computers are effective would say “yes” when compared to

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including individualised teaching or learning were systematically associated with small effect-sizes. It seems teachers spend little time per child during each day, there are few opportunities to provide feedback, and the time taken to structure the lessons may be better spent on managing other aspects of the learning environment (such as implementing peer tutoring). There is a correlate of individualisation that may be more critical, and that is feedback. Ideally, individualized programs offer more opportunities for feedback (particularly tailored to the individual when he or she has success, makes errors, or has incorrect misconceptions). Most individualised programs are abject failures in providing this feedback. The use of computers may increase the likelihood that individualisation is successful because of the greater potential and opportunities to provide feedback.

We know that boys and girls differ in their use and attitude to computers only during later secondary school. The differences relate to control over process and product.

We systematically reviewed the literature and located over 100 articles that discussed the differences between males and females: all arguing that females are disadvantaged with respect to computer usage (Hattie & Fitzgerald, 1987). Only 19 of these studies, however, had reported some kind of research on this topic. There is a place for speculation and conjecture, but there is a stronger place for research to avoid self-fulfilling prophecies and opinions that may not be in the best interests of students. There is too much advocacy and not enough research.

Our meta-analysis of these 19 studies, and our own studies based on 1868 students and 1000 schools converged on similar conclusions. There are no differences relating to achievement outcomes, and the magnitude of the differences for attitudinal outcomes is not indicative of substantial differences between males and females (effect-size = .15). The effect-size was greater with older students, with the effect becoming more apparent as a child progressed through adolescence.

We located 24 reasons that have been suggested as explanations for the differences between males and females. On the basis of our research, reasons not considered important included those relating to ability and affective attributes (e.g., no interaction between males and females attitudes to computers and prior mathematics ability, aggression, spatial skills, and self-concept), and role models in schools. Reasons considered important included: computers are perceived as masculine; role models in society (e.g., males see more need for computers in their later lives, male bias in books, software, and advertising), and control and reinforcement. This later aspect, which is of most interest, includes the lack of (particularly verbal) feedback, the presence of competition, the mastery orientation, the lack of negotiation and conversation, and the soloness of computing. All aspects not considered desirable by adolescent females.

Many of the factors listed above that were not rejected as possible reasons for why girls have less positive attitudes to computers, and use them less in secondary schools, relate to the notion of 'control'. That is, more girls than boys tended to yield control and feel more helpless when confronted with computers (see also Wood & Correll, 1988).

There are various notions of control, and the one that seems to be most supported by the research studies is the minimax hypothesis. This view claims that controllability provides the individual with more than extra predictability. In addition, there are known expected outcomes. That is, the individual with control expects a less aversive outcome than the individual without control, and there is also a desire to minimize the maximum danger to themselves. 'A person who has control over an aversive event ensures having a lower maximum danger than a person without control. This is because a person with control attributes the cause of relief to a stable internal source - his or her own response - whereas a person without control attributes relief to a less stable, more external source' (Miller, 1980, p. 80).

Thus, it is suggested that girls rather than boys have a sense that they are not so much in control when they confront computers. These girls do not know how to minimise negative outcomes, are not as aware of how to reduce the aversive impact, do not know how to reduce stress, do not understand how to control the amount of exposure to the negative aspects of computers (such as error messages) and, at the same time, they believe that computers can adversely affect them. Our society seems to influence young adolescent girls to believe that compliance, negotiation and non-risk taking are desirable attributes — the very attributes that are not needed when confronting a computer.

The sense of control proposed here is more akin to Bandura's (1986) theory of self-efficacy. Those persons high in self-efficacy have the perceived ability to cope with aversive events, and because they believe they can minimize the effects of unpleasant events they have fewer reasons to be stressed or fear computers. Those who believe they are low in control or self-efficacy expect more aversive events (and that these events may be intermittent, seemingly without pattern) and thus they have higher levels of anxiety or arousal.

Those who have high control believe that there are 'stable' factors involved such that they can control these factors so as to limit aversive events. When persons believe that
The Itinerant Children's project is based on giving students control over the computer

another individual has more control (even though this other person may be less 'able'), they are prepared to relinquish their control to that other person. So learning a sense of control such that the individual has a known reaction to aversive stimuli is probably a more efficacious procedure to encourage girls to use computers than merely teaching them computer skills or awareness. This learning should involve both a behaviour sense of control, whereby individuals learn the actions that can forestall or attenuate aversive events, and a cognitive sense of control whereby they learn to believe they can manage these unpredictable events.

Thus, it is the perceived efficacy to cope that can make potentially aversive events less stressful. To the extent that we believe we can prevent, terminate or lessen the severity of aversive events, we have little reason to be perturbed by them. Those who have extensively used computers become expectant that the computer is stable and predictable. These persons have modified their behaviour to effectively use the computer. For the novice, there is a belief that it is the computer that must be modified, but they do not know how to do it.

Bandura argues that no source of self-knowledge is more influential in everyday life than conceptions of personal efficacy. The following extracts or paraphrases from Bandura's writings (1986, 1988) have direct implications for my notion of personal control.

a. The types of outcomes anticipated depend largely on judgements of how well individuals will be able to perform in given situations. Those who judge themselves ineffectual in running a software package conjure up outcomes of wreckage and disaster, whereas those who are fully confident of their computing abilities will anticipate pleasant outcomes and satisfying interactions.

b. People tend to avoid tasks and situations they believe exceed their capabilities, but they undertake and perform assuredly activities they judge themselves capable of handling.

c. Reasonably accurate appraisal of one's own capabilities is of considerable value in successful functioning. Large misjudgments of personal efficacy in either direction have undesirable consequences. The efficacy judgements that are the most functional are probably those that slightly exceed what one can do at any given time.

d. Judgements of efficacy also determine how much effort people will expend and how long they will persist in the face of obstacles or aversive experiences.

e. Those who judge themselves inefficacious in coping with computer demands dwell upon their personal inadequacies and cognize potential difficulties as more formidable than they really are.

f. In seeking solutions to difficult problems, those who perceive themselves as highly efficacious are inclined to attribute their failures to insufficient effort, whereas those of comparable skills but lower perceived self-efficacy ascribe their failure to their inherent inadequacy.

g. To regulate effort effectively, performers must have some idea of the performances they are seeking to attain and have at least some information about what they are doing, as they are doing it. The importance of feedback! Otherwise, they are at a loss to know how much effort to mobilise, how long to sustain it, and when to make corrective adjustments in their strategies. When people are not aiming for anything in particular or they cannot monitor their performance, there is little basis for translating perceived efficacy into appropriate magnitudes of effort. The problem of performance ambiguity arises when aspects of one's performances are not personally observable.

These conjectures have been the basis of further studies, which I briefly cite here. Reading and I surveyed the actual use of software among girls (in a co-ed school) and found that "generally the most popular software was that which allowed the girls to achieve or produce something". This software included word processing, spreadsheets and many simulations. Hume and I interviewed a number of students (users/non-users, and males and females) and particularly probed the control aspects. The non-users (e.g., both boys & girls) told us about the computer being in charge, the power of the machine, the hassles when things go wrong, and their desire to know that nothing would go wrong. The users told us about how they like to master the computer, are not concerned whether there was a conclusion to a program, commented about how they were in control, the fun of adventure games, and the desire to beat the system.

The Itinerant Children's project is firmly based on giving the students control over the computer. This project is funded by the Bernard van Leer Foundation ($250,000) and we have also received assistance from the WA Ministry of Education, The University of Western Australia, and the involvement of many teachers and communities in the remote areas of Western Australia. The purpose of the Itinerant Children's project is to provide for the particular needs of children aged from five to twenty years of itinerant families by preparing for their use special educational programs - using technology as the medium for delivery - which will offset disadvantages they may suffer in terms of academic achievement, self-esteem, or social adjustment.

A package of software relating to numeracy, literacy and self-concept has been developed and is under trial in the schools. We are now writing communications protocols to allow for transmission of data from the schools direct to UWA, and for teachers and students to communicate among themselves. In Pert and Kalgoorlie to work with students in these schools interactively, and teachers and principals to interrogate the system and find information of new (itinerant) students or about new students as they move around the schools. We are involving the communities and we have at least one site in a community situation.

The major point for this paper, is that the software is written to give the students a sense of the product and how they can achieve immediate control over the process. The programs include much feedback, the process is predictable, the content is appropriate, and there evolves a sense that the student is in control of the learning. It must be noted that many of the teachers are itinerant and thus part of the success of the program may relate to giving the students more control over their learning and progress. We have incorporated other aspects from our previous research relating to simultaneous processing (which aboriginal children are quite adept, Klich, 1983) and successive processing. Briefly, simultaneous processing relates to the ability to see the "whole" or gestalt and then parsing within an understanding of the whole; successive processing is more related to sequentially learning each part to form the whole. Our previous research, when I wrote a number of separate packages to teach statistics to undergraduates using simultaneous and successive processing taught me that students (particularly CONTINUED ON PAGE 24
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if they think you do not know) will run through both packages (Fraser & Hattie, 1983). I am now convinced that versatility in learning strategies is more effective than using one particular style (Hattie & Hattie, 1987; Hattie & Tumner, in press). I know that students can optimise both strategies. They have many routes through the packages.

The Itinerant Children's project is 6 months into its third years and we have placed Macintosh's into remote schools, written the software (based on the K-3 WA syllabus), had an official opening involving networking the 6 remote schools, Kalgoorlie and Perth, and have 24 research projects underway. All the software is written to give students control over process and product, while not taking away the teacher's perception of control over the learning. This is critical.

Another aspect of the Itinerant project leads me to my third issue.

The literacies involved in computing may lead to exiting findings effective children's thinking processes.

A few years ago I spent some time in Liberia, West Africa. While there I read the fascinating work by Sylvia Scribner and Michael Cole (1981) with the local Vai people and literacy. It made me wonder if similar developments could occur when people first confront computers.

Instead of concentrating on literacy as a technology of a writing system, Scribner and Cole approached literacy "as a set of socially organised practices which make use of a symbol system and a technology for producing and disseminating it. Literacy is not simply knowing how to read and write a particular script but applying this knowledge for specific purposes in specific contexts of use. The nature of these practices, ... will determine the kinds of skills ("consequences") associated with literacy" (p. 236). There is a complex set of skills required to apply this knowledge, and to identify the consequences of literacy it is necessary to consider the larger social system that generates certain kinds of practices and, not others, and poses particular tasks for these practices and not others. For the Vai, literacy is not a vehicle for introducing new ways of life but at best, can engage individuals with familiar topics in new ways. Literacy is not a prime mover in social change, has not set off a dramatic modernising sequence, has not been accompanied by rapid developments in technology, art and science, and has not led to the growth of new intellectual disciplines.

I wonder about the parallels between the implications of literacy among Aboriginal peoples. Like the Vai, their agricultural or nomadic basis does not need a developed literacy, and literacy is possibly a less important determinant than other experiential factors such as age and kin. My interest is to assess the effects of introducing computers at the same time, or even preceding the introduction of reading and writing literacies. At least, given the above comments on control of product and process, will computer involvement change the way aboriginal children think about their world, and the world of school-based knowledge. Will their knowledge structures develop differently after interacting with computers.

There is an established field of study comparing preliterate and literate school children to assess the thesis that literacy makes possible a unique form of logical competence (Olson, 1977). Olson argued that literacy allows children to master the logical functions of language and to separate them from their interpersonal functions. Literacy biases cultures toward the development of formal reasoning systems. Does the same manifestation occur when students are first exposed to computers?

Olson (1988) has argued that computers play three important roles in children's learning: they can provide rich data-bases that children can use as information sources in their own construction of knowledge, they permit students to organise knowledge in a new way, and via talking about what they are doing, trying to do, and why they succeeded and failed, computers permit a greater understanding of one's own and others' minds.

We know so little about children's thinking processes when using computers. This is particularly intriguing given that computers can be cognitively demanding, are interactive, complex, challenging, can provide immediate feedback, have the possibility of multiple solutions, can provide opportunities for control over process and product, and (via the mouse) does not need a written literacy.

Conclusion
These three propositions form the basis of many research programs within the Department of Education at the University of Western Australia. They are exciting issues and answering them provides many golden opportunities for the student, teacher, researcher, and computing. Let us move from what was and what is, to what could be; then we are ready and ripe to tap the golden opportunities of computers.