The educational benefits of computing have been demonstrated but are not widely enjoyed. Laptop computers are promoted as the way to transfer the benefits to larger numbers of students. However, there has been little serious debate about the advantages and disadvantages of laptops relative to alternatives. Few of the benefits claimed for laptop programs are specific to the use of laptops and the expense puts them beyond the reach of many schools or reduces the capacity to provide other resources. More affordable alternatives may be capable of delivering the same benefits to a broader population. At the very least educators need to seriously examine the alternatives.

**Introduction**

Whether portable computing is the answer depends on the question being asked. In their enthusiasm to join the vanguard of the next educational revolution by mandating laptop computers for every student, it is doubtful that educators have paused to ask questions or, if they have asked, whether they have waited for reasoned answers.

Despite the resources devoted to acquisition of computers, the much anticipated benefits to education have not materialised. Cuban (1993) commented that, compared to other areas of human activity, education has been relatively little affected by technological changes. He argued that fundamental reasons in schools distinguish them from other organisations and militate against rapid adoption of technological change.

Nevertheless, there remains widespread belief that computing is important to education both for the skills it provides relevant to future employment and for direct benefits to the quality of teaching and learning. Broad community acceptance of this belief is evidenced in the commitment of governments to public funding of computing in schools.

Research conducted in association with Apple Classrooms of Tomorrow (ACOT) has demonstrated that increased access to computers can lead to worthwhile changes in the behaviour of teachers and learners (Dwyer, 1994). Although when the ACOT project commenced each teacher and student was provided with one computer for school and another for home, that approach was later modified to enable more students to benefit from the same total number of computers. Beneficial changes in teaching and learning continued even when computers were not allocated one-to-one.

Undoubtedly teachers and students who have convenient access to computers with suitable software will use a computer more often than those for whom access is difficult. Moreover, the ACOT experience suggests that educational benefits ensue. These are key planks in the platform of laptop advocates who argue that personal portable computers for everyone is the ideal way to ensure the access necessary to make a difference.

Educators can too easily accept these arguments and conclude that laptops are the answer without thorough examination of the evidence and alternatives. A laptop program may be based upon unimpeachable educational grounds or upon perceptions of such a program as an indicator of school quality and hence a marketing tool. Occasionally it may lead to apparent defiance of logic as in the instance of a school (best not identified) which instituted a voluntary laptop program ostensibly for educational benefit but assured parents that students who did not participate would not be thereby disadvantaged.

ACOT has achieved demonstrable benefits with less than one computer per student. A laptop for every student may be desirable where it is an addition to a full complement of other resources. However, many schools lack a range of basic resources and should undertake a thorough examination of alternative uses of funds before adopting the norm of a portable computer for every student as championed by the evangelists of laptop orthodoxy.
Preaching the laptop gospel

Most of what has been published about laptops in education comprises uncritically enthusiastic accounts of selected implementations. In this respect it resembles evangelism rather than dispassionate inquiry.

Based on experience with the early Australian laptop implementations, especially at Methodist Ladies College (MLC) Melbourne, Stager (1995) proclaimed the leadership of “laptop schools” in professional development for computer use and argued that

“... it is counterproductive to dispute the universality of every student having a personal computer. This reality for many Australian schools is sure to become the norm in the near future.”

(p.1080)

Spender (1995) wrote with enthusiasm about the “commitment, concentration, enthusiasm and sheer enjoyment” of students working with their computers at MLC and noted that the “response has been positive on every count”. Not only were there changes in the attitudes and behaviours of students, but teachers adopted less directive roles and the physical and temporal arrangements of classrooms and timetables were modified. Spender concluded her account of the MLC experience thus:

“Teachers, policy-makers and parents who persist with the idea that computers are an impediment to serious learning, are making a statement about their own inability to appreciate the significance or potential of the new medium.”

(p.114)

Most laptop programs appear to have been in private schools where the laptops were an addition to already extensive resources. Because students enrol in such schools by choice, it is possible for the school community to decide that all students should have and use laptops.

Frankston High School (Lyall, 1997) is one instance in which a voluntary laptop program in a public school has extended beyond a funded trial. Effects similar to those in other programs are reported but it is also noted that some students are tiring of laptop use suggesting that for some, at least, there may be a novelty effect.

Although the laptop movement was initiated by educators in schools it now has the enthusiastic support of major technology suppliers. Gross (1997) suggested that the enthusiasm of firms such as Toshiba and Microsoft derives from slowing sales in key business and domestic markets. Education represents a large potential market for computing, often with centralised purchasing structures that are more easily reached than individual purchasers.

Anytime Anywhere Learning (Microsoft Corporation, 1998) proposed a vision of a “connected learning community” in which every student and teacher has a personal portable computer. Examples of schools which have implemented the program are cited along with the benefits of individual learning paths, increased collaboration and improved critical thinking skills. Significantly the promotional material proclaims that “Many Educators Ask HOW?” However, scarcely anyone, least of all suppliers of hardware and software, seems to be encouraging educators to ask “Why?” Only rarely are voices raised to ask questions such as whether “money would be better spent on programs such as teaching phonics to struggling readers or hiring more teachers.” (Gong Jr, 1996)

Whatever the answers, such questions deserve to be asked.

Looking for reasons

Researchers studying laptop programs have typically not made comparisons with the use of desktop computers or of programs with shared access. Consequently most reports of educational trials with portable computers tend to reinforce the laptop orthodoxy since any benefits are attributed to the use of the laptops without distinction as to whether the same effects could have been achieved using desktop computers.

Rowe (1993) described a study in which 115 Year 6 and 7 students at Coombabah State School in Queensland were provided with laptop computers for use in school and at home. Data were gathered twice (April and November) during the 1991 school year and examined a range of variables including computer knowledge, subject matter knowledge, attitudes to computers, computer use, learning decisions and practices, ability, educational achievement and classroom context.

During the year students improved in computer awareness and related knowledge and skills while becoming more critically aware of aspects of the laptop program. Many perceived that they were missing out on benefits enjoyed by students in other (non-laptop) classes. There was some reduction in anxiety about possible damage to computers but this was still significant for a quarter of students by year end.

Students were motivated by the computers and used them for a variety of tasks in school and at home. However, there is no indication of the proportion of class time that was spent using the computer. Neither is it clear how the use of laptops may have contributed to different effects than would have been obtained with equivalent access to desktop computers.

Shears (1995) reported on a laptop project conducted in 10 Victorian secondary schools during the final term of 1994 and the first term of 1995. Each school was allocated a set of 25 laptop computers for use as determined by the school. In some schools the laptops were held by the school and borrowed daily by students in one or more classes. In others the laptops were issued to students for the duration of the project.

The report comprises a series of case studies prepared by the project members from each school. Overall the reactions of teachers, students and parents were positive with reports of increased motivation and other educational benefits. However, of the opinions summarised in the report the only items which could be considered specific to the use of laptops, as opposed to desktop computers, appear to be related to portability as an asset and to problems with limited battery life and with the weight to be carried. Moreover, as
in the previous study (Rowe, 1993), there is no indication of the typical periods of use except so far as this is implied in concerns about battery life and mention of computers being secured in lockers during certain teaching periods or left at home on certain days of the week.

Despite what seems to be a lack of effects specifically attributable to the use of laptops as distinct from desktop computers, the concluding statement (p.142) of the report states:

“A... the team members accepted ‘accessibility’ as being educationally, socially and professionally desirable for their students. From this flowed a belief in the inevitability of the use of a more portable form of computer such as the laptop... Overall our analyses have led to the conclusion that in the long run (to some, because of cost, the very long run), portable computers such as laptops would inevitably become an integral part of the resources in schools.”

Statements such as these appear to be founded less on available evidence than upon assumptions consistent with the laptop orthodoxy.

A pilot laptop program, sponsored jointly by Microsoft and Toshiba, was evaluated in its first year of operation at 53 US elementary, middle and high schools (Walker & Rockman, 1997). Circumstances varied across the sites. At some sites each student had a personal laptop available at all times in class and at home. At others, class sets were available for borrowing by teachers, a small number of laptops was available in the classroom or just a few students in each class had a personal laptop.

As in the Australian studies, the attitudes of teachers, students and parents were positive and they were convinced that there was educational benefit. Changes in teacher and student behaviour towards more student centred and collaborative approaches with teachers often learning along with students were consistent with those reported in the ACOT studies (Dwyer, 1994). In 54% of classes, the laptops were used for less than 25% of the available class time and in only 14% of classes did the use exceed 50% of class time.

Walker and Rockman identified benefits which they considered attributable to the use of laptops rather than desktop computers. For schools in which the laptops came in addition to already extensive computing facilities, teachers and students appreciated the portability which guaranteed convenient one-to-one access. For schools with limited computing resources prior to the laptop program, the greatest impact was having access at all. Laptop computers also offered advantages in crowded classrooms where desktop computers for every student would not be practicable and the ability of students to take laptops home removed the disadvantage suffered by students without access to a home computer.

Another claimed benefit of the laptop programs is more dubious. It is suggested that the formation of partnerships between schools and families to bear the costs of laptops allowed schools to stretch scarce resources and, thus, is a benefit of a laptop program. However, there seems no reason why similar partnerships could not fund provision of desktop computers.

Participants reported hardware problems as the most common difficulty. Screens and latches seemed too easily damaged and teachers reported between 10% and 30% of computers out of commission on a typical day. Other problems included limited battery life and the weight of computers especially for smaller students.

Taken together, these three studies of laptop implementation present a consistent picture. Teachers and students respond with enthusiasm and appear to find motivation for changes in classroom behaviour and improvement in student work. However, few of these benefits are peculiar to the use of laptops rather than desktop computers. On the other hand, there are some difficulties such as limited battery life that are restricted to laptops.

**Advantages of laptops**

The most seductive promise of portable computing in education is immediate access for each student to a suitably configured computer whenever and wherever they require it. This is implied in the title of the Anytime Anywhere Learning project (Microsoft Corporation, 1998).

Workers in occupations most changed by computing typically have one computer or terminal per worker where schools have commonly had shared access with typical ratios of one computer per 10 students. Clearly change will be easier where access to the computer is constant than where access is, at best, inconvenient because of location and sometimes impossible because the computer is in use. Teachers and students who experience difficulties in accessing computers are apt to adopt alternative strategies to accomplish a task. Personal portable computers, by virtue of their consistent availability, are more likely to be used.

Students typically undertake significant components of their work in locations other than a single conventional classroom. They may move from room to room for lessons, study in the library or undertake field excursions. Often they will have homework. Portable computers can be available in any of these settings, making it possible for teachers and students to assume access wherever and whenever it is required.

A second significant benefit of laptop programs relates to the one-to-one correspondence between students and computers. Where students work with
computers shared by others, efficient use of the equipment dictates that the computers are prepared and maintained in a standard configuration. System managers often restrict configurability to ensure predictable encounters for users with the disadvantage that students do not gain experience at simple system maintenance tasks.

When students have personal systems they are free to explore and learn by experiment. However, they must accept responsibility for ensuring that the system remains useable. As Spender (1995, p.111) noted, "Having a personal computer, organised the way you want it, is very different from using a school computer that is programmed for use by everybody." Supporters of laptop programs suggest that the autonomy enjoyed by students in managing their own computer is accompanied by increased acceptance of responsibility for their own learning.

**Disadvantages of laptops**

Participants in the laptop programs have identified various problems related to the management of equipment. The problems included limited battery life, transport issues such as weight, security or susceptibility to damage and system maintenance when students have freedom to adjust system configurations. Solutions require careful planning, provision of facilities such as power outlets, network connections and secure storage and employment of support personnel. One school in Harlem (Gross, 1997) has established parent patrols for security of laptops travelling to and from school. Some laptop schools maintain workshops certified for warranty service but there will still be times when students cannot access their own laptop.

Probably the greatest single disadvantage of laptops is cost, since portability attracts a premium in pricing. An entry level laptop can be expected to cost at least 50% more than an equivalent desktop computer and depending upon specifications it may cost twice as much or more.

Questions have been raised about the equity of laptop programs. The original programs were in well resourced private schools already regarded by many as places of privilege. Many programs, whether mandatory or voluntary, require funding by parents and may subject families to considerable financial pressure to maintain position in a school. Some schools have attempted to address this by subsidising the cost of a pilot program in one or more classes. In such cases questions may reasonably be raised about the reduction of funds available for other programs with potentially broader benefits.

Paradoxically, laptop proponents have argued that their programs actually address inequities by making computers available at home for all students rather than a few (Walker & Rockman, 1997). Such arguments are spurious, given that up to 60% of Australian homes with school age children already have computers (Downes, 1997), that this number is no doubt increasing and that most families could more easily afford a desktop computer (at less than $2000) than one or more laptops (at over $3000 each).

Finally, some consideration should be given to health and safety of students using laptops. Few people can be unaware of the risks of prolonged computer use with incorrect posture or poor lighting. Descriptions of deskless classrooms in which students sprawl on the floor to work with their laptops (Spender, 1995) may appeal as a sign of relaxed enthusiasm for learning. However, schools which fail to educate students about appropriate posture for computer use may be contributing to expensive health problems for the future and, in increasingly litigious times, they may be asked to bear the cost.

**The right question and alternative answers**

If we accept that evidence for the beneficial effects of computers in education is consistent across different circumstances (Dwyer, 1994; Rowe, 1993; Shears, 1995; Walker & Rockman, 1997), then it follows that efforts should be made to extend the benefits to the greatest possible number of students. With the displacement of command line systems by graphical user interfaces, convenience of access is likely to be a more significant factor than ease of use. Hence the key to educational benefits from computing is probably ease of access and the question that educators need to ask is "How best to match computer access to anticipated use?"

Considering battery life, other maintenance issues, the undesirability of locking every school activity to computer use and the prevalence of group work, it seems unlikely that a one-to-one ratio of computers and students is necessary to achieve the reported benefits of computer use (Dwyer, 1994; Walker & Rockman, 1997). On average one computer might meet the needs of 3 or 4 students if it were available at the appropriate times and places. A school with some computers in laboratories, others in classrooms and a few laptops for flexibility might well meet the criterion for convenient access.

Laptop schools have demonstrated through their commitment to professional development and support that the cost of an effective computing program goes beyond the purchase of hardware and software. The cost of an "empowering technology-rich education" including one desktop computer for every two students and ancillary services has been calculated at $2000 (USD) per student annually.
Data, software and processing power more than $20 per month, would be accessible to appropriate processing power, which may be some years away, network advantage. Mobile networking solutions for purchase or around $100 per month to computers appear to be a development in conditions, this approaches $4000 (AUD) development at Xerox PARC, it was affordable for a greater number of families proposed that computers would become a personal computer moving with the user, would be mostly resident in the network are possible, but they are relatively expensive and mostly of low bandwidth.

As technology develops we may experience “ubiquitous computing” as described by Weiser (1991). In this development at Xerox PARC, it was proposed that computers would become as common, and hence “invisible”, as electric motors with a typical room containing many networked computing devices of varying sizes and functions. Data, software and processing power would be mostly resident in the network and accessible anywhere using any of a multitude of devices with characteristics appropriate to the task at hand. Instead of a personal computer moving with the user, the user would move within a computing environment which provided multiple access modes.

Although ubiquitous computing may be some years away, network computers appear to be a development in that direction. A network computer (NC) will be a less complex, hence cheaper, device than a personal computer. In some versions it would rely upon network connection for all data and software but in others it may have local storage and other facilities (Every, 1997). For educational use, the benefit of network computers would lie in lower purchase costs, reduced support costs through centralised configuration and flexible access to software and data from any point on the network. Ideally students could access the same software and data from home or another location. Already there are companies seeking to integrate these types of solutions with laptop computers (NetSchools, 1997).

**Conclusion**

Effective integration of computers can provide educational benefits but depends upon students and teachers having convenient access to appropriate hardware and software. Although laptop programs appear to offer an answer to educators’ questions about how to achieve computer integration, they are an expensive solution and appear to offer few compelling advantages when compared to desktop computers.

Portable computing may be one answer for education but it may not be the best. What is needed is accessible computing which may include portable computing among a variety of resources.

Above all it is important that educators continue to ask questions and insist upon reasoned answers. The truth or otherwise of the laptop orthodoxy will be tested not in unthinking acceptance but through lively debate.

**REFERENCES**


