The impact of portable computers on classroom learning environments

There are convincing arguments for the integration of computer applications into school programmes to support the learning of students. After more than 30 years of increasing investment in educational computing researchers are concerned that there has been very little impact on the experiences of students in schools. In the 1990s, a significant development in computer technology has been the emergence of low-cost, high-powered portable computers which some schools have introduced into classrooms. It is not clear what the impact of this development might be.

A three year study was conducted at a school to address issues concerning the impacts of student-owned, portable computers on students, teachers, the curriculum, and the classroom learning environment. In each year of the study, data were collected about students, teachers and a selection of classrooms using observations of lessons, interviews, questionnaires, and administrative data and documents obtained from the school’s administration.

Among other things the study found that, apart from isolated teacher-class combinations, there was very little change at the classroom level which could be attributed to the presence of the computers. Very few teachers implemented substantial computer use and many of those who had, supported only a very limited role for the computers. This paper argues that the lack of use of the computers is largely related to the teacher’s preferred pedagogy, their lack of experience and knowledge in using computers in the classroom, and a lack of time to experiment with computer applications. Increasingly, the teachers who chose to facilitate the use of the computers did so to support predominantly student-centred learning environments. These findings have important implications for educational policy makers, administrators and teachers and enable a clearer understanding of the factors which determine the successful implementation of computers into school programmes to support student learning.

Introduction

Educators have increasingly claimed that for the potential of computers in education to be realised critical changes will be required in schools and classroom learning environments. However, the finding of Plomp and Pelgrum’s (1992) international comparative study was that there was little evidence in any of the participating countries of real changes in the structure of schools or classrooms as a result of new technologies. Will these changes come about due to the avalanche of computers into schools, particularly through schemes to provide one computer per student or must these changes occur before embarking on such schemes? The popular press often portrays the belief that the technology will instigate the changes. The following statement by Schumpeter (1993) is typical of this, “A Melbourne school is pushing the boundaries of educational development in a laptop experiment that could make traditional teaching methods redundant” (p. 1).

Now that access to computers in classrooms is more readily available, even to the extent of one per student, why are so few teachers realising the potential? If computers were extensively used by students to support school-based learning, it has been suggested that this would necessarily change the role of the teacher and the nature of the classroom learning environment (Reeves, 1992; Rieber & Welliver, 1989; Schank & Cleary, 1995). Further, it has been suggested that such an extensive use of computers may reform the structure of schooling and the curriculum itself with a greater focus on student-centred learning, across curriculum activities and more flexible school structures. That is, widespread use of computers in schools may either require a restructuring of schools or could support the restructuring of schools.

While it is relatively safe to contend that most students in the future will have some form of portable computer processing in much the same way as most secondary students now have calculators, given the historically robust nature of school-based education it is difficult to predict in practice what impact this will have on schooling and the curriculum. Longitudinal research into the use of
portable computers by students needs to be conducted at many school sites before any reasonable predictions can be made about their likely impact. Marcinkiewicz (1994) suggests that “there is little research evidence for the effectiveness of educational technology and that which exists provides little direction for informing teachers about how they can use the technology most appropriately” (p. 221). Research is needed to guide school systems, school leaders, teachers, parents and students in the application of such a resource to school-based learning. This paper reports on a study which set out to address this need by considering the use of student-owned portable computers to support the lower secondary school programme at one school over a three year period.

Method

The researcher was invited by the Principal of the school to conduct an independent evaluation of the implementation of an initiative, eventually known as the Portable Computer Programme (PCP), designed to encourage every student to have and use a portable computer to enhance their learning. As a result the researcher became immersed in the school community for a period of three years and collected a wide variety of data from students, teachers and the administrative records of the school. To investigate the impact of a computer-related innovation on classroom learning environments it was necessary that the study be both longitudinal and grounded in ethnographic research traditions.

The study used both qualitative (lesson observations, formal and informal interviews, and viewing documents and software) and quantitative (questionnaires, log sheets, administrative records) data collection strategies. The study relied more on the qualitative data sources for the majority of its findings. The quantitative data sources tended to be used to give contextual or background information or to corroborate findings based on the qualitative data.

Data were collected from over 60 teachers, 350 students (three cohorts labelled A, B and C as indicated in Table 1) and the observation of a large number of lessons (71 were analysed). These data were continually analysed to address an evolving series of focus questions and thereby provide evidence to support a developing and increasingly more comprehensive understanding of the impact of student-controlled, portable computers on students, teachers and the implementation of the curriculum in the classroom learning environment.

Findings

Only a few of the findings of this large study can be discussed in this paper. The study focused on teacher and student attributes and their perceptions related to computer use, classroom activities, classroom and home use of the computers. The study also considered practical issues in implementing the PCP and its overall impact on classroom learning environments. Classroom learning environments which incorporate computers were considered using the model in Figure 1 and therefore the findings are discussed in terms of elements of this model: the portable computer systems, the students, the curriculum, and the teachers. Although each finding may have been related to all of these elements, each tended to relate more strongly to one element or one set of relationships between the elements.

Most experts in the field of educational computing, such as Olson (1988), Rieber (1994) and Lynch (1990), would characterise computers as interactive and thus admit them a place within the relationship structures within the classroom. Carter (1990) goes so far as to claim that “new technologies construct a totally new environment” (p. 34). Therefore the model in Figure 1 depicts the relationship between particular elements, including the computers. Strictly speaking, the computer systems and non-interactive technology are part of

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**Table 1**

<table>
<thead>
<tr>
<th>Cohort</th>
<th>No. of students</th>
<th>Level of schooling</th>
<th>Period of time</th>
<th>Model of Macintosh computer</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>38</td>
<td>Year Seven</td>
<td>1993 Semester 1</td>
<td>Powerbook 100</td>
</tr>
<tr>
<td></td>
<td>98a</td>
<td>Year Eight</td>
<td>1994 All year</td>
<td>Duo 230</td>
</tr>
<tr>
<td>Bb</td>
<td>95</td>
<td>Year Eight</td>
<td>1993 Semester 2</td>
<td>Duo 210</td>
</tr>
<tr>
<td></td>
<td>108</td>
<td>Year Ten</td>
<td>1995 All year</td>
<td>Duo 210</td>
</tr>
<tr>
<td>C</td>
<td>103</td>
<td>Year Eight</td>
<td>1995 Semester 2</td>
<td>Powerbook 150</td>
</tr>
</tbody>
</table>

A Students from Cohort A in Year Seven were joined by students from other primary schools. B The study also collected data on a small number of students from this cohort in Semester 1 of 1994.

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![Figure 1. A model to consider the relationship of computer systems to the elements of the classroom learning environment.](image-url)
the context of the curriculum but since computers are two-way interactive it is more helpful to highlight them by separation. The elements of the traditional classroom learning environment (shown in the box) provide a complex pattern of relationships. When computers are used within this environment, the complexity of this pattern of relationships increases, with all elements of the traditional classroom learning environment needing to interact with both the hardware and software.  

Portable Computer Systems in Schools  

The Macintosh notebook-style computers appeared to be well matched to the needs of the students in terms of operation and portability, but not physical reliability. Although most models of computer used did not appear to be sufficiently robust, this in itself was not an inhibiting factor for either students nor teachers. Students were inhibited in their use of the portable computers by some features such as the short battery life and their perceived heaviness, resulting in some students leaving their computer at home if they did not think it would be needed. Many students preferred to use the school’s desktop computers because they liked the colour screens, larger keyboards, access to the network and greater processing power and memory. Similar problems and high level of maintenance costs have been reported from other schools using portable computers (Lyall, 1997).

The computers were mainly used as writing tools using the word processor in Clarisworks(r) with occasional use of Artgrabber(r) to insert clip-art. Apart from these applications, most students in classes other than specialised computing classes, used the computers only for game playing and the very occasional subject specific application such as Math Master(r) or MacGlobe(r). In computing classes, students used a wider range of applications on the computers from databases and spreadsheets to Hypercard(r), where they often found that the amount of memory (RAM) was inadequate.

While the value of the computers to students and teachers can not be fully quantified, consideration should be given to their effect on productivity. It is not possible to measure exactly the costs or outputs associated with educational processes such as the use of a technology in a learning environment. However, a rough estimate of the quantitative productivity of the computers, considering the best possible scenario recorded during the study (Year Eight Cohort C), was 0.5 hours/$A or about $A2 per hour. On the face of it this seems a very reasonable cost for the powerful tool it placed in the hands of the students. However, this does not take into account qualitative issues concerning the type and value of the activities to which the computers were applied. The limited role and application to learning activities diminishes even the quantitative productivity value to the students of using the computers. On top of this, there would be costs associated with teacher training, provision of infrastructure, cost of technicians and other support personnel, and the opportunity costs to students and teachers (i.e. the other things they could have been doing).

Students’ Skills and Attitudes  

In general, students preferred choice in the possession of a computer, expected them to be used regularly to replace the need for paper-based files, quickly developed a reasonable level of computer literacy and associated independence, and expected the school to provide them with systematic training.

One of the major aims of the PCP was to increase the computer literacy/awareness of all students. To a large extent this occurred for all students, however, most students developed skills in a haphazard way, relying on information gleaned from other students, particularly those students in computing classes. A major lack of competence was backing up work, particularly when the computer supplied did not include a built-in floppy disk drive. Students still required more guidance and instruction in the efficient use of the machines and a better understanding of the concepts connected with computer systems and their use.

About 95% of students were either positive or ambivalent towards using computers. Irrespective of how well the programme was implemented it was likely that about 5% of the student population would have negative attitudes towards either the computers, their own competence in using the computers or the programme itself. However, after three years using the computers 20% of students in the Year Ten cohort (B) were in this category. It is likely that this was due to the fact that they were the first group to go through the PCP from Year Eight. However, it is explained later how this may also have been due to the nature of the Year Ten curriculum and the associated learning activities.

Generally students were positive about the PCP, although many students felt that the computers needed to be used more in class and that teachers should have facilitated more use of software within their curriculum. Many students preferred being given the choice of whether they had a computer and what sort of computer it was. While the PCP had increasingly positive outcomes for more students over the three years, particularly for those who were boarders or attended the school in Year Seven, the experiences of many of the students in Cohort B put them off using computers. Many didn’t enjoy having to carry a file and...
computer and would prefer one or the other. Generally they didn’t like being forced to use their computers. Many would have liked either more classroom-based computers or some system of short term loan.

Clearly the school could be satisfied that the PCP had improved the computer literacy and attitudes of students and had not significantly disadvantaged or perturbed more than a handful of students. Most students who appeared to be at risk in this regard had, by the end of Year Eight, overcome their negative attitudes towards the PCP and computers and had increased their skill and knowledge to an adequate level to make significant use of the computers. The school’s computer support teacher and the computing classes played important roles in overcoming the problems of these students.

The Curriculum

The subject area in the curriculum was a major determinant of the amount of computer use and the breadth of applications used by students. Students were more likely to use the computers for classes associated with subjects such as English and social studies in which teachers required a substantial amount of document production. Both students and teachers perceived that the use of the computers for document production improved the quality, quantity and ease of production.

The computers were less likely to be used in classes with older, higher ability students than younger and/or lower ability students. This seemed to result from teachers’ perceptions of the requirements of preparing students for tertiary entrance examinations. The tertiary entrance examinations dominated the curriculum for most teachers and students, even in the lower secondary school. Both teachers and students were aware that tertiary entrance examinations preclude the use of the computers in class-work. It was perceived that students needed to practice handwritten work in all subject areas to be prepared for these examinations. While there was little that could be done about the examinations themselves, further investigation should be conducted on the perceived link between using computers within the curriculum over the five years of secondary schooling and the performance of students in the tertiary entrance examinations.

Teachers

In responding to the presence of the portable computers in a class, a teacher’s actions could be classified into three broad types: (1) actively facilitates the use of the computers (Active), (2) permits the use of the computers by those students choosing to do so (Passive), or (3) unconsciously or otherwise discourages the use of the computers (Negative). Most teachers typically responded in either Negative or Passive ways which limited the use of the computers. Only a few (about eight) usually responded in Active ways which is consistent with Becker’s (1994) finding that only 5% of computer-using teachers are exemplary. His definition of such teachers would classify them as responding in an Active manner.

Many teachers were interested in facilitating the use of the computers but were not sure how to go about doing so with their classes. They did not want to be forced to use them but rather felt that they needed more examples of computer use applied to their area of the curriculum. Others did not see the computers as relevant to either their curriculum or their preferred teaching strategies. While many indicated a good level of computer literacy, a lack of operational knowledge of computers was still perceived by many as inhibiting their ability to facilitate students’ use of the computers.

The computers were not perceived as a necessary or even critically useful technology by almost all teachers. While most teachers encountered obstacles to facilitating the use of the computers which, when removed, may change this perception, it is likely that for most of them there were no compelling reasons to implement computer applications.

An obstacle either cited or inferred by many teachers concerned a lack of knowledge of, and access to, appropriate software. Often teachers claimed that there was no good software in their area of the curriculum. While Rieber and Welliver (1989) criticised most instructional software for being hardware-centred, representing a technocentric approach to software design and failing to tap the facilitation of higher-order thinking skills, Hannafin and Savenye (1993) suggest that software is rapidly improving. Most teachers were not aware of a reasonable range of software whether of good or poor quality. Many expressed a need for relevant information about software, typically represented by a request for a person to become a sort of software clearinghouse.

Given that many researchers (e.g. Becker, 1994) are now claiming that teachers need up to five years of experience in using computers in their learning programmes, it is perhaps not surprising that, after three years, this study should find that most teachers at the school were supporting only minimal use of the computers.

Classroom Learning Environments

Because of the minimal and limited use of the computers in classrooms very few classrooms were observed in which the use of the computers made any sustained or major impact on the learning environment. Only those teachers who aimed to create classroom learning environments which promoted student-centred learning (refer to Brady (1985)) tended to regularly facilitate the use of the portable computers with their classes. Where teachers employed an instructivist pedagogy (refer to Reeves (1993)), students were either required to use computers for only the limited role of a writing machine or were rarely required to use the computers at all. Research is increasingly supporting the notion that if computers are to be of significant value in classrooms, their introduction must be accompanied by a shift towards more student-centred teaching strategies (Dwyer, Ringstaff, & Sandholtz, 1991; Fishman & Duffy, 1994; Hannafin & Savenye, 1993). In the present study, those few teachers making this transition...
appeared to find the computers to be a valuable tool in the process.

**Evaluating the Success of the PCP**

The PCP was perceived by teachers, students and the researcher to be implemented most successfully in Year Eight in the third year of the study. The computers were applied more often, by more Year Eight students, in more learning activities, across more of the curriculum in increasingly meaningful and appropriate ways. The PCP increasingly facilitated the development of a greater degree of confidence, skills, understandings and attitudes which are likely to enhance learning and be applied to future situations (e.g. workplaces). However, the PCP clearly was not successfully implemented for the oldest student cohort (B) involved in the PCP, who were in Year Ten in the third year of the study.

This study set out to consider the impact of portable computers on the learning environment offered to students at the school. It was assumed that the most important concern was the amount and variety of use of the computers by students and teachers. Clearly, after three years, the computers were not used widely enough nor consistently enough to warrant their pervasive presence. However, encouraging signs had emerged by the third year of the study in Year Eight that the computers could play an important role in classroom activities and learning programmes. Where this was demonstrated in the school, it was usually associated with more student-centred approaches to learning. The overall level of computer literacy of students and staff involved in the PCP steadily improved, although further improvement was still necessary.

Despite the increasing success of implementation, the computers were still not used at school by most students for a large amount of time, but were used by all students at home for a reasonable amount of time. The limited use of the computers at school by even relatively interested teachers is consistent with the findings of wider surveys reported by those such as Becker (1994) and Plomp and Pelgrum (1992). Becker (1994) quotes that in one survey of computer using teachers only 11% of English teachers had students using spell-checkers and only 1% of mathematics teachers regularly facilitated the use of spreadsheets.

The computers were mainly used for word processing by all students and they were viewed by most students as essential for preparing assignments. However, there was a common perception amongst the staff that the computers were non-essential and merely supplementary items in their classrooms. This was reflected in the types of tasks which they allocated to the computers, typically replacing writing and at a low cognitive level. Most teachers had difficulty adapting the use of the computers to their own personal teaching style and subject curriculum. Fundamentally, to be successful, more teachers needed to employ student-centred approaches to learning more often in their learning programmes.

**Implications for Policy and Practice**

The findings of the study have a number of implications for educational policy and practice at both the school and system levels. Educational policy makers are currently concerned with what form of computer access should be implemented in schools to support learning. These deliberations include a consideration of what hardware and software is required and what level of standardisation is required. Questions also arise about the level and type of support needed by schools, teachers and students. The portable computer alternative is attractive to schools and education systems from both an educational and promotional point of view. These issues are considered in terms of a series of questions.

**Should Schools and Education Systems Implement Portable Computer Programmes?**

This study found that a programme such as the PCP could be successful but, without significant changes to the traditional curriculum and structures of schooling, this would be difficult to achieve. Also, without a transformation of the pedagogical philosophies of the teachers involved, it would have little impact on teaching and learning. In line with common international wisdom (e.g. Rieber & Welliver, 1989), policy makers should start by considering educational aims and instructional problems before considering technological solutions. Becker (1994) considers that if such a transformation is required then this will make it very difficult to extend the best practice use of computers in the classroom to a wider population.

In particular there is a need to remove or reduce the influence of paper and pen external examinations on the curriculum and organisation of schools. The organisation of schools needs to be dictated less by time and subject area boundaries and more by learning activities and the needs of students. There is a need to focus curriculum on processes rather than content, and there is a need to focus more on student-centred rather than instruction-centred strategies in learning programmes. Without changes in these fundamental components of the curriculum and schooling it is unlikely that the implementation of portable computers in schools will be cost effective.

**Should Students be Required to Standardise Hardware and/or Software?**

In the present study, students were not forced to use the recommended hardware and software, however almost all chose to use it because of the support offered by the school. It is not clear that this required strict standardisation because, if the school had chosen to outsource hardware maintenance, there would have been little reason for students to use the computers recommended. The students did not rely on teachers for operating instructions, they owned the licenses to almost all the software they used. It was probably more important for students to be able to personalise their hardware and software and choose configurations, provided they could connect to the school’s infrastructure. Students tended to indicate that they wanted choice...
of whether to have a computer and which one to have. This would indicate that the acquisition of the computers by students should not be mandated but rather encouraged, and could include some system of short term loan.

While flexibility needs to be provided, it is clear that there is a minimum configuration of hardware and software required to allow effective use of portable computers in schools. Portable computers should include a backup storage device (floppy disk drive was adequate) and require enough RAM to concurrently open at least two of any of the software packages students are going to use regularly. Student computers should be supplemented with classroom-based computers with peripherals needed for some activities but not regularly, such as, large monitors, printers, scanners, better keyboards, graphic tablets, and CD-ROM drives. All classrooms need to be connected to the school’s network, or at least enough rooms so that interested teachers can be allocated such rooms. Teaching rooms, or at least a workable sample of rooms, need to have at least one colour screen and a CD-ROM drive available.

What Support do Students Require?

Students developed a reasonable degree of independence but still required and requested a more formal approach to learning how to use the computers. This will require the provision of specialist computing classes with highly competent computing teachers allocated to them. Perhaps one session per week or fortnight could be allocated so that it could be related to cross-curricular needs. Student access to computing staff and technicians is an important and necessary source of support which needs to be accommodated in some manner.

What Support do Teachers Require?

As with students, teachers should not be forced to use computers particularly where they are perceived to be of little value. Rather, teachers should continually be encouraged to make more use of the computers in class and use a greater range of software within their curriculum. This will involve the need to experiment with more student-centred, open learning strategies. The use of demonstration lessons or supported lessons would also help this process. Teachers need continuing access to professional development in the use of computers and applications to their own curriculum areas. It is commonly perceived, and was supported by this study, that the computer literacy of most teachers is still a major obstacle to greater application of computers to learning (McIntosh, 1997b).

Teachers need relevant information about software, with perhaps a person allocated to become a software clearing-house. In the provision of more software, the emphasis needs to be on increasing the range of software which can be targeted at the educational problems identified by teachers not simply increasing the quantity of software available. This type of information can be made available using Internet/Intranet technology. Therefore, in providing access to the Internet, the priority should be access for teachers before students.

This study found that the successful implementation of computers into learning programmes is fundamentally dependent on teacher beliefs, attitudes, perceptions and experiences. While all the key relationships within the classroom learning environment have some influence on, and are influenced by, computer implementation it is the relationship between the teacher and curriculum which is most important. This supports to some extent the argument of Miller and Olson (1994) that, “the computer environment as a consequence of teacher intention - its place in the scheme of the classroom is constructed by the teacher and the student” (p. 136). However, with the portable computers, the study found that only teachers who wanted to set up student-centred open learning environments tended to make use of the computers in the classroom (other teachers at best just required the computers to be used for written assignments). Perhaps other forms of implementation (e.g. laboratories, demonstration machines etc.) may be more likely to be used by teachers wanting to create more traditional learning environments.

Teachers should be encouraged to consider the computer as one of a range of technologies which they can call on to help them solve educational problems. With the development of ever more powerful portable computers and ever more extensive network systems, the range of problems which may have realistic computer-related solutions is expanding rapidly. Teachers should expect that computers will become an integral part of learning programmes and should gradually develop the skills, understandings and experiences required to exploit these opportunities. This also provides an opportunity to reflect on current practice and pedagogical beliefs with a view to realising preferred aims for learning programmes.

How Should Schools Aim to Support Learning by Implementing Computer Support?

A computer system is like a Swiss Army knife in that it is a flexible and varied tool which extends not only the physical (e.g. non-artists can create graphics) but also the intellectual capabilities of the user. In a sense Taylor (1980) was premature with his classification system of the three Ts, for there is really only one T, and that is Tool. His Tutor function is instructional-tool, while a Tutee function is a mind-tool (or cognitive-tool), what Taylor called Tool is a manipulative-tool (or psycho-motor tool). There are many types of computer-related tools which, just like other types of tools, must become “one” with the user to be used most effectively (Rowe, 1993). Therefore students need to become one with their computer systems which is facilitated by having their own software, both instruction and data files, but not necessarily their own hardware. They can then tailor their tools to their own specifications and liking.

The answer to questions concerning appropriate access to computer processing does not primarily
Conrad notesbooks, desk-tops, networks or even palm-tops, for this is what Papert (1987) calls techno-centric thinking. Discussion should centre on the software-tools, the data students collect and what they create with those tools and, therefore, it is the software and data that students should carry around with them, not the full computer system hardware. Students need to carry this software with them and plug it into different hardware configurations depending on the task requirements. This may eventually include carrying around an operating system interface. What schools need to do is provide a range of hardware configurations into which students can plug their stuff and encourage appropriate hardware configurations at home to support this. A school may have sets of notebook computers to be used by individual students, or classes of students, they may have powerful desktop systems in classrooms and work-areas with many peripherals, attached to networks, connections to the internet etc. Students may have PDAs (Personal Digital Assistants) which they carry with them into which they can also plug their stuff. This is not quite the Network Computer because the focus must be on students controlling their own tools and data and keeping them available at all times. However, the Network Computer could be one of the configurations used in some places of the school. At present, this approach may be best facilitated using a removable hard disk such as a Zip(r), whereas perhaps in the future this will be done using a Flashcard or a PCMCIA hard disk.

Conclusion

For much of this study the results were disappointing from the researcher’s, and probably the school’s, point of view. In the words of Collins (1989), “We haven’t succeeded yet in demonstrating to teachers that there are real educational needs that IT tools can help them address more effectively than they could using other tools” (p. 8). However, provided the researcher, the school and wider education community with further information and a clearer understanding which will assist in increasing the successful implementation of computers into learning programmes. The quality and accessibility of hardware and software is now a minor problem for schools in developed countries. In all of these countries, problems of computer literacy of teachers and students are being addressed. What is left is a refocussing on the purpose and aims of schooling, reflection on the nature of learning and the problems schools have in facilitating learning, and the structuring of curriculum and schools to solve these problems. Then, provided teachers are given sufficient support and are permitted time to reflect on their own practices and experiment with solutions, computers will find a natural place in schools, fully integrated into the learning programmes to support student learning.

REFERENCES


