Project report

Open Source Software in Schools

A study of the spectrum of use and related ICT infrastructure costs

May 2005

Becta
British Educational Communications and Technology Agency

This report records work that Becta has done with schools which have implemented a range of open source software (OSS) solutions. This project, funded by the DfES, was one of an interrelated series, all looking at ways of helping schools make effective and sustainable use of ICT by exploring the total cost of ownership (TCO) of their ICT infrastructure.

The project started with a pre-existing set of 33 non-OSS primary and secondary schools that had agreed to take part in more general TCO work. Becta used existing OSS contacts and websites to identify a number of additional schools that were already using OSS, and invited them to take part in the project. Fifteen of these schools agreed to participate within the project timescales.

While both sets contained a range of schools in a variety of settings, they were not selected to be matched sets or to be more widely representative, and four schools were members of a mutually supportive cluster. They therefore represent opportunity samples.

The details of the OSS schools' ICT-related expenditure were compared with those of schools that are not using such software. Further contextual information from eight case study schools is also provided, and explores the nature of the range of implementations, the effect the choice of implementation may have on cost, and how staff and pupils feel about using OSS.

The project has produced three related publications:

- The project report, which outlines the use of open source software in the project schools and related infrastructure costs
- A case study report containing details of how eight of the schools in the project implemented open source solutions
- An information sheet summarising the findings of the project.

All three publications can be ordered or downloaded from the Becta website [http://www.becta.org.uk/publications].

Contents

Executive summary

This project had three aims:

- To examine how well the open source software (OSS) approach works, compared with proprietary offerings, in supporting delivery of the school curriculum and administration, and the effectiveness of OSS to provide adequate functionality to the educational user.
- To compare the total cost of ownership (TCO) of using OSS within school environments against that of non-open-source solutions. This includes the potential hidden support costs associated with using all types of software.
- To highlight examples of successful school-based open source implementations and produce case studies.

The TCO profiles of an opportunity sample of 15 OSS and 33 non-OSS schools were compared, and case studies of eight of the OSS schools were produced.

How OSS solutions were introduced

Schools introduced OSS solutions in three ways. They used them to:

- run the school's servers and provide school-wide services such as internet access
- provide the operating systems for classroom and/or administrative computers
- provide applications software for classroom and/or administrative computers.

It is important to distinguish between the different kinds of use as they often require different OSS products and provide different mixes of costs and benefits to different groups within the school. The use of OSS varied from full spectrum – more than the threshold value of 30% use of OSS on servers, PCs and the use of educational applications – through to narrow spectrum use of applications such as StarOffice[1] and OpenOffice in the classroom.

Use of OSS in the curriculum

Our findings show that OSS can provide a suitable technical infrastructure and a basic set of applications for classroom use.

Overall, the project schools had 20–30 OSS programs relevant to the curriculum, nearly all of which were open-ended applications such as graphics and music composition packages, rather than content-specific programs. There was a perception that open source productivity software was easier or simpler to use than the non-OSS equivalents.

Our findings show that open source software can provide a suitable technical infrastructure and a basic set of applications for classroom use.

Technical infrastructure and school administration systems

Technical infrastructure was well supported with around 27 packages being used. Surveys of staff satisfaction with the reliability and performance of ICT equipment and with ICT facilities and services show that satisfaction was higher for OSS schools overall, especially in the primary school sector.

We did not encounter any use of OSS to support whole-school administration and management. Incompatibility with other more specialised administrative packages was sometimes given as the reason for this.

Relative total costs

We have measured seven main elements in the total cost of ownership for both non-OSS and OSS schools using Becta's Total Cost of Ownership Model (see Appendix 1). Cost data for a three-year period was collated for hardware, software, network, consumables, training, formal support (both internally funded or bought in) and informal support (ie the equivalent cost of personal time spent on support or technical self-help). For comparison purposes, the average annual cost per PC has been taken as the most important measure to use, as several costs (eg consumables, software, peripherals and support) are primarily related to the number of PCs available.

The study indicates that:

- the annual total cost per PC was less for nearly all the OSS schools at both primary and secondary school levels. For OSS schools, cost per PC at primary school level was half that of non-OSS schools, and cost per PC at secondary school level was around 20% less than that of the non-OSS schools.
- the case studies show lower relative costs for OSS, with savings being mainly used on ICT-related improvements. The potential cost savings depend a great deal on the way a school implements the OSS solutions.

Relative support costs and training

Proportionally, support costs accounted for about 60% of the total annual cost per PC in both OSS and non-OSS schools. Annual support costs in individual OSS schools varied widely, but on average were 50–60% of those of their non-OSS counterparts, except OSS secondary schools which had slightly higher costs for informal support.

The varying support costs between OSS schools are closely related to the purpose and type of OSS implementation chosen by a school and the purposes for which OSS is being used. The most cost-effective support level and the kind of support required will vary accordingly.

Expenditure on training across all four sets of schools was low. This could partly explain the high support costs; perhaps more or better training could reduce the need for this.

Teachers in the OSS schools view their own skills and confidence in using ICT much more positively than the teachers in the non-OSS schools do, and lower levels of training could therefore be expected.

[1]StarOffice is not 'open source' in the true sense of the definition, but it is considered part of this category as it is an inexpensive alternative, and has a number of open source components.

Models of support
We compared formal and informal support (self-support) costs to the total cost per PC in each of the case study schools, identifying key differences by looking at extreme cases of ICT investment. These key differences suggested that the most cost-effective model for ICT support responds to cycles of innovation, because the demand for support and the kind of support required will fluctuate according to amount of ICT investment and the way new ICT is introduced into the school.

Cost advantages in the use of OSS solutions
The case for using OSS rests largely on the cost advantage, with cost savings, as distinct from cost cutting, achieved through the introduction of OSS.

It is important to adopt a strategic approach to financial planning in which any savings are then allocated to best meet the wider educational aims of the school.

Successful school-based use of OSS solutions
In order to link our findings to the wider setting of English schools as a whole, the study explored five characteristics of innovations that are likely to affect the speed at which OSS solutions are likely to be taken up by schools.

In our study of OSS in schools we identified the use of OSS in the following areas:

Technical infrastructure

- The use of open source operating systems for servers was generally seen as having a high level of relative advantage, having lower costs, superior reliability and greater ease of use than non-open-source systems.
- Linux on PCs took up less memory, increasing speed and allowing the continued use of older and more limited machines without any loss of performance.
- Dual-platform PCs, which allow users to switch between open source and non-open-source operating systems and applications, had a number of relative advantages over those running only an open source system. This solution gave users the opportunity to try new facilities, but, by providing both operating systems, overall cost savings were reduced. open-source-only PCs have a slower take-up, probably because of unfamiliarity with the desktop, and reluctance to use non-proprietary software.

Administration and management

- There were clearly divergent views on the relative advantages of OSS and non-OSS applications, with administrators generally undecided or lukewarm about their use, and pupils and teachers divided on their relative merits.
- The concerns of administrators and senior staff centred on lack of compatibility with other administrative packages, on training issues and the previous experience of administrators.

Curriculum software

- The range of content-specific OSS used was very small.
- The use of OSS by some teaching staff was often not apparent to others, possibly working in different rooms, unless there was an active policy within and between schools of discussing, encouraging and supporting its use.
- Another possible barrier to take-up was the fact that many teaching staff were unaware that software they were using was OSS, and therefore might not specifically look for other OSS resources.

Conclusions

- Our study indicates that OSS can be implemented successfully as a networking solution within the technical infrastructure and with obvious cost benefits.
- The use of office-based OSS such as StarOffice and OpenOffice offers a cost-effective alternative to proprietary office software.
- The lack of curriculum OSS and the real or perceived incompatibility with proprietary systems are obstacles to a more general introduction of OSS applications and content-specific software for classroom use. However, dual-platform PCs which contain both open source and proprietary systems could avoid problems with interoperability in administration, management and some curriculum applications. For these systems, however, there may be reduced or no cost savings.
- Whether or not migration to OSS is the best option for a school will vary from case to case. It is something that would need careful planning and discussion within the school. The potential cost benefits and savings clearly make it an option worth serious consideration. Cost, however, is not the only factor. The culture within the school and the context in which changes are introduced are crucially important factors to be taken into account.

Introduction

Open source software has been defined by Becta as:

'software for which the underlying programming code is available to the users so that they may read it, make changes to it, and build new versions of the software incorporating their changes. There are many types of open source software, mainly differing in the licensing term under which altered copies of the source code may be redistributed.'

The potential for OSS to make a significant contribution within the public sector has been explored in a number of UK Government publications (Briggs and Peck, 2003; Office of the e-Envoy, 2002; Office of Government Commerce, 2002; Office of Government Commerce, 2004). This series included a report on trials of OSS in the public sector. It concluded that:

'Open source software is a viable and credible alternative to proprietary software for infrastructure implementations, and for meeting the requirements of the majority of desktop users.

The main obstacles to widespread implementation of open source software are: for desktop applications, the current lack of complex functionality which can affect ease of migration and interoperability for some organisations; and for business applications, the lack of open source products to compete with large-scale proprietary enterprise-level products; no significant obstacles were noted for the adoption of open source in infrastructure developments.

Adoption of open source software can generate significant savings in hardware and software costs for infrastructure implementation, and reduce the licensing costs and hardware refresh requirements for desktop implementation.

Adoption of open source, particularly for the desktop, requires investment in planning, training of users, development of skills for implementation and support, and detailed consideration of migration and interoperability issues.'

Office of Government Commerce (2004)

The present project is, therefore, a more detailed evaluation of the use of OSS to see how far the general conclusions above apply within the school context.

Project context

The aims of the project were to:

- examine how well the open source approach works in practice in supporting delivery of the curriculum and administrative management in schools, and the degree to which OSS currently in use is effective and provides adequate functionality to the educational user
- compare the TCO of using OSS (including the potential hidden costs associated with using any software) within school environments against that of non-OSS solutions
- highlight examples of successful school-based OSS implementations and produce case studies.

Methodology

The project started with a pre-existing set of 33 non-OSS primary and secondary schools that had agreed to take part in more general work to investigate the TCO. Becta used existing OSS contacts and websites to identify a number of additional schools that were already using OSS, and invited them to take part in the project. Fifteen of these schools agreed to participate. While both the OSS and non-OSS groups contained a range of schools in a variety of settings, they were not selected to be matched sets or to be more widely representative, and four schools were members of a single mutually supportive cluster. The schools selected therefore represent opportunity samples. Eight of the OSS schools were chosen for case studies to explore the context and perceptions of OSS in those schools. Details of these schools are given in 'Open source software in schools: a case study report' (Becta, 2005).

Becta built upon existing work on developing a methodology for assessing the TCO of ICT in education. A specially developed tool helped schools assess both the visible costs and hidden costs associated with ICT investment and use. The approach considered a range of output measures designed to help identify the most cost-effective approach, rather than simply the lowest cost solution.

The details of the OSS schools' ICT-related expenditure were compared with those of schools that were not using such software. Further contextual information from eight case study schools is also provided, and explores the nature of the range of implementations, the effect that the choice of implementation may have on cost, and how staff and pupils feel about using OSS.

In addition, a survey of staff was carried out to gather information about their satisfaction with and their perception of the reliability of ICT facilities and services. The survey also collated their views of their own skills and training.

Appendix 1 describes how the data was analysed.

The availability of open source software provides students with a wider view of operating systems and software.

Open source software: a multi-level innovation

Our study observed that OSS can be introduced at three different levels in schools, to:

- run the school's servers and provide school-wide services such as internet access
- provide the operating systems for classroom and/or administrative computers
- provide applications software for classroom and/or administrative computers.

It is important to distinguish these levels, not only because they largely use different kinds of software, but also because they provide different mixes of benefits and costs to different groups within the school.

OSS can be introduced in any combination of these three levels, and there is no technical reason why, for example, all of a school's servers need to run the same system. They are therefore essentially three different potential innovations rather than one.

Profiles of OSS use

In the event, the project schools showed considerable differences in the distribution of, and weight given to, OSS at each of these three levels (Table 1).

The table below shows that:

- only five of the schools were full-spectrum OSS users, covering all three levels with substantial (more than the threshold value of 30% use) OSS availability for servers, PCs and laptops and applications
- five schools had a substantial OSS provision at only one of the three levels
- the percentage of OSS provision within a level varied considerably from school to school, but there was a strong tendency to have 0 or 100% provision
- four of these schools formed a cluster – three primary schools were supported by a secondary school.

It should also be noted that four of the eight case study schools were in the 'full spectrum' group, and only one of the other four had a low level of OSS provision. This meant that the case studies gave us a good picture of what we might assume to be the schools most committed to using OSS. It also indicated that these cases may be giving an over-positive picture of the responses of the project teachers overall to OSS.

			Open source operating systems (% use)		Open source applications (% use)	
School	Category	Phase	Server	PC	StarOffice	OpenOffice
A*	Full spectrum	Pr	100%	100%	100%	0%
B*	Full spectrum	Pr	100%	100%	100%	0%
C	Full spectrum	Sec	66%	80%	0%	90%
D	Full spectrum	Sec	63%	100%	0%	100%
E*	Full spectrum	Sec	60%	33%	0%	100%
F*	Server plus applications	Sec	100%	20%	100%	10%
G*	Server plus applications	Pr	100%	0%	100%	0%
H*	Server plus applications	Sec	86%	20%	0%	90%
I*	Server plus applications	Sec	70%	0%	0%	100%
J	Server plus applications	Sec	33%	20%	0%	70%
K	Server only	Sec	80%	0%	0%	0%
L	Server only	Sec	75%	1%	0%	15%
M	Server only	Pr	33%	0%	0%	0%
N	Applications only	Pr	0%	0%	100%	2%
O*	Applications only	Pr	0%	0%	75%	2%

Table 1: Distribution of OSS provision across levels in the project schools
* Indicates the school was also used as a case study

Open source software can be implemented successfully as a networking solution within the technical infrastructure.

Effectiveness of open source software

Teachers and pupils are the two main groups of educational users of ICT, so what do they expect OSS to do for them? Arguably their three main requirements are that OSS provides:

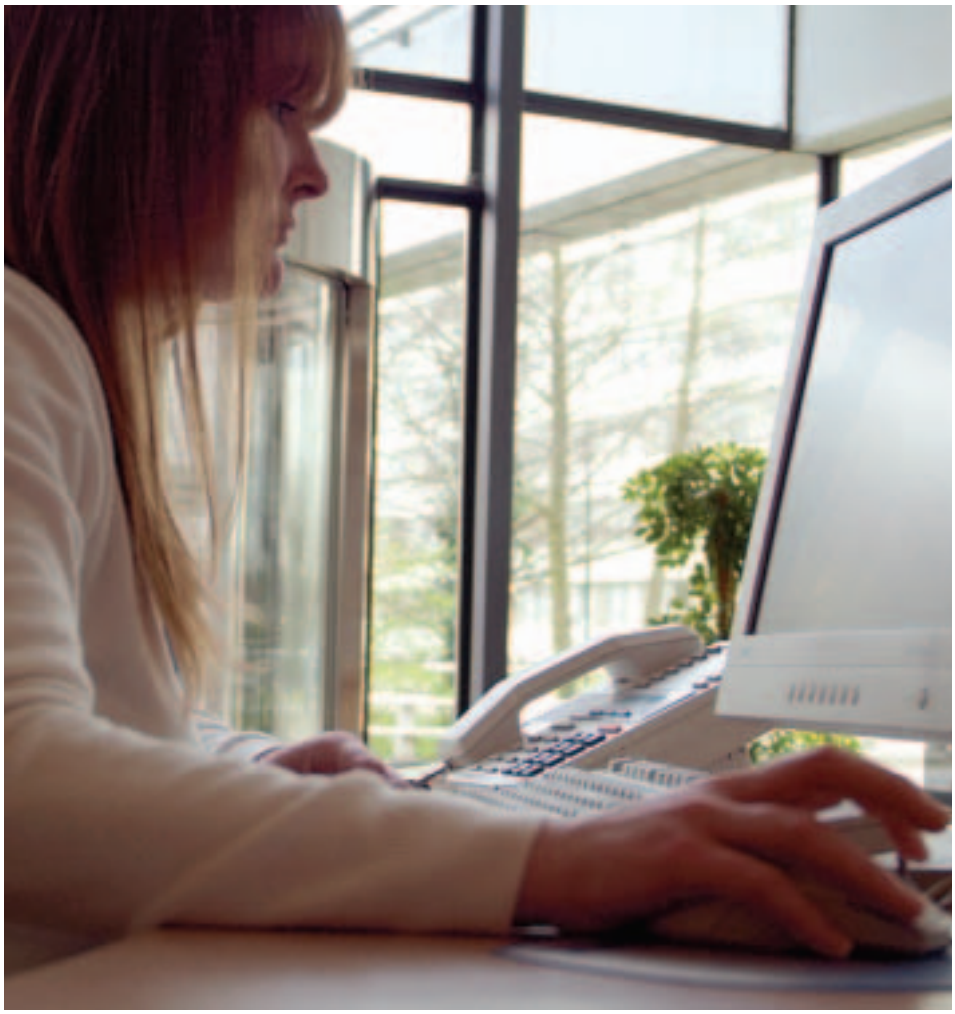
- support for curriculum delivery through a full set of basic applications and content-specific software across the curriculum
- support for school-level administration and management
- a technical infrastructure for the school that enables the delivery of the curriculum.

In the next three sections we examine each of these areas in turn.

Impact on curriculum delivery

Between them, the 15 project schools had around 50 different software programs (Appendix 2), if application suites such as StarOffice and OpenOffice were viewed as including several programs. Around half of these were relevant to the curriculum and were generally open-ended applications, such as graphics and music composition packages, rather than content-specific programs. This may reflect the wider usability of the OSS application packages, making them the obvious ones to start with, or perhaps an emphasis within the open source community on process rather than content.

The perceived lack of curriculum-specific OSS compared with proprietary products can be countered by the availability of internet-based open source content which is freely available to teachers and pupils via OSS browsers.



Within the OSS applications, the two office suites (the relatively low-cost StarOffice and the free OpenOffice) have a particular importance. They include the basic applications: word processing, spreadsheet, presentation, drawing and (in the case of StarOffice) a database. These can be used both by teachers and by pupils, and there were many references to them in the case studies.

In general the view appeared to be that these open source office applications were easier or simpler to use than the non-OSS equivalents. As one teacher put it:

> "I think it is more straightforward for a learner. That's certainly the feedback I am getting from the Year 6 children. That it's simpler. One of the examples one of the children gave me was of importing a picture or a photograph from the internet. She used StarOffice because she said it was easier than doing it through other packages."

The attitudes of teachers were also seen as very important. One primary school teacher noted that StarOffice had been introduced by the head teacher who:

> "did a staff meeting showing everyone how to use it. I think there was the odd comment, that it seemed simpler than Microsoft Word and there are adults in the school that think it is easier than Word and that's it's better for children, but there are others who just dismissed it, who've thought 'No, I know Word and that is what I am sticking with.' It's been quite a mixed reception."

This emphasises that having OSS applications available does not necessarily mean they will be used. For example, a respondent in one secondary school with an open source office applications package on all its PCs estimated that this was used only for between 5 and 10% of the time in preference to the non-OSS alternative, which was also universally available. Similarly, in one secondary school, staff laptops all had OSS applications installed, but the researcher found no evidence that the teachers were aware of this.

The reported views of one teacher in another secondary school illustrate some of the confusion which may lie behind this:

"[He] is not a fan of StarOffice – going so far as to describe it as 'the bane of my life'. He prepares all his lessons on Microsoft Office and teaches entirely through the computer. He's a big PowerPoint user and finds that things don't translate easily to StarOffice. He doesn't want StarOffice on his own laptop because, he says 'I've seen it and it takes over.' He suspects that students, who bring in their work as hard copy, use Microsoft Office at home. In spite of all this, however, he says that students seem happy with StarOffice and that it probably is not impacting on attainment levels. In spite of the 'inconvenience' of StarOffice, he feels it is probably worth it for the savings – in order to put more hardware into the school."

Other staff viewed the availability of both OSS and non-OSS as a positive advantage rather than a problem. One primary school head teacher had no particular feelings about OSS herself, but observed that:

"It's nice to have both. [Our teaching assistant] tends to use StarOffice for straight text processing but likes to use Microsoft's WordArt facility for preparing display materials. What she uses depends on just what she wants to do."

Interestingly the member of staff she mentioned, although of course well aware of the differences between the two packages, was not aware of 'open source' as a term, or of Linux.

This willingness to 'mix and match' was also mentioned by the head teacher in the case study report on another primary school:

"Children don't seem to care if they have Word at home, or StarOffice. At school they have never complained about which they use. No one has said to me, 'Oh, we haven't got that at home'; it's transferable skills that count. However, some pupils have commented that Word is faster than StarOffice, and that the toolbar is easier to read on Word."

Finally, there were two indications that OSS was also valued in some cases for its more general educational significance. In one secondary school, the OSS philosophy was seen as resonant with that of the school's specialist engineering status. In another, the ICT co-ordinator saw the availability of OSS as providing students with a wider view of operating systems and software.

Management and administration

Management and administration software is a part of school ICT. None of the schools in our sample used OSS for these purposes. As far as we are aware, there are no specialist OSS packages available for management and administration in the UK, although some are under development elsewhere (Shuttleworth Foundation, 2004). It would have been possible for schools, nevertheless, to use relevant generic OSS applications such as word processors and spreadsheets. These were widely available in all but three of the project schools.

The decision not to use OSS applications for management and administration was sometimes linked with the administrator also needing to use specialised packages that were not OSS-compatible. In one full-spectrum school, for example, the administrator had been trained on, and was very used to, Microsoft Office, and doubted if StarOffice would be compatible with other packages.

Technical infrastructure

Between them, the schools reported 27 different software packages available to support the technical infrastructure. There were no indications that ICT managers in any of the schools thought that this range, or the quality of the OSS, was inadequate.

For staff as a whole, the survey collected information on two areas of staff satisfaction: their view on reliability and performance of ICT equipment, and their satisfaction with ICT facilities and services. The staff were generally satisfied with the reliability and performance of equipment, with all the OSS schools except one rating this as 'OK' or above. The results for non-OSS schools were similar. Schools' views on ICT facilities and services were much more mixed, but satisfaction was higher among the OSS schools overall, especially in the primary school sector.

In general the view appeared to be that these open source software applications were as easy to use as the non-open source software equivalents.

For staff as a whole, the survey collected information on two areas of staff satisfaction: their view on reliability and performance of ICT equipment, and their satisfaction with ICT facilities and services.

Relative costs

Data collection

There are a number of ways in which TCO can be calculated (Scrimshaw, 2002). The tool that the project team used was designed to identify seven main elements of the TCO, namely:

- hardware
- software
- network
- consumables
- training
- formal support (both internally funded and bought in)
- informal/self-support (ie the equivalent cost of personal time spent on support or technical self-help).

The cost data we gathered from project schools covered a three-year period and complemented the results of the user survey to provide annual TCO figures per PC and per student. In addition, various other very detailed analyses were carried out of, for example, the software costs per PC for different categories of software. These were also compared with equivalent figures from the set of 33 non-OSS schools. Appendix 3 provides a general summary of these figures.

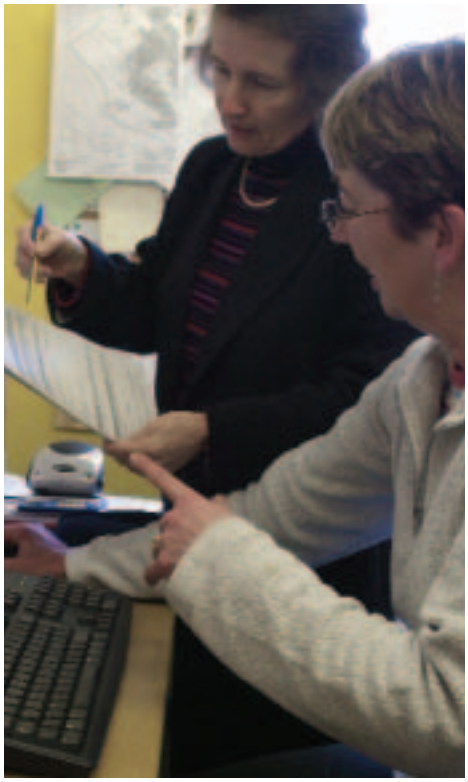
Comparisons between these OSS and non-OSS costs are given below, but have to be viewed with caution for three reasons. Firstly, the detailed figures show considerable cost variations between the OSS schools. Given the very small number of schools involved, this means that had the team replaced one OSS school with another, it could have produced substantially different figures overall.

Secondly, there are indications in the data that the OSS schools were, as a group, different from the non-OSS schools, which suggest that we are not dealing with equivalent sets of schools.

Finally, as shown earlier, the OSS schools in many cases had quite limited OSS provision (and actual use was sometimes reported to be much less still). We are therefore not looking at 'non-OSS' and 'all OSS' schools, but at schools ranging across the full spectrum of OSS provision from 0 to 100%. At best, then, these general comparisons of the sets of OSS and non-OSS schools give very limited indications of what relative costs are likely to be more generally.

The total cost of OSS ownership

In most of the analysis that follows, the average annual cost per PC is taken as the most important figure to use. This is because several costs (such as for consumables, software, peripherals and some kinds of support) are fairly directly related to the number of PCs available. Figure 1 below shows an overall comparison of the total costs per PC (broken down into the categories listed) for all the OSS schools in the study (primary = P1–P6, secondary = S1–S9) compared to those of non-OSS schools.



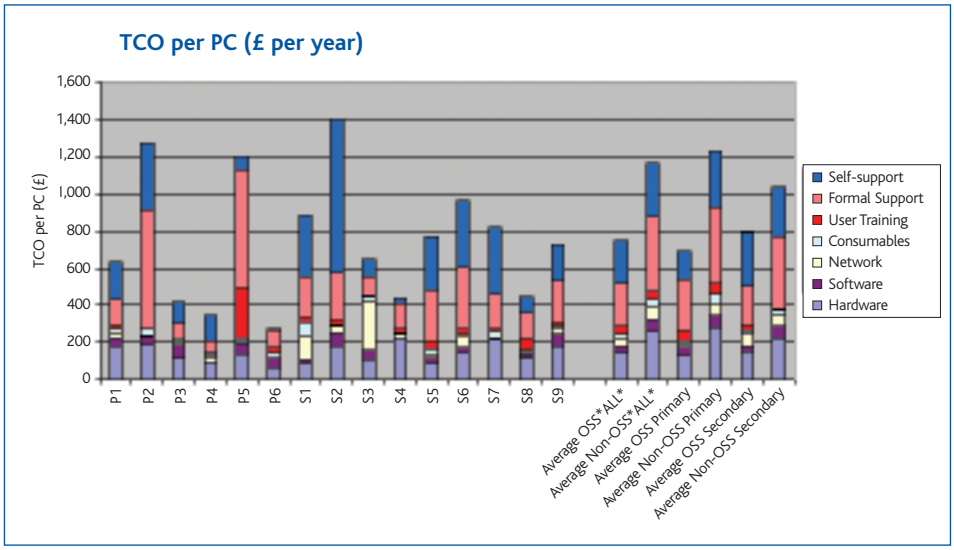


Figure 1: Annual TCO per PC for OSS primary and secondary schools

The distribution of costs, as a percentage of the total, for OSS primary schools is shown in Figure 2 and Table 2 below.

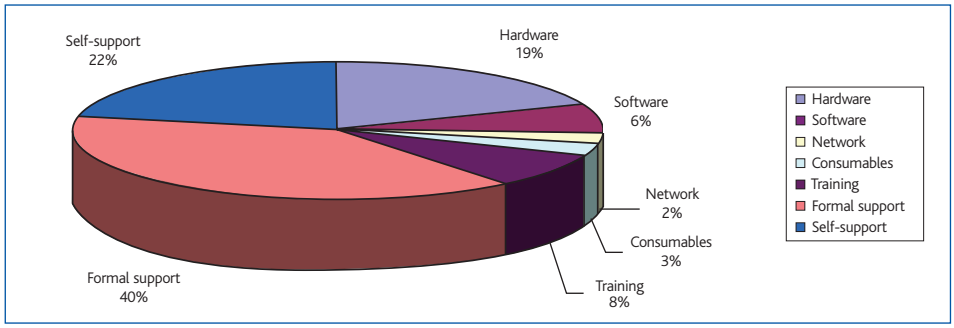


Figure 2: Annual TCO per PC for OSS primary schools

Cost category	Cost per PC (£)	%
Hardware	131.71	19
Software	44.68	6
Network	14.11	2
Consumables	21.89	3
Training	57.50	8
Formal support	273.17	40
Self-support	148.86	22
	691.92	

Table 2: Annual TCO per PC for OSS primary schools

The annual TCO for OSS secondary schools is given in Figure 3 and Table 3 below.

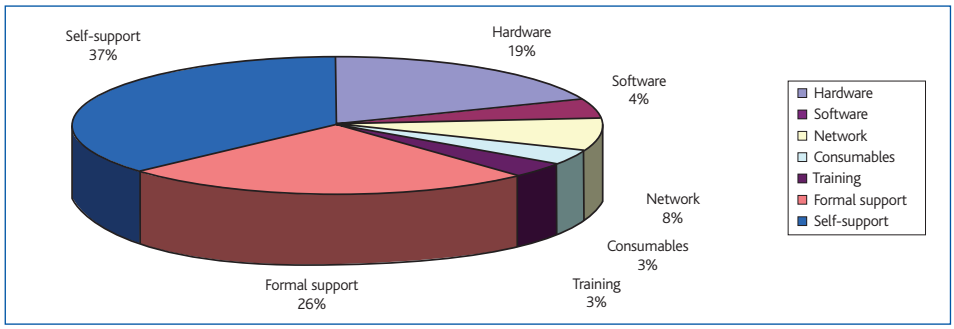


Figure 3: Annual TCO per PC for OSS secondary schools

Cost category	Cost per PC (£)	%
Hardware	151.93	19
Software	32.56	4
Network	61.58	8
Consumables	24.21	3
Training	27.04	3
Formal support	206.61	26
Self-support	283.39	37
	787.32	

Table 3: Annual TCO per PC for OSS secondary schools

The cost data we gathered from project schools covered a three-year period and complemented the results of the user survey to provide annual TCO figures per PC and per student.

Comparison of costs for OSS and non-OSS schools

Figure 4 and Table 4 below show the costs of OSS schools as a percentage of the costs in non-OSS schools. The percentage distributions of total costs between the categories are roughly similar for both the 15 OSS and the 33 non-OSS schools. However, in absolute terms, the costs are nearly all less for the OSS schools. This is true both for the primary and secondary school sets.

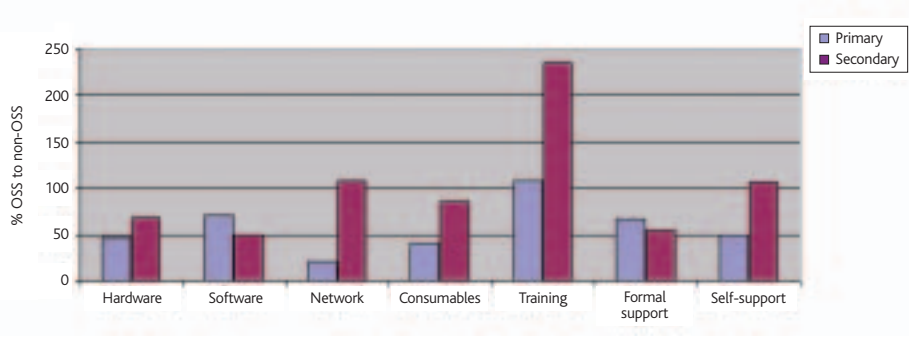


Figure 4: OSS schools' costs as a percentage of non-OSS schools' costs for primary and secondary schools

Annual TCO per PC (£)	OSS primary	Non-OSS primary	OSS secondary	Non-OSS secondary	OSS as % non-OSS primary	OSS as % non-OSS secondary
Hardware	131.71	280.53	151.93	221.88	47	68
Software	44.68	64.14	32.56	67.10	70	49
Network	14.11	66.94	61.58	56.76	21	108
Consumables	21.89	53.13	24.21	28.33	41	85
Training	57.50	53.31	27.04	11.53	108	235
Formal support	273.17	406.16	206.61	385.62	67	54
Self-support	148.86	303.83	283.39	264.48	49	107
TOTAL	**691.92**	**1228.04**	**787.32**	**1035.70**	**56**	**76**

Table 4: Comparative TCO per PC for OSS and non-OSS schools, by cost category for primary and secondary schools

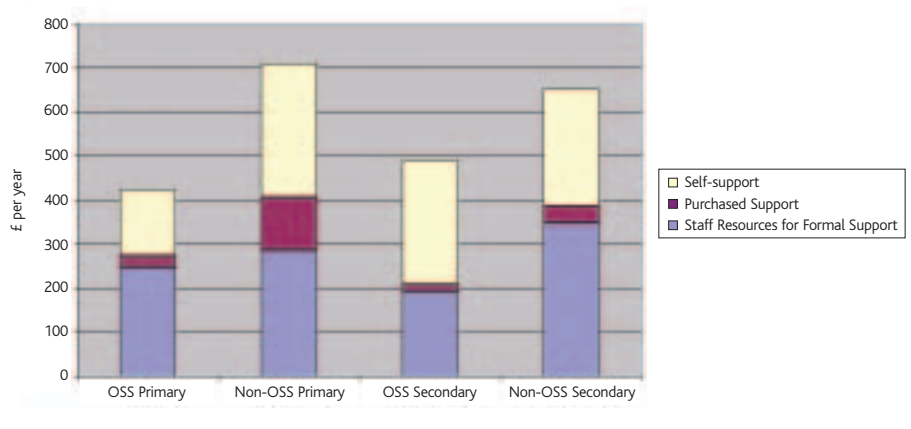


Figure 5: Average annual support costs

If the full-spectrum OSS schools are compared with the remaining OSS schools, they tend to have lower TCOs per PC, again suggesting that OSS costs are generally less. However, this is clearer with primary than with secondary schools.

The same feature of lower relative costs for OSS also emerges from the case studies. Six of the eight case study schools gave cost savings as their main reason for introducing OSS, and six of the eight later reported that such savings had in fact been achieved. In one case the money had been used to pay a part-time ICT teaching assistant; in another it had been used to improve the pupil:computer ratio and provide extra technical support. As the ICT co-ordinator put it:

> "If I moved anywhere else [...] I'd implement OSS because the financial savings are considerable and this releases more resources to tackle successful implementation."

In order to achieve flexibility, and for schools to run their chosen software, some needed dual-platform systems with both open source and non-open-source operating systems, which significantly reduced the cost savings.

When savings are made in an OSS school, the question arises of who 'owns' the savings. Three schools specified how these savings were spent: in all three, the money went back into ICT-related improvements. This could well be the best policy in many situations, but the decision would naturally depend on individual school management.

Relative support costs

Support costs made up about 60% of total cost in both the primary and secondary school sets, for both OSS and non-OSS schools.

The costs of support in OSS schools were generally around 50–60% of the equivalent non-OSS support costs, except for self-support in secondary schools, where the OSS schools had slightly higher costs. (See Figure 5.)

The very low figures for training across all four sets of schools are also notable. (See Figure 6.) This may partly explain the high support costs; perhaps more or better training could reduce the need for support.

Teachers in the OSS schools perceived their ICT skills much more positively than the teachers in the non-OSS schools did. The same was true for their perceptions of their confidence in using ICT. It is possible that the OSS teachers are more experienced and confident with ICT than their non-OSS colleagues. If so, lower levels of training could be expected, as training would be seen as less necessary. However, the non-OSS schools also had the same low proportion of expenditure on training per PC, so training does not appear to be related to teachers' perceptions of their ICT skills and their confidence.

Figures 7 and 8 show that all the OSS schools reported higher levels of teacher confidence and ICT skills than the rest of their non-OSS colleagues.

Given that support costs form a very high proportion of total costs, a key question concerns the optimal balance between training teachers and supporting them. The related issue of what specific kinds of support and training are needed is also important.

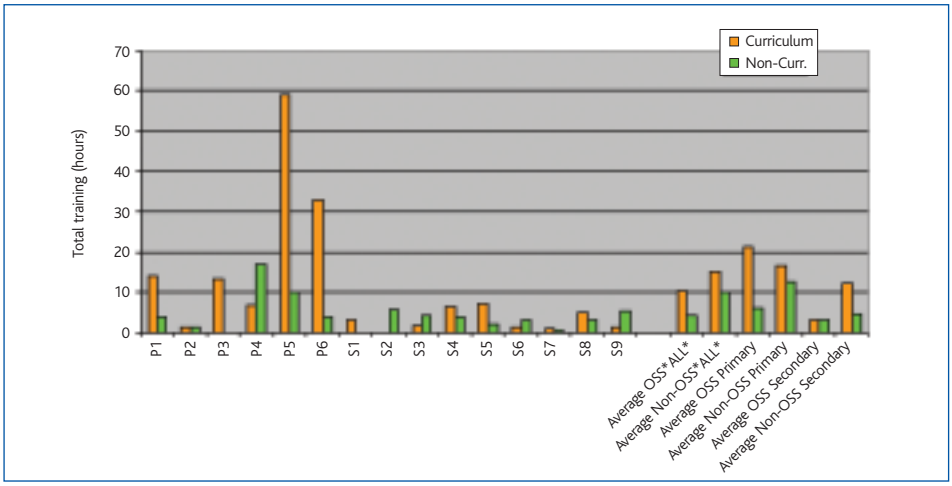


Figure 6: Training in the last two years

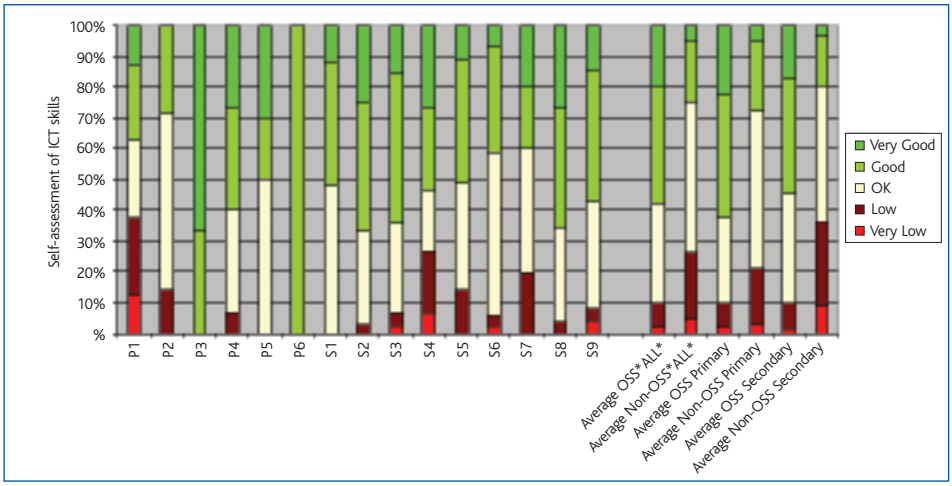


Figure 7: Staff self-assessment of ICT skills

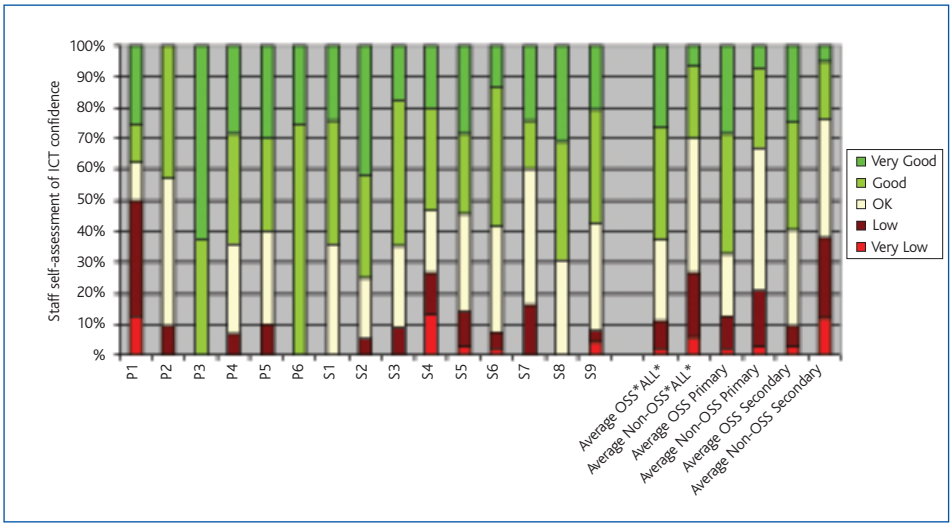


Figure 8: Staff self-assessment of confidence in use of ICT

The way forward

Cost-effective models of support in OSS schools

We might assume that the more cost-effective support models were those where staff satisfaction with ICT facilities and services was high, but support costs per PC were relatively low. On these measures, we can group the eight case study OSS schools into three broad categories:

- Schools with relatively high staff satisfaction and relatively low support costs (one secondary school, three primary schools in the cluster – see below).
- Schools where both staff satisfaction and support costs were medium (two secondary schools, one primary school).
- A secondary school where satisfaction was medium, but support costs were high.

If all schools are grouped into these three categories, it can be seen that non-OSS schools generally had medium satisfaction and support costs. The exception is the non-OSS primary school average, which shows medium satisfaction and high support costs. This suggests that it is the first and third categories that require further examination as they may yield more pertinent information on different support models.

The four high satisfaction/low cost schools were all members of the same cluster of schools, which we will call the 'Evenlode' cluster. All four had all their servers running under OSS, and all their PCs ran OSS applications. However, the schools varied greatly in how many PCs had open source operating systems available, and in the proportions of formal support and self-support. The Evenlode schools believed that the LEA did not support OSS, although it had provided generic funding and assisted the schools with non-OSS support.

Much of the drive to introduce OSS within the cluster came from the IT administrator in the secondary school, who was an enthusiastic and knowledgeable advocate for OSS. He installed the networks in all four schools, beginning with the secondary school in 1999. By the end of the project, the secondary school had two full-time staff providing support not only to their own school, but also at a distance to their colleagues in the three primary schools. Each of these schools had a member of staff who was seen as essential to promoting and supporting OSS use. In one case this was an advanced teaching assistant, in another a school administration officer and in the third the head teacher was personally well informed and enthusiastic about OSS. Her interest was another factor in spreading its use, because she introduced OSS into her first cluster school and, on becoming head teacher of a second school in the cluster, took OSS with her. Another important contributor was a Unix programmer who lived locally and wanted to give something back to the community. He gave his services free of charge to the secondary school. When he later left the area he still supplied advice whenever required and, on occasion, visited the secondary school. This contribution has a notional value which has not been applied in this study due to the lack of detail relating to the programmer's time and effort and complexity of the support offered.

For some of the participants, it was clear that OSS was chosen not only to save money, but because it was seen as embodying and helping to implement a collaborative ethos. One shared objective of schools within the cluster is to provide all pupils with a single user ID and password which they may use at any of the Evenlode schools in the future.

A partially contrasting picture was provided by an OSS secondary school, which we will call 'Mornington', outside the Evenlode cluster. Here staff satisfaction was medium, but support costs were high. Staff satisfaction with ICT facilities and support was quite similar to that for the secondary school in the Evenlode cluster. Both were 'server plus applications' schools, with the Evenlode school having OSS on 100% of the servers, on 20% of the desktop PCs, and with 100% of the PCs with OSS applications. Mornington had 70% of servers with OSS, no desktop PCs running open source operating systems, but 100% of them running OSS applications. However, the schools differed in the proportion of user self-support, this being around one-third of all support in the Evenlode school and around four-fifths in Mornington. Another major difference was that total support costs per PC for the Evenlode school were around one-fifth of those for Mornington. The schools also differed in size: Mornington had around three times as many pupils as the entire Evenlode cluster, which suggests that it should have been achieving greater economies of scale than the smaller cluster spread over four sites.

At first sight all this might suggest that support in Mornington was far less cost-effective than in the Evenlode schools. However, this assumes that a simple cross-checking of support cost per PC against staff satisfaction is a sufficient indicator of cost-effectiveness. It also assumes that the best arrangement is for the ratio of the two to stay the same over time. However, when the two cases are looked at in more detail a rather different picture emerges.

First, much of the introduction of OSS into the Evenlode schools took place between 1999 and the first half of 2001, meaning that the innovation was quite well bedded in at the time that the data was collected. Although two of the schools planned to introduce data projectors or interactive whiteboards, the overall emphasis across the cluster was on building on existing progress and maximising the benefits for pupils from what has already been achieved. The case study report for the secondary school, for instance, records that:

'The school aims to place the now-developed ICT infrastructure fully at the service of teaching and learning. Increasingly, ICT will be central to all teaching and learning and the means by which they are made exciting. Now that the nuts and bolts are in place, the creative use of the ICT is of major importance.

We shall use ICT increasingly to communicate with each other and, as the technology continues to become more reliable, we'll become more reliant on it.'

The position in Mornington was rather different. The case study report shows that this school was at the time very active in a wide range of different kinds of ICT development:

'The ICT facilities in school are exceptional and amongst the most comprehensive in any school [a new ICT-based learning facility was opened in 2002] and plans are in hand to develop a wireless network during this academic year. Staff expertise in ICT is very good, with a continuous programme of training provided through the New Opportunities Fund, and they are in the process of providing a laptop for every teacher, and an electronic whiteboard or equivalent for each department.'

Teachers in Mornington were dealing with a considerable variety of new equipment. Furthermore, laptops, wireless networks and electronic whiteboards present very different operational and pedagogical problems and possibilities. In those circumstances it might be expected that the teachers would either need more support or need to spend more time on self-support, which in fact is what is reported.

This suggests that, in thinking about the most cost-effective support, we need to view the need for support as not being static, but relating to cycles of innovation in which the demand for support and the kind of support required will vary from phase to phase.

Best practice in the use of open source licensing solutions

It is probably not possible to answer this question on the basis of the project evidence, for the following reasons. Best practice is that practice which best achieves the desired ends, while using only ethically acceptable means to do so. In the case of schools, the main aim relates to pupils' learning, but the project was not designed to provide any direct information on the link between OSS use and pupils' learning. However, in general, anything that reduces the cost of some part of the mechanics behind the teaching and learning activities potentially helps learning by freeing resources that can be used in other ways. Hence cost saving, as distinct from cost cutting, through the introduction of OSS, could lead indirectly to better educational attainment.

There seems to be no reason why OSS in general should achieve better educational outcomes than non-OSS products. While a particular OSS package may be better than a given non-OSS alternative, there does not seem to be any reason why, in general, that should be so. If this is correct, the case for OSS rests very largely on the cost advantages rather than any direct educational benefits. This emphasises the importance of a strategic approach to financial planning, in which cost savings are then allocated to best meet the wider educational aims of the school; it is here that cost savings can turn into educational gains.

"If I moved anywhere else [...]
I'd implement open source software
because the financial savings are considerable and
this releases more resources to tackle
successful implementation."

Successful implementation of OSS

Perhaps one good test of a successful implementation is the willingness of those involved to continue with the innovation after a project has ended. To check this, the project team asked head teachers whether they had any plans to continue or extend the use of OSS. These were the responses:

"This is difficult because of the views of the teachers on it – they seem to prefer Microsoft Word, but only because they are more familiar with it."

"I'd like to see a mixture of open source and proprietary software. We had some resistance from staff when we tried to set up open source on their laptops as they also wanted Microsoft, and it caused us a bit of a hassle. We didn't want to have to spend money on licences, but in the end we had to."

"Without doubt, OSS will continue to be used at least as much as at present."

"The school intends to continue with OSS in the same way it is used at present."

"...anything that reduces the cost (...) behind the teaching and learning potentially helps by freeing resources that can be used elsewhere."

"OSS works and so we'll stay with it. Importantly, it works across the whole cluster. There's a 'critical mass' benefit there."

"The school already uses OSS as much as possible. This will certainly continue." "New systems introduced into the school will run OSS – so its use will increase. The intention is only to use proprietary products when absolutely necessary."

"There are plans to build an electro music suite using open source software that is currently in development and nearly ready for use. [We are] always looking for open source alternatives for all the current subject-specific software being used."

This is an encouraging set of responses for supporters of OSS, bearing in mind that some of the schools were already covering the full spectrum of OSS use. However, it should be emphasised that these schools were identified as ones that were already using OSS before the project, so are highly atypical of English schools generally. How can we summarise the views of the participants in a way that links their very different experiences and responses to the wider setting of English schools as a whole? One way is to look at the characteristics of the OSS which would be expected to affect its uptake in schools, and then see how this compares with the introduction of OSS in our project schools.

In his book summarising research on the diffusion of innovations, Rogers (1995) draws out from the studies he analysed five characteristics of innovations that are likely to affect the speed at which they are taken up. Innovations are more likely to be adopted quickly if they have high relative advantages, compatibility, trialability and observability, and less complexity. So how well, on the basis of the project evidence, does introducing OSS at each of the three levels meet Rogers' criteria? A summary answer is given in Table 5.

This table shows that the innovation profiles of the three levels at which OSS was introduced were different in a number of respects. The innovation profiles for PCs with an open source operating system alone and both an open source and a non-open-source operating system (the dual-platform approach) were also significantly different.

Using OSS to run the school's servers and provide school-wide facilities

The use of OSS for servers was generally seen as having a high level of relative advantage, having lower costs, more reliability and similar or greater ease of use than non-OSS systems. Thus it matched well to any interest a network manager had in adjusting the infrastructure to suit the needs of the school, and its relative cost-effectiveness matched the concerns of senior staff to make best use of the funding available.

Migrating a school's technical infrastructure to open source is not, however, something easily done on a trial basis. In schools with a single server, there is no way of trialling the change for a system that has to be running continuously. Schools with more than one server are better placed, and it was perhaps significant that schools in this position appeared to be trialling OSS on some servers only.

Finally, it is not generally obvious to others in the school whether or not a server is running OSS. Although it might be expected that the reduced costs and improved reliability would be seen by others, this may not always be so. Some senior management teams were not fully aware of the cost savings, while the number of faults occurring was so low that, for any individual teacher, improvements here might not be that noticeable either.

Overall, however, the prospects for a more general take-up of open source at the server level look good.

Factor affecting speed of take-up of innovation	OSS servers	OSS PCs		OSS applications
		OSS only	Dual platforms	
Relative advantage: the degree to which an advantage is perceived as better than the idea it supersedes.	High	Variable	Variable	Variable
Compatibility: the degree to which an innovation is perceived as being consistent with the existing values, past experiences and needs of potential adopters.	High	Variable	High	Variable
Complexity: the degree to which an innovation is perceived as difficult to understand and use.	Low	Variable	Low	Variable
Trialability: the degree to which an innovation may be experimented with on a limited basis.	Generally low	Low	High	High
Observability: the degree to which the results of an innovation are visible to others. The easier it is for individuals to see the results of an innovation, the more likely they are to adopt it.	Low	Generally low	Generally low	Generally low

Table 5: The three levels of implementation of OSS rated against Rogers' five criteria for speed of take-up of an innovation (based upon Rogers, 1995, pp. 15–16).

Using OSS to provide the operating systems for classroom and administrative PCs

The provision of OSS on PCs/laptops can either involve having only an open source operating system or setting up the computer with both an open source and a non-open-source operating system. These dual-platform PCs allow users to switch between OSS and non-OSS applications as they wish. As Table 5 shows, the innovation profiles of these two approaches differed considerably.

The PCs with only an open source operating system had a number of relative advantages over those running only under a non-OSS system. One advantage mentioned was that a system such as Linux takes up less memory, increasing speed and allowing the continued use of older and more limited machines without any loss of performance.

While open-source-only PCs might be viewed positively by ICT support staff and senior teachers because they embody their commitment to open source values, they were not necessarily viewed in the same way by those classroom teachers who had reservations about using OSS applications. For these teachers, the introduction of open-source-only PCs meant also that they had to learn to use OSS applications. An open-source-only machine also lacked trialability – the move to OSS-based working had to be complete from the start. As with all classroom innovations, the visibility is low unless there is a structured forum for OSS discussions and support among users.

Overall, then, open-source-only PCs have a number of weaknesses in terms of quick take-up being likely. In some case study schools this led to the dual-platform approach being tried instead.

The difficulty with this was that it reduced cost savings, as the PCs still had to have non-open-source systems as well, which made the continuing use of older PCs at the classroom level less attractive. Nor did it necessarily make the use of OSS any more attractive or less complex to teachers. An advantage of the dual-platform approach was that it allowed far better trialability. Again, as a classroom innovation, dual use was not particularly visible to others.

So the two ways of introducing open source operating systems both had problems: the first sometimes being seen as offering too steep a learning gradient, the second having so low a gradient that there was no real pressure upon a teacher doubtful about OSS to make the move to explore it at all. This suggests that the successful introduction of open source operating systems would need to be part of a carefully planned and argued overall strategy.

Using OSS on classroom and administrative PCs

The position with application software was less clear-cut. There were clearly divergent views on the relative advantages of OSS and non-OSS applications, with administrators generally opposed or indifferent to OSS, and pupils and teachers divided on the relative merits of the two.

The concerns of administrators and senior staff about administrative OSS use centred on lack of compatibility with other administrative packages, and with the training and previous experience of administrators. This was not because OSS packages were seen as more complex. In general they were described as less complex or as complex as equivalent non-OSS packages.

OSS applications were trialable in two respects. First, OSS was sometimes introduced on different sets of PCs within the classroom at different times. Secondly, the possibility either of running dual systems or providing OSS applications that ran under non-open-source operating systems meant that a classroom user could often have the choice of using the OSS or the non-OSS version of an application. Indeed, as we saw above, this was exactly what some pupils and teachers reported doing.

The range of content-specific software used was very small, but it is unclear how far this was because a limited range of good quality software was available or because its existence was not known to the schools. (Some possible sources for additional software are given in Bruggink, 2003, and Vuorikari, 2003.)

However, like most classroom innovations, the use of OSS was not likely to be highly visible to other teachers working in different rooms, unless, as in the Evenlode cluster, there was an active policy of discussing, encouraging and supporting its use within and between schools.

Overall, the prospects for an expansion of OSS application use and content-specific software look good.

"New systems introduced into the school will run open source software – so its use will increase. The intention is only to use proprietary products when absolutely necessary."

Conclusions

The findings from the survey and case studies suggest that OSS has the functionality needed to provide a suitable technical infrastructure and to meet the requirements for a basic set of applications for classroom use. The position on content-specific software appears weaker, although the full range of available software and its quality would need to be reviewed to clarify how serious an obstacle this is. There are also questions about interoperability in the area of administration and management packages. However, the possibility of setting up dual-platform PCs indicates that OSS already has adequate functionality, which in future could be developed to support administration and management.

It is clear that there are potential cost savings with OSS, and a significant number of the sample schools originally considered OSS because of budget constraints. However, these savings are not evenly distributed across the three areas investigated – server and computer operating systems and applications. Cost savings are likely to depend a great deal on how the school implements and supports the change. For example, feeder primaries that were part of a mutually supportive cluster clearly benefited from their local support agreement.

The project schools indicated a degree of reliance on an informed and experienced 'champion' of OSS, driving the implementation as appropriate. Schools wanting to take advantage of the potential cost benefits of OSS would need to consider how to access appropriate skills and knowledge to underpin and support any proposed migration or implementation of open source.

There appeared to be a culture of well-defined user support in OSS schools, where attention was focused on training in the use of new applications. Strong strategic leadership in ICT requires a clear vision and strategy. The implementation of OSS promoted positive discussions between the senior management team, ICT managers, staff and users. This is a good example of how introducing a new innovation into the school environment can foster change and develop institutions at many levels.

Migration to open source may not be the best option for all schools, although the potential benefits clearly make it an option worth serious consideration. Careful planning and discussion would be needed within the school, and it is important to think about what combination of elements of open source it might be worth introducing and why.

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"This is a good example of how introducing a new innovation into the school environment can foster change and develop institutions at many levels."

Appendices

Appendix 1: Data collection and analysis

Data collection

The main instrument used was the Becta Total Cost of Ownership (TCO) Model – an online tool which has been used to collect and record data from schools in a range of projects. The outputs of the Becta TCO Model can then be represented as total annual costs per PC for each school or per student to enable comparisons. You can view the Becta TCO Model and example data online [http://tco.ngfl.gov.uk] – username, ExampleSecondary; password, ExampleSecondary16.

In addition, a survey of staff was carried out to gather information about their satisfaction with and their perception of the reliability of ICT facilities and services. The survey also collated their views of their own skills and training.

All of this data was tabulated in a form that allowed comparisons between the individual OSS schools, and also comparisons with the average results for the non-OSS primary and secondary school sets.

One or two key staff in each OSS school also had an opportunity to take part in a structured feedback session in which they could compare their school's TCO figures against those of others. In one or two cases this revealed a misinterpretation that was corrected and the results revised accordingly.

A standard format was provided by the project team for the eight case studies. Researchers were appointed to collect and collate this data and to interview key staff and, in most cases, pupils, in each of the case study schools.

Method of analysis

The school case studies were analysed to identify trends highlighting how OSS was being used; from this the case study report was drawn up.

The project report was prepared by an independent researcher using all these data sources, working closely with the project team. The content of the report was based on recasting the project objectives and aims in question form to provide the section headings used above. The various data sources were then studied to identify their relevance to each of these questions. This method of analysis is a variant on that proposed by Yin (2003). It was selected as arguably offering the most elegant match with the project's overall design and methods of data collection. It also had the advantage of mapping the results closely onto Becta's original intentions, with potential benefits for subsequent implementation.

Appendix 2: The open source software packages available in project schools

The software listed below are those which one or more project schools reported using. This is not therefore a complete list of OSS relevant to schools, or necessarily always the best available. For other possibilities, see sources mentioned in Bruggink (2003) and Vuorikari (2003).

Apache is a popular web server, with a range of standard features – other more advanced features are available through optional add-in modules.

Audacity is a free audio editor for recording, editing and playing sounds and for importing and exporting audio files in a range of common formats.

Bridge Builder is a freeware computer game. The object of the game is to construct a bridge, using a limited number of beams, that a train may cross.

Calc is an interactive calculator for making large numeric calculations, but which can also be programmed for difficult or long calculations.

Crocodile Clips is a real-time circuit simulator that uses animation to demonstrate electronic concepts.

Fake Ident is a tool that replies with a standard answer to all incoming identd requests on a host.

Fcron lets you schedule jobs to run at a specified time. The system does not need to be running continuously to use Fcron.

Fetchmail fetches emails from a remote machine; it does not require a 24-hour internet connection to do this.

GIMP can be used as a simple paint program or for image-manipulation – for example for retouching photos, rendering images or converting images into different formats.

Grep utilities are a family of Unix tools that are used for searching the contents of files for specified text.

IrfanView is a very fast, small, compact and innovative freeware graphic viewer for Windows.

Ipchains is an IP accounting and packet filtering administration service.

GTI JPEGSaver is a screensaver slideshow that allows users to turn image files into a slideshow, complete with transition effects.

Konquer is a file manager that can display the contents of a file or directory, and also displays web pages and the contents of some text files.

Linux is an operating system for which the source code is freely available. It runs on many different hardware platforms, and a vast range of applications have been written for it.

Mozilla is an open source browser that forms the basis for Netscape and other browsers. It helps users create web pages, check and send email, and read and respond to newsgroups. It also includes an IRC chat program.

MSW Logo is one implementation of a computer programming language designed to be easy to learn and use by everyone, including children. Although created with children in mind, it is still a complete and powerful programming language.

Nmap is a security tool used to determine what ports are open on a given system.

OCS inventory is an application designed to help the network administrator keep track of the computer's configuration and the number of copies of software installed on the network.

OpenOffice is a free, open source, cross-platform office suite with many of the same features as commercial suites.

Passook automatically generates passwords. Users can choose different levels of security for the password.

PasswdGen is a utility for system administrators who, for security reasons, want to generate random passwords based on their own criteria.

PDFCreator provides a simple method of creating PDF files.

Postfix is a Simple Mail Transfer Protocol (SMTP) email server for UNIX.

Pro/DESKTOP is a commercial computer-aided design (CAD) software package that enables users to design using 3D solid models, and then go on to produce engineering drawings and photo-realistic renderings.

PuTTY is a terminal emulator for various network protocols. It can run on a Windows machine, and connect to, for example, a Linux machine.

Qpopper is the most widely used server for the POP3 protocol (this allows users to access their mail using any POP3 client).

Rosegarden-4 is a MIDI and audio sequencer, notation editor, and general-purpose music composition and editing application for Unix and Linux.

Samba is a software suite that runs on a platform other than Windows (eg Linux/Unix) and provides seamless file and print services to Windows-based clients.

Secure Shell (SSH) is a program for logging into, and executing commands on, a remote machine. It is intended to provide secure encrypted communications.

Sniffit is a network protocol analyser or packet sniffer that listens to network traffic and produces analysis based on the traffic and/or translates packets into some level of human readable form.

Squid is software that caches internet data. If a user wants to download a web page, Squid obtains it from the remote server and transfers it to the user's machine, keeping a copy for any future requests.

squidGuard provides URL-based filtering supported by database categories to stop users accessing unwanted sites.

SquirrelMail is a standards-based webmail package written in PHP4.

StarOffice is an office productivity suite that offers word processing, spreadsheet, presentation, drawing and database capabilities. StarOffice is not 'open source' in the true sense of the definition, but it is considered part of this category as it is an inexpensive alternative, and has a number of open source components.

Super Duper Music Looper allow users to create music on their PCs. It is primarily designed for children aged 6–10.

Music Box is a commercial music-making package for children that covers sounds, chords, percussion and composition in four self-contained parts. It is designed with the non-specialist teacher in mind.

Tux Paint is a drawing program for young children, with a simple interface and fixed canvas size.

Vi is a text editor that runs under Unix.

Virtual CD ROM lets the user create a virtual CD drive on a hard disk.

Wine makes it possible to run Windows programs alongside any Unix-like operating system, particularly Linux.

xinetd helps control network connections to a computer and provides security against intrusion.

Appendix 3: Summary of the total cost of ownership (TCO) by school phase and availability or non-availability of OSS

Annual TCO per PC (£)	OSS primary	Non-OSS primary	OSS secondary	Non-OSS secondary	OSS as % non-OSS primary	OSS as % non-OSS secondary
Hardware costs	131.71	280.53	151.93	221.88	47	68
Software costs	44.68	64.14	32.56	67.10	70	49
Network costs	14.11	66.94	61.58	56.76	21	108
Consumables costs	21.89	53.13	24.21	28.33	41	85
Training costs	57.50	53.31	27.04	11.53	108	235
Formal support costs	273.17	406.16	206.61	385.62	67	54
Self-support costs	148.86	303.83	283.39	264.48	49	107
TOTALS	**691.92**	**1228.04**	**787.32**	**1035.70**	**56**	**76**
Annual TCO per student (£)						
Hardware costs	29.92	42.39	42.84	50.41	71	85
Software costs	11.00	9.34	9.93	14.81	118	67
Network costs	3.68	10.04	19.42	12.78	37	152
Consumables costs	5.15	8.03	7.02	6.27	64	112
Training costs	11.44	7.16	8.42	2.33	160	361
Formal support costs	41.96	65.92	59.89	102.32	64	59
Self-support costs	30.14	52.57	79.75	57.69	57	138
TOTALS	**139.88**	**195.45**	**227.27**	**246.61**	**72**	**92**
Annual software costs per PC (£)						
Office	3.97	10.68	8.86	27.77	37	32
Email	0.30	2.84	0.16	2.43	11	7
For management	2.40	1.67	3.29	3.60	144	91
For curriculum	30.91	33.01	10.52	19.35	31	35
For administration	1.75	5.73	4.54	12.82	52	467
Operational	5.33	10.21	5.18	1.11	52	467
TOTALS	**44.66**	**64.14**	**32.55**	**67.08**	**70**	**49**
Annual network costs per PC (£)						
Internet costs	5.59	40.06	19.78	25.44	14	78
LAN costs	4.03	16.05	36.14	24.06	25	150
WAN costs	3.94	3.52	4.99	2.03	112	246
WAN link costs	0.54	7.30	0.66	5.23	7	13
TOTALS	**14.10**	**66.93**	**61.57**	**56.76**	**21**	**108**
Annual support costs per PC (£)						
Formal staff support costs	247.08	285.34	191.98	347.92	87	55
Purchased support costs	26.08	120.82	14.62	37.70	22	39
Self-support costs	148.86	303.83	283.39	264.48	49	107
TOTALS	**422.02**	**709.99**	**489.99**	**650.10**	**59**	**75**

All figures are calculated from the outputs of the Becta Total Cost of Ownership (TCO) Model. The model is designed to give annual TCO figures for schools using data contributed by schools, including responses from the staff user survey. These can then be represented as total annual costs per PC for each school or per student to enable comparisons.

You can view the Becta TCO Model and example data online [http://tco.ngfl.gov.uk] – username: ExampleSecondary and password: ExampleSecondary16.

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