Bring Your Own Device (BYOD) with Cloud 4 Education

Ruth Lennon

Computing Department, Letterkenny Institute
of Technology
Letterkenny, Co. Donegal, Ireland.
Ruth.Lennon@lyit.ie

Abstract

This paper presents an outline of the issues encountered in the progression from wired PCs to supporting Bring Your Own Device (BYOD) for learners. The paper also documents the simultaneous transition to cloud hosting of teaching resources. The paper describes the issues that Letterkenny Institute of Technology faced in the planning and evaluation phase during the move to BYOD. It is expected that the details provided here will be of benefit to other educational institutions considering such a move.

Categories and Subject Descriptors C.0 [**General**]: Modeling of computer architecture, System architectures, Systems specification methodology. C.4 [**Performance of Systems**]: Reliability, availability, and serviceability H.1.1 [**Models and Principles**]: Systems and Information Theory - General systems theory. H.3.4 [**Information Storage and Retrieval**]: Systems and Software - Distributed systems. H.3.5 [**Information Storage and Retrieval**]: Commercial services.

General Terms Management, Design, Reliability, Experimentation, Security, Human Factors, Standardization.

Keywords Cloud, System Architecture, Data Governance.

1. Introduction

This paper focuses on research carried out on the application of BYOD and Cloud support for learners in an Institute of Technology in a rural part of Ireland.

SPLASH '12 October 19–26, 2012, Tucson, Arizona, USA

The well documented economic downturn in Europe has led to many countries seeking to refocus their human resources into new highly skilled areas. The Irish government, in particular, is looking to reduce the number of young skilled people emigrating by investing in new research programs. Funding is being focused on encouraging innovative technological companies to be established in Ireland, which enables new avenues for graduates and the unemployed. An investment of €1.2 million euro was just announced [1] in Ireland in an attempt to make Ireland a world leader in Cloud technologies.

In the Irish educational system, Institutes of Technology are higher educational institutions that are separate and distinct from universities. Institutes of Technology focus on applied research, and universities focus on the arts and theoretical scientific research. Institutes of Technology offer learners a choice of technical degree programs and certificate programs in a wide range of practical fields, and the learner body is very diverse in age, skills and prior education.

We have experimented with a combination of BYOD and Cloud support for learners in order to meet several educational challenges in our environment:

- Many of our learners are part-time learners;
- Commuting learners who live and work far from the Institute may find it more convenient to do class work remotely instead of in our on-campus laboratory facilities;
- Younger learners are comfortable using new high-tech computing and communications devices, but most older non-traditional learners are not so proficient with the latest technologies.

The design and deployment of a BYOD and Cloud environment must consider the following issues:

- The computing environment must conform to the data security and data privacy policies of the

educational institution and all applicable laws and regulations on data privacy;
- Software licenses and digital media copy protection.

The BYOD and Cloud deployment needs to include the following elements:

- Secure network storage – both private password-protected network storage and shared network storage for a course or a research program;
- Security and privacy policies – the policies for how network storage is allocated and used must be defined and communicated to all users;
- Rapid setup of a "virtual lab" – a set of virtual machines for use by a group of learners for a defined time period (from one week to an entire semester).
- Software license management – there must be a simple process for users to set up the correct software licenses in a virtual lab;
- Hands-on-training for users on the use of cloud applications – especially for non-traditional learners who might be unfamiliar with web applications - especially for non-traditional learners who might be unfamiliar with web applications, smart phone apps, social networking, Dropbox;
- Hotline support for laptop and application configuration problems –occasionally problems will arise when connecting to the campus wireless network, attaching to a virtual lab, searching for on-line resources, or adding files to a shared repository.

2. The Modern Learner

Most young learners have some experience with popular devices and network tools: smart phones, e-book readers, web browsers, social networking sites, blogging tools, and web-based file sharing tools.

The current recession in Ireland has resulted in increased age diversity in the classroom. We now have many learners returning to education after years in employment. These people may have been employed on a factory line in business or management positions prior to returning to education. These learners have been away from formal education for a number of years, and they are often unfamiliar with modern teaching methods. Tools such as virtual learning environments, hosted resources and modern approaches to pedagogy might seem daunting to these learners.

We have other kinds of diversity, including learners from different countries. The standards of the European Higher Education Arena make it possible for learners to start a program of study in one country and continue it in another.

3. The Cloud Environment at LYIT

The private cloud at LYIT consists of 50 virtualized servers on a Storage Area Network (SAN) with 40 TB of local storage. This environment replaced a data center with 110 servers on the main campus. The new configuration uses less energy, and it also allows learners and staff to have individual virtual drives on the SAN.

Virtual learning environments are not new to LYIT, but the use of virtual learning services has been increasing. In the current environment, staff and learners use the Blackboard system, which is hosted in a public cloud. This system has been adopted by 55% of all academic staff in the past two years.

The cloud environment at LYIT is a "mixed model" – a private cloud that supports many applications, but with some use of computation and storage capabilities from public cloud systems. For example, the Blackboard system is hosted on a public cloud. Also, a public cloud is also used for some storage services: each learner has 25GB of storage on SkyDrive, thanks to an agreement negotiated for all of the third level educational institutes in Ireland.

Some classes are starting to define and use virtual Windows and Linux servers for course exercises and activities. There has been some exploration of the use of virtual machines to support specialized applications for various courses and departments. There are big differences in the complexity of the VMs depending on the department and course. VMs used by departments such as nursing and business studies are relatively basic. On the other hand, many engineering courses require modeling tools and analysis packages. VMs for these courses might require a machine with more memory and faster processor to have adequate performance.

The main impacts of cloud and virtualization services have been:

- Reduction in energy costs;
- Lower equipment costs;
- First-year learners like the new environment, which has improved retention;
- On-line resources have allowed classes to continue during bad winter weather;
- Discussion boards in Blackboard have encouraged work in teams.

On the other hand there have been some issues and problems:

- The current network configuration has made it more complicated for learners to get their virtual environment running;
- Learners should be using moderated forums for collaboration, but moderated forums take a lot of staff time; un-moderated forums are a risk because there is a potential for abuse of resources
- Licensing issues for deploying commercial software in a cloud environment;

- Data privacy issues – ensuring that personal data (such as learner identification numbers and grades) are protected from public disclosure.

4. Bring Your Own Device (BYOD)

In the initial investigation period the range of devices currently employed by staff were examined. Next, a number of devices were identified for suitability based on future need, basic software and hardware requirements. Finally, an initial security assessment was carried out. Four devices were purchased and were supplied to the heaviest wireless throughput users within the staff.

Testing of these devices is ongoing and at an early stage, however the issues surrounding how the BYOD system should work are described here. There is a large branch of a multi-national company in Letterkenny who is currently moving completely to laptop devices as opposed to desktop PCs. In a business where staff are fully employed and all devices belong to the company this is feasible.

An educational institution has a different set of usage scenarios than a business, and there are different data access and data security issues to consider. In an educational institution there are three categories of users with different needs: learners, administration staff, and teaching/lecturing staff. Administration staff has issues regarding data privacy but the data privacy constraints are not more stringent than for a bank, for example. For teaching staff, there is an issue with the types of materials they may place on their device. Teaching staff may place large amounts of raw research data onto their device, and this data may be irreplaceable if lost. The teaching staff often chose to install software or place personal data on their work device.

Learners will likely need grants or loans in order to purchase outright their own device conforming to the specification provided. In this way the learners will be able to get the best deal possible and the educational institution will ensure that all learners will be able to purchase an appropriate device.

Issues that might arise include:

- Learners might register for a course but refuse to purchase the specified device
- Learners might fail to bring their device to the scheduled class
- Learners might have problems replacing a device that fails or is damaged mid-term in sufficient time to complete the specified course

The strict application of rules and regulations may be considered an interim solution to some of these issues. On the other hand, it would be better to have a more flexible policy about which devices they are permitted to use, to allow learners to bring a different device if they already had one, or to borrow a device if they could not afford one, etc.

5. Using Cloud Computing and Teaching Cloud Computing

The importance of Cloud computing has been much documented and is therefore is not covered here. The ACM/IEEE-CS Science Curricula for 2013 [2] as outlined in the Strawman document is direct evidence of the importance of cloud computing in education. When describing the characteristics of graduates, topics to be covered in Core Tier1 Networking include cloud networking, scaling in the cloud and the social and legal aspects. Indeed, the document further requires learners to understand the impact of cloud computing on social interactions at a personal level.

Cloud Computing has become a part of many courses outside of computing science. For example, many courses make extensive use of cloud storage products such as Dropbox. Both staff and learners use these products extensively already, although they are not currently endorsed or supported in any way.

The first useful service that a local educational cloud ought to support is local cloud storage. This is just one step away from the current use of public drives and virtual private networks.

The next extension of the system to use the local cloud to support course resources such as software and other materials. This would improve learners' access to educational materials, and it might also provide avenues of revenue for the educational institutions. They could become online portals for a wider community of learners than the conventional learner community.

5.1 Using Cloud Computing.

Cloud computing has been provisioned to all courses in the form of the Virtual Learning Environment (VLE). The VLE utilized in the institute is Blackboard. When considering a new course such as the Bachelors of Engineering (Honours) in Fire Safety Engineering, it is not always easy to see how such a course could be supported via the cloud. The course has been developed as a four year *ab initio* course. There are many subjects on this course which lend themselves easily to cloud hosted VLE's such as: computer aided design, fire modeling and reliability and human behavior in fire. These subjects all include mathematical, statistical or computer aided modeling packages. However, practical subjects such as Fire Service Operation and Fire Dynamics require further consideration.

Fire Dynamics laboratory exercises include a number of pieces of laboratory equipment used for practical tests, such as a cone calorimeter and flame spread apparatus. The learners must test the flammability properties of various

materials. The test data may include the rate of burn, the intensity of the flame, etc. In Figure 1, fire technology learners may burn a tray of kerosene in a scaled down version of a room. Each data item regarding the path of the flame can then be recorded on a data logger. This laboratory may be videoed and placed on the VLE for learners to watch. The raw data from the data logger may also be placed on the VLE. From the raw data the learners then perform their calculations to indicate the relative flammability of the materials. Instructions on how to carry-out the calculations may be placed in a pdf file hosted on the VLE. Podcasts of the relevant theory may also be hosted on the cloud through the VLE. In this way learners who might require a second look at the experiment have an additional opportunity to review the steps carried out.

Figure 1. Recording fire data for use in a course

5.2 General Impact of the Cloud on the Teaching Environment.

While most courses can be supported via the Cloud through resource sharing, some issues have become apparent. The choice of VLE has an impact on the quality of the materials delivered. Most VLEs provide useful tools for learners and instructors, such as on-line discussion groups and support for automated marking of test materials, but the system's capabilities vary with the provider.

The Blackboard system hosts all the materials on the cloud, which greatly reduces the number of servers required by the institute. Further it reduces the time spend by technical support staff in maintaining the service. However, Blackboard has some limitations: for example, it does not support a wide variety of web browsers. The lack of support for some combination of browsers, operating systems and file types can cause significant difficulties for lecturers when deciding on the most appropriate format for learning resources. The cost of developing and host a private cloud solution for a virtual learning environment is prohibitive.

5.3 Teaching Cloud Technology on the Cloud.

The learning resources for a course on cloud technology will need to include some type of cloud environment for learners to explore in class exercises. The environment they use must consider both the security of learner laptops and the security and performance of the institute's private cloud.

Teaching networking technologies through virtual learning environments also has highlighted interesting problems. When learners install a virtual network on a virtual server hosted on a windows machine the firewall and router grind to a halt. This may be the case with specific virtualization software or may be a more widespread problem. Further investigation of this problem is ongoing.

One potential security issue for learners: When they use their laptops to connect to a local cloud to run some cloud lab exercises, it might be necessary for them to temporarily disable their laptop's firewall software. Instructors and technical support staff need to maintain a higher standard of security for a cloud environment used for cloud lab exercises, and learners also need to remember to enable their local firewall again before resuming normal work.

6. Physical Access to Resources

The Institute is broken into a number of campuses. In the main campus of Letterkenny Institute of Technology there are approximately 800 PCs in offices and labs. At present there are also approximately 550 associated devices on the wireless network at any given time and of these currently only approximately 250 are authenticated devices. An authenticated device is a device that has been authorized and fully authenticated by the IT department. An associated device is any device that the wireless network can see, such as a laptop, iPod, xda, etc. Although the Letterkenny Institute of Technology currently only supports laptops, it can be seen that seen a significant number of mobile devices are attempting to access the network.

6.1 Remote Access to Resources.

Given the increasing number of unauthenticated devices connecting to the network it was deemed necessary to review the level of support for remote access to the network. Learners were surveyed to ascertain the level of broadband support each could access from their home. Seventy six percent of learners described their home location as a town with only 24% indicating that they lived in a village. Just over 70% of learners had a wireless router with the remainder using dongles. The prevalent line speed paid for by learners was 8GB. Not surprisingly 69.5% of learners indicated that they did not often get the line speed they paid for. When the 64% of learners who work from home for more than 20 hours per week, this is certainly a concern. The high number of hours worked at home was most often due to family constraints. Another concern was security: 94% indicated that their connection was secure, however when further investigated, this involved simple WEP security. The vast majority of learners did not update

their virus protection software and had little or no knowledge of the security risks in using open networks.

Clearly an increased level of risk awareness is required. A course on the correct usage of BYOD devices and their security will be mandatory for all BYOD users. It is not anticipated that this will remove all risks. It should however in combination with enforced security such as mandatory virus updates and remote wiping provide a much more secure system.

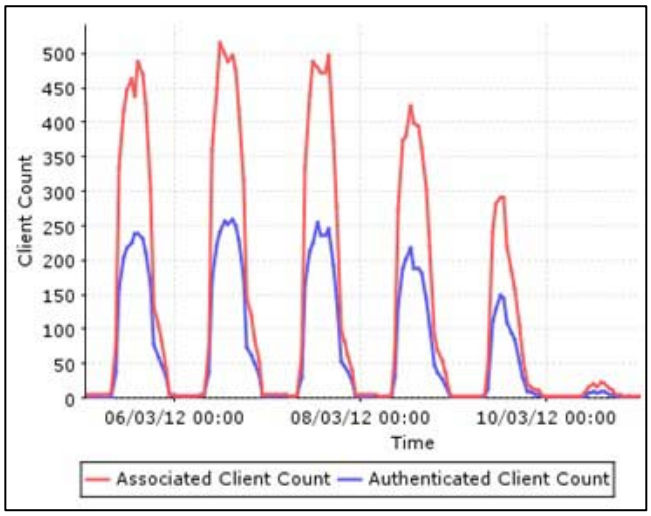


Figure 2. Port Road Campus Client Count.

6.2 Increased Classroom Capacity.

It was anticipated that the utilisation of BYOD would provide greater utilisation of teaching resources including classrooms. A survey of the utilisation of all teaching rooms is carried out at the end of each academic year. This survey provides an indication of the efficiency of the timetabling of courses to optimize resource usage. The percentage utilisation of each room by classification is provided in Figure. 3. From this it can be seen that there is significant underutilisation in classrooms while the computer laboratories are running at close to maximum efficiency.

The institute is located in a rural part of Ireland. This has a significant impact on the hours during which classes can be scheduled as the buses travelling to other parts of the country depart at lunch-time on Fridays. Thus learners returning home for the week-end will not attend classes on Friday evenings. In an effort to combat this, some of the most important classes were scheduled for Friday evenings to increase learner attendance. Unfortunately it simply resulted in a lower retention rate. Thus 13:30-17:30 on Friday are considered dead hours.

BYOD helps tackle the inefficient use of classrooms by enabling the re-designation of classrooms as computer laboratories. Each learner will have access to his/her own device with the appropriate software installed. If the 'dead-hours' are not considered, then the application of BYOD has an impact of approximately 26%.

Utilisation of laboratories also increases as specialized software is no longer limited to a small number of laboratories. An increased number of courses can therefore be run within the 40-hour week. There is a move towards a 45 hour teaching week, 9:00-18:00, which would provide further efficiencies in room utilisation. These efficiencies are further extended via a greater distribution of incidental costs such as lighting/heating across a greater number of courses. Consequently the implementation of BYOD has a greater impact on overheads accumulated during courses than was first realized.

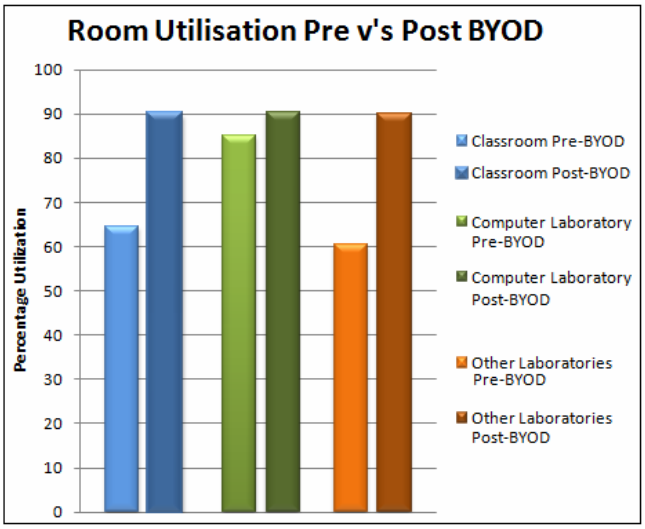


Figure 3. Port Road Campus Room Utilisation.

6.3 Power Consumption.

It is anticipated that there will be a significant increase in power consumption if not carefully reviewed prior to the final roll-out of BYOD. This increase in power consumption could not be absorbed by the educational institution. As such it would be necessary to apply new technologies to enable the BYOD clients to attach to power sockets on a pay-as-you-go system.

Companies such as ChargeBox (www.fleetconnect.ie) would enable the deployment of charging stations at a variety of locations throughout the campus. At present ChargeBox provide locations for secure charging of personal devices which can be plugged into and then locked in a secure cabinet. This has many advantages such as security of the device, 95% reduction in carbon emissions, PAT security, and a reduction of electrical costs to the institution. The ChargeBox for laptops will be available for general sale from the end of October. Based on implementations currently deployed in universities in England it has been calculated that between 150 and 200 units would be required to support 3,000 learners. With a

unit cost of £3,000 stg. and a per unit electricity charge of £1.50 for 30 minutes use to the learner, the ROI is realized in approximately 1 year. An obvious disadvantage to these systems is that the device cannot be used during the charging period as the device is securely locked away.

Sony is currently developing hardware to use a touch-card platform, Felica, to enable a pay-per-use form of electricity at the socket. These types of systems could be adapted in a similar fashion to current photocopying facilities with each learner having a card which they would 'top-up' with credit. This would allow the BYOD user the flexibility of utilizing the system while charging. It is envisaged that a combination of both these types of technologies would be required for efficient BYOD adoption.

6.4 Learner Retention.

In the current economic depression, it is necessary to ensure that the maximum number of learners may be accommodated using the least number of resources. Many new learners have previously been in employment and are now returning to education to re-skill. Retention of traditional and new learners is essential to ensure that each of our client obtain the maximum benefit possible from their time in education. The application of BYOD enables learners to work from home and indeed access more of their learning resources while travelling or between items of personal obligation. The application of the cloud through the Virtual Learning Environment (VLE) has enabled the lecturers to develop teaching resources in bite-size portions often referred to as learning nuggets. These learning nuggets may be downloaded from the cloud onto the learner's personal device for on-the-go learning. This is particularly helpful also for those learners with shorter retention spans. It is the combination of BYOD with cloud resources that enables this form of learning.

The placement of learning resources such as podcasts, videocasts, lecture notes and laboratory instructions onto the cloud results in an increased time-frame during which learners may complete their work. Enabling learners to continue their learning when mitigating circumstances intervenes will have a knock-on effect of increasing retention.

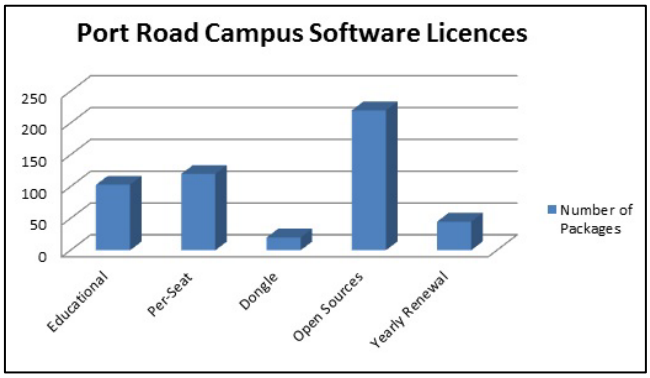
7. Software Licenses and Deployment

There are many legal issues to supporting the learner through their own devices many of which are discussed in the next section, however in this section mention is made of the complexities involved in supporting the variety of software licenses for products commonly used in Letterkenny Institute of Technology (LYIT). As far as possible the author has attempted to provide a general picture of the issues that educators face when supporting learners in such a fashion so as not to focus on issues that may be specific to this campus. To ensure that there is no ambiguity here it is worth point out the variety of courses provided in LYIT. Courses include: Computer Science, Networking, Computer Forensics, Digital Media and Entertainment, Enterprise Applications, Fire Safety Engineering, Business Studies, Design, Nursing, Mechanical, Electrical, Culinary and Science Courses. This is simply a sample of the courses selected specifically due to the specialized software each require and the types of issues each bring about when planning the support of BYOD.

There are over 250 separate packages which technicians are responsible for in each 'phase' of each campus of the educational institute. In the example graph below from the Port Road, Main Building Phase 2B, it is clear that there is a wide variety of licensing applied to the various types of software.

Figure 4. Port Road Campus Client Count.

It is worth taking a closer look at the software that is utilized by learners during the academic year. To simplify the discussion, software from the east wing of the campus



is discussed here. Figure 5 provides a breakdown of software by type of license. As 72% of the software is proprietary, it is necessary to establish the appropriate licenses for BYOD or cloud hosting. In some cases restrictions by the vendor will dictate whether or not the software can be hosted on the cloud. With some smaller companies producing specialist software, such as CFAST for fire modeling, negotiations on licensing agreements are possible. However with the majority of software vendors this is not possible.

Some of the computing courses use open source software, so these courses have few software licensing issues. But the Fire Engineering course requires a commercial fire modeling software package with a license that uses dongle-based authentication. The simplest solution is to move to hosting of the software to a virtual server, accessible to the learners. However, as the software is a modeling package, it requires significant processing power and involves the transfer of large amounts of data across the network. The execution of the software on each

learner's individual device would require a higher specification of device than would be necessary for the majority of learners.

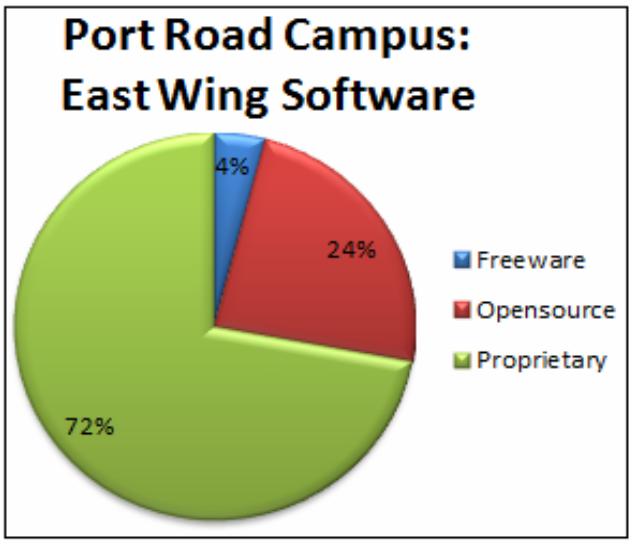


Figure 5. Port Road Campus: East Wing Software

As there are only a relatively small number of users of the specialized package, negotiations are underway with regard to licensing for hosting on the cloud. It is not anticipated that the new licenses will be available for the next academic year. However, as the licenses are renewed yearly on a per-seat basis, it is anticipated that this will be resolved for the final phase of roll-out of cloud hosted support for learners.

It is interesting to note that only 28% of the software packages are Microsoft and 24% of packages are Open-source. While there are obvious potential security risks with many open source packages, they have proved most helpful when deploying BYOD & Cloud. The remaining 48% of software packages are either freeware or limited license software.

It is also important to consider which software is necessary to all learners and which packages may be needed only by learners in a narrow specialty. This knowledge aids with selective deployment of software packages, which can reduce the cost of purchasing licenses for packages that have a per-seat or per-device charge. Further, the knowledge of which combination of specialized packages are needed for each specialty will enable a more precise definition of the minimal requirements of the BYOD devices to be purchased by the learner. It should be noted that the analysis here is of the software currently used in one wing of the main campus of the institute and does not cover the myriad of courses that the institute offers. It is presented as an overview as it houses a greater variety of courses than other wings. For example there is one wing of the college that is devoted to science and nursing science only.

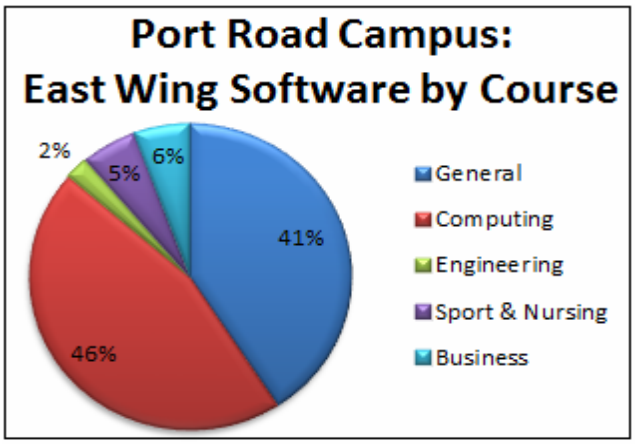


Figure 6. Port Road Campus Proportion of MS Software.

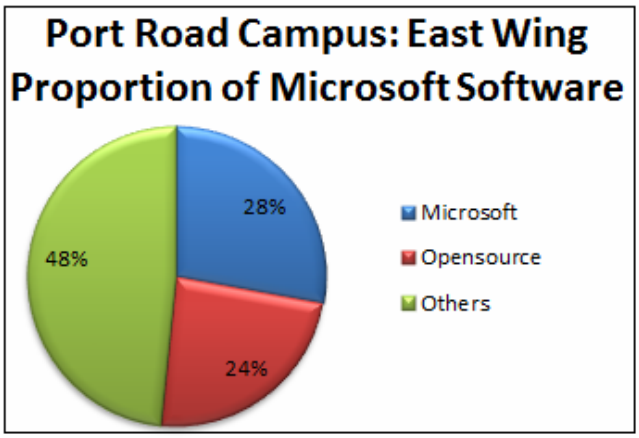


Figure 7. Port Road Campus: Classification of Software Packages by Specialty

Another difficulty that educational institutions face that is not as great a problem in other industry is the need to deploy 'bleeding edge' software to learners. Learners are provided with the background theory to legacy and modern technologies. While a great number of the software and hardware technologies in the institute are widely used and commercially accepted, it is also necessary for degree and postgraduate students to have experience with ground breaking technologies. As these technologies are constantly evolving, it not always possible to anticipate the impact of the installing a new software package on the end system. Problems can quickly be corrected on institute-owned PCs, but deployment to BYOD devices is a significantly more complex problem due to software/hardware constraints, access to the devices and legal implications.

8. The Law

The variation in laws from one country have caused significant concern in the application of cloud computing.

In Ireland the Data Protection Act 2003 is a cause of concern when transferring data between Ireland and the E.U. This is particularly important when the data being transferred is personal data [3]. Certainly the storage of learner's grades could be considered personal data. It is unclear however whether submitted continuous assessment, thesis, code segment or other items could be considered personal data. If this data is stored with a cloud provider with locations outside the E.U., that data may become transferred to a variety of locations. If the personal data is transferred out of Europe, it is no longer covered by E.U. laws and therefore becomes subject to the laws of the country where is resides. This is particularly important as the Data Protection Act labels a number of countries as prohibited for data transferal [4]. This means that if the educational institute does not religiously monitor the provision of the cloud, we might easily violate EU law.

The Act is written with the directive of protecting user privacy. The European Data Protection Regulation 2012 was created to standardize data protection throughout Europe. These rules may be seen as a significant impediment to cloud computing. As part of this regulation the Data Protection Commissioner may request the physical location of data storage. When data is stored in the cloud this information is not always readily available.

The educational institutes are audited regularly both by internal bodies and external bodies. This makes knowledge of what data is held, where it is held and in what form important. Neelie Kroes [5] in her vision for a European Cloud Partnership outlined the economic and security benefits of having these updated laws. There is however significant concern that requirements such as the disclosure of security breaches within 24 hours are unworkable. In the educational institute it may be seen that this provides little if any time to gather evidence of the breach. Consider an attack late on a Saturday evening after normal closing. The attack may not be discovered during limited coverage hours on a Sunday where limited staff levels are on duty. This simple example would leave the educational institution in breach of E.U. law.

The duration the personal data must be stored is also important. At present learners examination scripts and continuous assessment materials are kept for 18 months. If these materials are stored on the cloud, they may be required to be removed with a clear record of the removal process. It would be particularly difficult to establish the recording procedure and the location of all copies of the materials as well as all references to the materials such as the marks awarded for each element of the continuous assessment.

There may be operational issues that cause the data on the cloud to become corrupted or lost, and this might lead to the educational institution being placed in "Statutory Default" of the European Law, which has serious ramifications.

The Legal issues are such that the Irish Department of Finance has warned its own government departments and public sector bodies, of which the education sector is just one, that they should not purchase cloud computing services without first obtaining legal advice [6].

The use of external service providers through tenders is a measure often used by the education sector to obtain economies of scale. The Data Protection Act 2003 requires that appropriate security measures must be implemented to counter unauthorized access to data in addition to the unauthorized destruction of or leaking of data. Where staff and learners are supplying their own devices for access to the cloud it becomes increasingly difficult to regulate the security to an appropriate level. While it has been deemed appropriate to limit the variety of supported devices and to physically impose restrictions to ensure updates/patches are applied, there will always be a number of users that evade the regulations.

This Law is also significant as it has a greater impact when considering the throughput of learners within the educational institution. Is it required that the security system has to be applied to all learners own devices regardless of whether or not they remain within the education system? If so, then resources that will be spent on supporting the upgrade of their system, etc. as previously described might not be recuperated from learner fees. It is also difficult to regulate what the short term registered learner will do with the resources transferred to his/her device. While the obvious solution might be to add a hardware or software lock to resources once the learner deregisters, often the learners do not deregister or do so weeks after having left the course. This applies both to resources placed on learner devices and placed on the cloud with learner accounts.

The scenario does not arise as often with staff devices, it becomes an interesting issue with research learners who also occupying teaching positions.

9. Conclusions

The following is a rough outline of the conclusions that have been drawn to date from this research.

It is necessary to modernize the educational system to support learners not only through updated teaching pedagogy but also through modern devices.

The variety in technology skills, life skills, etc. of mixed ability classes makes it difficult to classify learners for ease of support.

Learners require support not only during any given course but also within the placement. Lifelong learning promotes the development of learning portfolios comprising of formal and informal learning.

The move to support learners through BYOD in Letterkenny Institute of Technology has thrown up a number of serious and some unexpected issues. The access to broadband facilities at home can be a significant difficulty which is outside of the control of the educational institution. Efficiencies in physical resources can be gained through careful timetabling of rooms when BYOD is applied.

Software licensing issues are not trivial and will not be resolved in the immediate future.

There are a number of legal issues which should be considered. The legal issues outlined in this paper focus on European law but similar issues exist in the U.S.

Acknowledgments

The author would like to thank the SPLASH Wavefront Experience technical panel and mentors for their helpful comments on earlier drafts of this paper. The author would especially like to Dennis Mancl for his invaluable advice. Finally the author would like to thank the LYIT technical staff and Liam McIntyre in particular for the in depth and inspiring technical discussions carried out over the past year.

References

[1] Breaking News, The Irish Times, 12 April 2012. www.irishtimes.com/newspaper/breaking/2012/0402/breaking21.html

[2] ACM/IEEE-CS Computer Science Curricula, SIGPLAN Education Board, CS2013 - Strawman Draft, http://ai.stanford.edu/users/sahami/CS2013/

[3] Philip Nolan, Cloud Computing: The Legal Issues, Irish Software Association – Breakfast Briefing, Mason, Hayes and Curran, www.mhc.ie/podcasts/download/4/. 22 February 12

[4] David Navetta, Legal Implications of Cloud Computing – Part One (The Basics and Framing the Issues), Law and Technology Resources for Legal Professionals, 12 September 2009, www.llrx.com/features/cloudcomputing.htm

[5] Neelie Kroes, Blogg of the Vice-President of the European Commission, 30 January 2012, blogs.ec.europa.eu/neelie-kroes/european-cloud-partnership/

[6] Warning over Cloud Computing Usage, The Irish Times, 2 February 2010.