Abstract - This research investigates the suitability of a web based pedagogic tool, for delivering network security courses in an educational framework. Our research is based on the Cisco Network Academy Program, a comprehensive web-based interactive curriculum, for computer networking. We consider the curriculum usage, and views expressed by lecturers and students, to assess whether this method could be usefully incorporated to include specific sections of Information Security subject domain. Curriculum usage data was collected, by analysing log files of the web server, which hosts the pedagogic documents. An on-line survey was administered, within the Network Academy community, in Europe Middle East and Africa. Results are extrapolated, to assess the suitability of the proposed deployment of network security curriculum. The deviation from current e-learning paradigms is addressed, in relation to the use of new technology such as Internet Protocol TV (IPTV) multicasting for distance learning, targeted at combining the social context of learning to content delivery.

Index Terms - E-learning, On-line Curriculum, Web-based learning, Web-based Teaching.

INTRODUCTION

In the course of only four decades, Computer Networks have come to play an important and a vital role in all sectors of organised societies. As a consequence, Network security has become an essential and integral aspect of Information Technology. In this perspective there has been an exponential increase in the demand for trained professionals in network security.

Consequently a market analysis conducted by the Department of Information Systems at Anglia Polytechnic University prompted to introduce the MSc in Information Security to cater to this demand. In the design process of the MSc our main target was to produce a good quality self-contained pedagogic program with easy access to the targeted audience student base.

The above considerations and restrictions such as time, cost and quality concerns involved in developing a curriculum from the beginning prompted us to consider adopting and integrating an existing security pedagogy which matched our defined course objectives. Furthermore the evolution of the course according to the rapid evolution of the technologies underlying the course contents was a very important consideration for us.

This prompted us to undertake research to assess the suitability of embedding a web-based pedagogy, Fundamentals of Network Security (FNS), developed and maintained by the Cisco Networking Academy, in the MSc Information Security. We already had a considerable amount of experience with a similar pedagogic tool in Computer Networking subject domain by the same vendor, namely the Networking component, Cisco Certified Networking Professional (CCNP) of Cisco Networking Academy Program (CNAP), run embedded in MSc Network Management program [1].

We selected to analyse the impact of the above Networking pedagogic tool (CCNP) on the MSc Network Management program and extrapolate the Empirical results to evaluate the potential impact of embedding the new Security pedagogy, Fundamentals of Network Security in MSc Information Security.

The sample cohort consisted of technically competent students some with professional experience in the IT industry, particularly in computer networking. The accuracy of results was critical since the success of the new MSc pathway depended on the success of it’s embedded modules.

CISCO NETWORKING ACADEMY PROGRAM (CNAP)

Cisco, a networking equipment manufacturer and education provider [2] provides network security solutions, as well as Network academy programmes. CNAP comprises of two core web based pedagogic tools for e-learning in Computer Network Technologies. CNAP has been successfully running worldwide the past 6 years, since it’s inception in 1997. The program is delivered in 152 countries, in 8 languages, with an estimated student base of 458,000 [3].

The two core pedagogic tools of CNAP are the Cisco Certified Networking Professional (CCNP) and Fundamentals of Network Security (FNS). CCNP has evolved on to its release version 3.0. The program has generated interesting statistics over the years. The four modules encompass Routing, Switching, Remote Access and Troubleshooting. Fundamentals of Network Security (FNS), is on the second revision. This mainly address infrastructure protection, Encompassing Router and Switch security, Firewalls, Intrusion Detection Systems (IDS) and Encryption technologies. Both programs address three facets of learning and teaching, the curriculum, practical skills and assessment.

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CURRICULUM ELEMENTS

The curriculum consists of semesters, which contain a number of chapters. The chapters consist of static and dynamic content. Static component is made of web pages written with cross platform compatible html markup language, and embedded PDF, Microsoft Word and Excel documents. Dynamic components consist of animations, simulations, audio and video based on Java, Javascript, dynamic html, Flash and Shockwave technologies. Quicktime player is used to play embedded audio and video. HTTP protocol is used to transport curriculum content across networks to client web browsers. Further URLs, which point to external sites, are embedded in pages to assist student research.

Laboratory work is a compulsory element of the pedagogy and are of gradually increasing complexity. Labs are linked to the learning objectives of the modules. Labs are about configuring switches, routers, Wide Area technologies and network troubleshooting. Lab sessions can be conducted either locally or remotely. Remote labs are supported using netlab [4] technology which provides a flexible remote access solution. Currently our experience is limited to labs conducted locally.

Assessment is conducted both online and offline. Online assessments consist of multiple choice questions, which are single answer or multiple answer type. Online assessments are conducted at 3 levels, end of chapter quiz, end of chapter exam and end of semester exam. At the end of each chapter a quiz determines the understanding of the chapter elements. This is an informal indication on the readiness to attempt the end of chapter exams. End of chapter exams examines the understanding of the chapter objectives and act as an indicator for the readiness to take final end of semester exam. End of semester exams evaluates student’s comprehensive knowledge on the learning objectives of the module and is a part of the module assessment. Since End of Semester exams contribute to the final module mark, student is required to undertake the exams at the university and is invigilated.

The end of chapter and end of semester exams are hosted on a separate server from the one, which hosts the curriculum. This requires the students to use login credential for authentication at the examination server. After completion of online exams the student is given instant feedback, onscreen as well as by email.

The offline assessment consists of an academic report based on a comprehensive case study of a hypothetical network design, which includes Wide Area Networks as well as Local Area Networks. In par with the university regulations the reports are submitted anonymously by the students only using the student identification number. The reports are double marked for accuracy and marks are compared with the marks for the online component. If online mark is significantly higher than the mark for the report this can indicate errors in the marking process for the report. If the online mark is significantly lower than the mark for the report, this can indicate the student has not attempted the report himself and does not meet the learning outcomes. In either case the student is invited for an interview.

Session T2C

In the process of embedding the web based pedagogy in the university MSc, assessment was one of the components that had to meet generic assessment requirements of the university at individual module level. Getting a good balance between online and offline assessments was a significant task due to the dynamic changes of the properties of the cohort, this consumed time and fine tuning to find proper balance. Currently offline assessment contributes 65% and online assessment contributes 35% to the aggregate module mark.

COURSE DELIVERY PARADIGM

The pedagogic model of web based CCNP is a paradigm shift from the traditional synchronous delivery model which is classroom and textbook based. The hybrid delivery model of CCNP combines both online and offline delivery. The web server, which hosts the pedagogic documents, is accessed by students through the Internet. Management of curriculum and student classes, is done online using the curriculum management system.

The offline component consists of lectures and tutorials conducted by the tutorial staff who are certified instructors. Further to aid the student learning model they are introduced to printed companion guides [5] to complement the online curriculum to make the transition from text book based pedagogy to web based pedagogy a smooth one.

STUDENTS

The students in a sample cohort consist of younger full-time students and mature part-time students. Generally the mature part-time students are from a professional IT background. The sample cohort included a minority of students from a non-technical background.

USAGE STATISTICS

The statistics were collected by means of analysing log files of the web server [6], which hosts the pedagogical documents. The web server is an Internet Information Server 4.0 (IIS 4.0) running on a Windows NT 4.0 platform on the local network which is connected to the backbone of the campus network. The log files for three years starting from 2001 were analysed using surfstats [7] log analyser. The generated statistics were used in assessing the effectiveness of the CCNP program. Among numerous statistics generated we specifically discuss, Usage during the day, Usage during the week, Most downloaded file types and Server errors generated.

Figure 1, Plots the number of visits against the hour of the day. Students preferred the morning and evening to study.
Figure 2, shows the usage during the week, minimal activity was recorded during the weekend.

Figure 3, shows most downloaded file types, varied types of media files were accessed, which are either static or dynamic components of the curriculum. Majority of the downloads consisted of static html files.

Figure 4, plots Server errors generated. The low percentage of server errors experienced by the users is a statistic, which emphasised the reliability of the web based delivery model. Our calculations indicate a very low error percentage, which further proves the effectiveness of web based pedagogic tools. 87 % of these errors were due to unauthorised access attempts.

\[
\text{Error Percentage} = \left( \frac{\text{Errors}}{\text{Total Hits}} \right) \times 100\% = \left( \frac{13349}{514662} \right) \times 100\% \cong 2.6\% 
\]

INTERVIEWS

Informal interviews were conducted among students to gather student experience. While a broad range of responses ranging from negative to positive were received from students, the main concern was adapting to the paradigm shift introduced by the web based pedagogy. Mainly the shift from traditional textbook and lecture based form of learning to web based self-managed learning where the lecture role is mainly of a mentor and of a pastoral capacity.

QUESTIONER

We were planning to find out the students desire and ability to participate in a course which uses a hybrid pedagogic model, how many hours one could devote a week to online training, and what the biggest advantages or disadvantages are of an online course. The statistics generated by the web server log files complemented these results. Out of the 38 who responded to the survey, 98% of them have regular uninterrupted access to the Internet at home and work. Only 17% of the survey participants had experience with an online training course before. During office hours, 49% of the respondents felt that they could devote one hour daily to on-line training and 31% felt that they could devote two hours daily.
After office hours, 36% of the respondents felt that they could devote three hours daily to online training and 27% felt that they could devote two hours daily. Many of the participants felt that the weekends might be a good time to undertake an online study due to spare time. But interestingly the usage derived from web log statistics contradicted this indicating the lowest usage is during the weekend.

Pedagogy based on a hybrid model has several advantages and disadvantages. The two biggest advantages that the survey participants gave were that such a course would be flexible and it would allow one to work at one's own pace and rhythm and it would offer cost effective training.

75% of the participants stated that the biggest disadvantage of an online course is the limited fact-to-face contact with other participants and lectures, our discussion on this aspect included possible solutions as use of IPTV.

Respondents revealed the wide range of complications in accessing the curriculum components based on proprietary technologies like flash as they required installation of plugins and enabling of script execution. Further they were concerned about security implications introduced by the above system modifications.

There were varied responses from the participants who had taken an online training course before as to when they took the course, which organisations offered the course and on what was the course subject. For those that had previously taken an online course, all responded that the online course was useful to their work and to their professional responsibilities. Further they wanted more dynamic content such as streaming video to aid their learning process.

EXAMINATION RESULTS

The overall results consisted of 35% out of online multiple-choice examination as well as 65% out of the offline report based on the case study. We haven’t included lab work as an assessment component. Over the 3 years the average was 66.6 with a standard deviation of 7.8 with a cohort of 65 students.

ANALYSIS OF CCNP

This web based pedagogic tool in computer networking encompass four subject domains including Routing Protocols, Switching, Remote Access and Troubleshooting. The duration of each course covering a subject domain is 6 weeks.

The target audience has very well accepted the programme. However it is also interesting to notice the age groups of participants ranging from young to mature. This confirms the usefulness of web based pedagogic tools for many different audiences.

The assessment of this programme is being considered in three different, complementary, perspectives: students’, academic staff and quality assurance team perspectives. Since September 2000, three batches were already run with a total of 65 students. Students largely give a high rank to the effectiveness of the hybrid pedagogic model which supported their learning style.

The student success rate is 70%. 12% of the students cancelled their enrolment in a course, because they were not able to manage their time as required according to the course calendar and attempt both online and offline assessments to meet the deadlines. 18% of the students have not been able to reach a minimum level of achievement; in this situation the student is invited to participate in the next annual release of the course.

As far as the quality assurance team is concerned the main issue is to monitor the participants’ profile concerning their communicational behaviour towards a set of pre-defined expectations. This included the students as well as the academic staff. It was realised that the overall quality of a course may be improved if some accompanying measures are taken in order to guarantee that a minimal threshold of specific, pre-defined, participation dynamics is accomplished by the participants.

Each student must contact the Lecturer to successfully overcome some basic operational procedures, such as obtaining authentication credentials for the servers which support the pedagogy and online assessment content. Another issue requiring special attention from the quality assurance team is the delay taken by an academic to answer a message conveying a question. Specifically one conveyed online. This delay is one of the key issues in the student’s perception of the quality of the course.

The quality assurance team monitor these events and guarantee that appropriate procedures and contingency measures are executed in a timely manner. Currently this is done manually and we propose a complete set of monitoring procedures to be defined under the course feedback system, including automatic and semi-automatic grade tracking at the academy server.

Currently accumulated experience as far as the final online examination procedure is concerned has confirmed the importance of undertaking all the assessment components by students even though they are not included in the final result calculation. Because this programme provides a postgraduate degree at MSc level and contain a significant amount of research, meetings between the academics and the student is considered to be an important element for the participants.

EXTRAPOLATION

With accumulated usage data of the pedagogic tool for Networking Technologies over the past 3 years, we extrapolate the known data to predict the success of embedding the network security pedagogic tool which use the same hybrid pedagogic model in a similar postgraduate level course for a similar cohort of students. We have chosen this technique since both these web based pedagogic tools share similar properties. This extrapolation of the data set with simple linear extrapolation makes a very conservative but a positive estimate about the usage of the new pedagogic in MSc Information Security.

CONCLUSION

This paper present the results obtained regarding the integration of the Fundamentals of Network Security (FNS) in the MSc Information Security. We have analysed the success of the embedded CCNP pedagogic tool in the MSc Network.
Management and extrapolated the results to predict the success of embedding FNS in the MSc Information Security program. The Web based pedagogic tools presented in this paper were developed by Cisco systems, CCNP program was adopted by the Anglia Polytechnic University and run embedded in MSc programs during the last 3 years.

Among many discussions about the disadvantages of e-learning [8]-[9]-[10], the hybrid model adopted in the web based pedagogy provides a good balance among several different factors, namely pedagogic effectiveness and management flexibility.

The pedagogic effectiveness is assessed by the success rate, the number of students attended and usage patterns of the curriculum server. Additionally, the outcome of compulsory online feedback forms completed by students as a course completion requirement, largely confirm their satisfaction of the learning experience.

Initially there was resistance from both staff and students towards the paradigm shift from traditional classroom based teaching to a hybrid web based pedagogy model. Staff were concerned about the introduction of vendor specific material, loss of flexibility in setting the syllabus and online multiple choice testing as opposed to traditional written exams. Further the intensive training staff had to undergo to qualify as instructors was a considerable strain on the department and staff.

Students too were initially concerned about the new learning model, which prompted them to use online material as opposed to the traditional textbooks. But the ease of access, level of support from the staff and evolution of course material were key factors in gaining students' confidence. Animation and simulations in the curriculum helped them to grasp advanced concepts in an effective manner. Further some of the disabled students found it difficult to read online material from a VDU screen, this was solved using the character magnifying functions in the Microsoft operating systems. Our survey found out that students would recommend this program for study at postgraduate level, this was confirmed by increasing number of student.

An interesting study of a pure asynchronous delivery model for e-learning can be found in[11]. Management flexibility is one of the strong points of our hybrid model, because it minimises the resources required to support the evolutionary development and release of the course. The constant and rapid evolution of underlying technologies requires periodical and, often, radical course updates, and with the hybrid model those updates can be achieved with limited resources and in a smaller time frame.

This model has many opportunities. One of them is that it can be used for pure synchronous or asynchronous distance learning in comparison to the current usage in a hybrid model. The remote lab facilities would enable this to be run in a pure asynchronous paradigm. Our experience shows that distance is not a limitation since the curriculum was accessed by students while they were abroad. Currently though our experience is limited to students that live locally, less than 100 km away from the University. The statistics generated by the global running of this program by the networking academy provides conclusive evidence that this distance limitation has been overcome.

One of the key quality factors is the support provided by the academic staff, concerning both scientific adequacy and response time. Difficulties were also found that require additional research work. One of them is the communication and social interaction among the students following a specific course. On an experimental basis we have tried Internet Protocol TV (IPTV) technology which supports on demand video using proprietary clients and servers. The results were moderate mainly due to the proprietary nature and the expense of related hardware and software. Furthermore shared virtual meeting spaces [12] (SVMS) is a promising technique to improve interaction between course participants. Although some efforts have been made promoting the relatively economical, discussion forums, the results are very poor. This may result from some specific cultural characteristics of the participants, but the potential of this type of communication justifies any efforts to understand how it can be achieved in distance education programmes.

Due to the positive results of this research we are currently planning the integration of the web based Network Security pedagogic tool in the MSc Information Security. In a few years we plan to accumulate a complete set of data for usage analysis.

Further research is conducted using the same methods, instep with our initiative to deliver all modules, in a fully asynchronous e-learning mode in an e-university paradigm for students' world-wide. This would require online communication between student and the academic staff to be confidential and authenticated. Currently PGP (Pretty Good Privacy) and Public Key Infrastructure (PKI) using Public and Private keys have been proposed for this purpose. The technique highlighted can be extended to analyse non-proprietary or in house developed web based pedagogic tools.

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