Developing and Evaluating a Training Program for Server Administrators in Schools*

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Abstract This paper describes a project in which we developed teaching materials and a complete teaching program using those materials aimed at educating information teachers in the knowledge and skills necessary to build, administer, and maintain a server in educational establishments, and includes an evaluation of the first iteration of the program. After identifying the skills and knowledge that would constitute a realistic minimum requirement, we developed a sequence of lesson topics, and created a textbook based on these topics. The next step was to develop a curriculum and detailed teaching program based around this textbook, considering optimal and efficient ways of teaching the material. Surveys conducted before and after the course indicate that students' understanding of and interest towards server-related topics deepened, as did their awareness of security issues, and students developed a desire to study these topics more deeply.

Key words : teacher training, management, server, curriculum, Linux, security

1. INTRODUCTION

In today's educational institutions, whether primary, secondary or tertiary, using a server to manage and broadcast the institution's information has become commonplace (The subsidiary enterprise such as surveillance study related to educational computing 2003; E-Education Association of Japan 2006). The responsibility for managing these servers tends to fall naturally to information science teachers. Servers in any context are computers whose clients demand services, and it is unacceptable that, when those clients access the server, a fault in the server should deny those services. Such failures could lead to a loss of confidence in the school from the broader society.

Linux is one of the main OSs used in servers (ThinkIT 2004). Linux is free and open source software and includes as standard several server programs, such that it can be considered an optimal solution for building a server (How to choose a file server 2008). However, security holes are discovered in Linux on a daily basis (Vine Project 2008), and attacks capitalizing on these holes, such as buffer overflows, are attracting attention (Japan Linux Information 2008). Further, its susceptibility to being used as a vehicle, or a zombie ant, for Denial of Service (DoS) attacks combined with attempts to obtain administrator privileges make Linux servers an attractive target. If the server is implicated in DoS attacks, administrators and the school itself can be held accountable as wrongdoers.

It is clear from the above that, in order to run a server securely, it is necessary to train information teachers to be able to build a robust server that does not engage in DoS attacks. Unfortunately, server security is generally considered a rather difficult or even abstruse field, and not something that a proficient general user, or even a graduate of a typical information course at a tertiary institution, can be expected to have mastered, and building a Linux server is known to be a difficult process. Thus, information teachers cannot realistically impart sufficient know-how to other staff, leading to a greater workload for themselves.

Another option is to leave the building and running of a server to an outside company. This can lead to cost reductions associated with

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outsourcing, reductions in teachers’ workload, and appropriate responses to any emergency situations. (Saga EDU-QUAKE 2009). However, not all schools have access to such networks (Mie School network 2000). Further, schools may not always have the skills required to describe the situation appropriately to the company. In addition, before the company arrives on the scene, there are cases where ports open to computers outside the school have to be blocked or the server has to be shut down immediately. Companies also need to have the ability to translate the school’s needs into an appropriate order when the time comes to replace hardware.

To address this kind of situation, we propose the following approach:

1. at university undergraduate level, teach the knowledge and skills required to run a server to students intending to become information teachers;

2. develop materials to help those already teaching in schools to learn efficiently the knowledge and skills necessary for running a server.

Research along these lines already exists, including a training program in server technology for information teachers (Itou et al. 2004), practical training in server building with Linux (Iida, Okano 2006), work on school–internal networks (Takagi et al. 2007), and development of an internal system using a server (Miyazaki, Takemori 2007). However, it appears that no research has yet been undertaken dealing specifically with training teachers in setting up and maintaining a Linux server. On the other hand, several universities have lectures in building networks or servers (Tokai University 2009); these, however, appear not to be focused specifically on fostering stronger awareness and knowledge of security issues. Considering the rapid growth in the Internet in recent years, we consider it imperative to foster heightened awareness of security issues alongside the technical ability to build servers.

Over the last few years, the authors have made proposals for curricular and syllabus changes aimed at students hoping to become information teachers that would include training in building servers (Kobayashi, Mukaidani 2006). These have, however, yet to be tested in actual classes, and no evaluation of their usefulness has been conducted.

In this paper, we consider what is needed at universities—in terms both of curricular changes and teaching methods—to educate a new generation of information teachers in the skills and knowledge necessary to build, manage, and maintain servers, without leaving all the work and decision making to outside companies. We created a textbook aimed at allowing information teachers and students intending to become information teachers to learn the necessary skills efficiently. We describe a year-long curriculum and teaching plan using this textbook and test this plan in actual classes, conducting an evaluation as to its usefulness, including surveys to ascertain its benefits, if any, in terms of students’ skills and awareness of security issues. We point in particular to the practical experience with building a server incorporating security measures in our system, which contrasts with traditional teaching of security that generally consists of lectures alone.

2. INSTRUCTIONAL PROGRAM

In this section, we consider the knowledge and skills that are called for in educational settings and the kind of teaching program that would meet those needs. We note first of all that, as Linux has become easier to install, it has become possible for those with even modest experience with PCs to build a server. The negative side of this change is that those with limited knowledge of security measures may build a server that subsequently is cracked and used as a platform for attacks; the obvious lesson is that the ability to build a server is of little use if one does not know how to administer it. Accordingly, we assign the highest priority to building an awareness of security issues before teaching an array of server building techniques. For example, before teaching how to set up a mailing list, we prioritize SMTP server settings. Secondly, we place a strong emphasis on the actual practical needs of educational institutions. One of the characteristics of most schools is that the number of students vastly exceeds the number of PCs, and hence the need for file servers is likely to be strong, as is the need for managing users. In addition, in order to share information with the world, a school is likely to need a Web server, along with an FTP server to enable uploading of information. Considering facts of this kind, we use the limited time available to teach the skills that are most likely to be useful, setting a clear theme for each session. Following these principles led us to decide on the following 15 topics, which we consider to constitute the
the bare minimum of skills and knowledge necessary for a teacher setting up a server in a school. We created teaching materials incorporating these 15 topics, and devised a teaching plan of 15 sessions based thereon (Kobayashi, Mukaidani 2008b).

Session 1: Introduction
Starting from the basic concept of what a server is, we lead students to an understanding of the types of server and protocol. After explaining the concept of client server systems, we introduce Linux, explaining its advantages and characteristics as a server OS.

Session 2: Installing Linux
Students need to know how to obtain Linux and install it. Installing Linux is very different from installing a typical Windows or Mac OS X application, and specialized knowledge of launching from a CD-ROM and setting partitions, file systems, and the bootloader are required. In particular, making a mistake with a Linux installation can in the worst cases lead to erasure of a Windows partition, and thus it is essential to take due care during the installation process and to proceed from a basis of reliable knowledge. Due care must also be taken with root access and passwords.

Session 3: Text editors
Text editors are necessary to edit system settings files. We use gedit, an editor whose usability is on a par with the Notepad utility bundled with Windows, and teach students how to edit text, including adding strings, and performing search and replace operations. In addition, since it may be necessary to log in via SSH to edit server settings, we recommend that students familiarize themselves with vi in addition to gedit.

Session 4: Commands & Paths
When building a Linux server, there will inevitably be occasions when it is necessary to use the command line. Accordingly, we teach the priority of the CUI over the GUI, insisting that students become comfortable with the command line, particularly how to navigate between directories and carry out move and copy operations on files. We also explain the directory structure of Linux, and teach students how to specify paths correctly. We focus particularly on the difference between absolute and relative paths and the importance of developing the ability to switch depending on circumstances between them.

Session 5: User Management
User management is a basic skill of server administration, and it starts with an understanding of user management policy. Following that, we teach students how to use the GUI to create new users and delete users, also teaching how to set passwords appropriately, how to manage groups, and how to manage permissions. We also teach the importance in terms of security of setting up a user without log-in privileges.

Session 6: Permissions
In system administration with Linux, we often run into cases where we need to handle files or directories connected with system settings. It is not desirable from a security point of view that these files should all be viewable and writable. We teach the importance of permissions and the skills needed to use chmod to modify permissions.

Session 7: Network Connections
Before connecting a server to a network, it is necessary to set access rights in such a way as to avoid unauthorized access or attacks. We teach how to launch and terminate services and the importance of terminating unnecessary services. We include training in the use of the comparatively easy to use TCPWrapper to manage access. We then teach how to actually connect Linux to the network, using the ifconfig command to check one’s own network configuration, and ping to check the connection between one’s own network and the host.

Session 8: Managing Applications
Installing software on Linux is very different from doing so on GUI systems such as Windows or Mac OS X. Accordingly, we explain the advantages of managing software with packages, and introduce the package management tools Redhat Package Manager (RPM) and Advanced Packaging Tool (APM) and how to use them. We also explain software licensing regimes under Linux.

Session 9: Philosophy of Server Administration
Before actually building a server, it is necessary for server administrators to take some preparatory steps. Since it is normal for server to be available on a 24/7 basis, there is permanent risk of attack. Thus, server administrators need to have a focus on reliability, be ready to install security patches as they become available, and understand the importance of a backup regime. They also need to understand the nature of zombie attack platforms.
and (distributed) denial of service attacks as well as know how to combat them. In addition, we teach the importance of domain names and how to obtain domain names through a dynamic DNS.

Session 10: Web Servers

Educational establishments almost invariably need a web server in order to offer a website to the world. We cover the role of web servers and introduce the httpd daemon Apache, including how to tune the web server by editing the Apache settings files, and enable access from external clients through access tests. We also explain the merits of opening user directories and how to do so.

Session 11: FTP Servers

When creating web pages, it is convenient to create the contents on Windows or Mac OS X and use FTP to upload the contents to a server. We also use FTP when we want to backup files on the server. In this session, we make sure that students understand the role of FTP servers, and teach students how to use the FTP daemon ProFTP. We train students in using commands to transfer files and teach the difference between binary and ASCII modes.

Session 12: SMTP Servers

Email has become an indispensable part of modern life, and this is as true in schools as anywhere. Confirming students’ understanding of the role of mail servers, we outline the functions of the SMTP daemon Postfix. We then move on to the appropriate settings for Postfix and mail clients to ensure that mail can be sent. Further, since SMTP servers may be misappropriated to send spam, we outline the dangers and measures to combat them.

Session 13: POP Servers

We explain the role of POP for receiving mail and cover the POP daemon Qpopper and how to launch it via the super server inetd. We move on to mail client settings for appropriate delivery of mail.

Session 14: File Servers

We build a file server using Samba to allow file sharing over Windows systems. In schools, setting up a file sharing space allows the exchanging of files between teachers and students. After introducing the concept of file servers and the basics of Samba, we look at editing Samba settings files, and move on to considering the various types of errors that can occur and how to deal with them.

Session 15: Administering and Protecting a Server

In the daily running of a server, log files play a crucial role. They allow us to check when a server was accessed and give us information about the accessing host, and also allow us to trace any errors. Since typically any problem necessitates examination of log files, the ability to read log files and knowledge of the types of log files are essential. We also cover the importance of using SSH to administer the server remotely, and teach students how to actually log in and familiarize them with the experience of remote administration. We also discuss the importance of security measures when using SSH, explaining what could happen if an SSH session was intercepted.

In each session, we cover content of practical usefulness, and our aim is to include anything that is necessary for improving security in educational establishments. For example, in Session 10 we cover Basic authentication. In addition, in Columns, we consider it important to cover installation of applications via tarball, how to use vi, and mailing list settings.

3. OUTLINE OF TEACHING MATERIALS

The teaching materials used in this project follow the teaching system described in section 2, above. They are aimed at information teachers and at students who wish to become information teachers, and the exclusive focus on the needs of this target audience makes them very different from books generally available on building servers. Such books generally have the following characteristics:

1. They cover various types of server, and the material cannot be covered in 15 sessions.
2. In regards to server access settings, there is no description of unified application use.
3. There is a focus on package installation.

Even in cases where these problems do not apply, important information is missing, and teachers are faced with the problem that there really is no suitable book available for a course of 15 lectures.

On the other hand, a standard Linux textbook is available at no charge (Linux Standard Textbook 2009). Unfortunately, this book contains a lot of information that Linux beginners would be well advised to skip. In addition, it focuses on the vi editor and necessitates the memorization of numerous commands in a limited time. Coupled with its length (about 250 pages), this makes it unsuitable for a 15-session course for Linux.
novices.

Our textbook is about 150 pages long, and we feel that it covers all the essentials for educational settings, allowing teachers to run a server and attend to their other duties. Chapters are organized along the same lines as the lessons described in the previous section.

4. PUTTING IT INTO PRACTICE

We tried out the described teaching program thus:

Time: We taught the course as an intensive program from November 22-24, 2008. There were five sessions on each of three days.

Place: Rm L310, Graduate Department of Information Science, Hiroshima University

Participants: 23, including 16 third-year and 6 fourth-year undergraduates, and 1 first-year Masters student.

The server we used had an Intel Celeron processor running at 1.7 GHz, with 248 MB of RAM, and a hard disk with a capacity of 14.6 GB. To avoid possible incompatibilities, students' computers had the same specs.

5. PRINCIPALS AND PRACTICE

In teaching the course, we paid attention to the following points:

1. Avoiding difficult technical vocabulary.
   This applies to other fields as well, but considering the reputation of servers as being a difficult field, we consider it especially important to avoid making things more difficult than necessary by introducing large numbers of technical terms. Thus, in the textbook and in the class, we used simple language to the extent possible.

2. Use of visual aids
   As with other fields considered to be difficult, the use of visual aids such as diagrams and tables can aid understanding. We used these as much as possible, including concept maps.

3. Use of an OS suited to use as a server
   For beginning computer users or users accustomed to Windows or Mac OS X, the unexpected errors and other system problems associate with Linux as a whole can be a major problem, and this makes the choice of distribution an important one. It is important to train students to choose one that suits the hardware and that is comparatively stable.

For this project, we adopted Vine Linux, one of the distributions in the Redhat line, as our server OS. Attractions include the fact that the OS is housed on a single CD and can be installed in 10 minutes, the quality of the Japanese-language environment, and the fact that it is fairly stable, making it unlikely that it will stall in the middle of an operation.

4. Appropriate response to unexpected errors
   In the course of training in building servers, it is quite common for unexpected errors to occur, and it is possible for these to derail lesson plans. Thus, we try to cover the most common types of error and standard ways of recovering from them in advance. We also train students to respond flexibly to errors when they do occur.

6. PRE-SURVEY

In order to ascertain students' understanding and consciousness of networks, we conducted a survey before the course began. We obtained valid responses from all 23 students.

6.1. Consciousness of computer networks and related matters

Students answered questions regarding computer networks, Linux, and building servers (which we refer to collectively as computer networks and related matters).

On Question 1, the most popular answer (7 students) was "somewhat difficult". For Question 2, the most popular answer (8 students) was

<table>
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<tr>
<th>Question 1</th>
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<td>(3)</td>
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<td>2</td>
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(4) In your daily use of computers, how confident are you in your anti-virus measures?

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<th>Question 2</th>
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<td>2.739</td>
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</tbody>
</table>

1: not at all confident; 2: not confident; 3: not very confident; 4: rather confident; 5: confident; 6: extremely confident
“difficult”, while no students answered “extremely interesting”. For Question 3, 10 students answered “extremely difficult”, while 8 students answered “difficult”, underlining the perceived difficulty of this subject.

Turning to the mean values, we find that Question 1, at 3.652, is the only question with a mean response exceeding 3.5. Both Questions 2 and 3 have a mean response below 3.5, with server construction having a very low mean of 2.217.

From the results of Questions 1–3, we can see computer networks and Linux are seen by students to be difficult topics, as is the topic of servers, reinforcing our point from section 1.

For Question 4, the most popular answer (8 students) was “not very confident”, with no students choosing “extremely confident”. The mean value, at 2.739, was well below 3.5, suggesting that many students lack confidence in security measures.

7. A SAMPLE LESSON

We devised a teaching plan based on this curriculum and 15 teaching sessions. As an example of what a lesson looked like, we describe here Session 12 on SMTP servers.

8. POST-SURVEY

After completion of the course, we conducted another survey to judge the usefulness of the curriculum. We obtained valid responses from all 23 students.

### Table 2. Teaching plan for Session 12: SMTP Servers

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<tr>
<th>Time</th>
<th>Activity</th>
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<tbody>
<tr>
<td>15min</td>
<td>Explanation of what mail servers do; Description using visual aids of mail forwarding</td>
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<tr>
<td>25min</td>
<td>Basic description of Postfix; Opened main.cf with demonstration of editing; Setting of mydomain and myhostname appropriately for one’s own network</td>
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<tr>
<td>20min</td>
<td>Use of SMTP for illicit mail transmission, and prevention thereof</td>
</tr>
<tr>
<td>30min</td>
<td>Demonstration of sending of a test mail; Students conduct a transmission test on Linux and confirm receipt; Demonstration of sending email from a Windows terminal to students’ cellphones</td>
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</tbody>
</table>

8.1 Changes in awareness

We attempted to find out what kinds of changes occurred as a result of the course in students’ attitudes towards computer networks. We examined students’ attitudes towards Windows updates and Linux security patches as an indication of attitudes towards security. Results are shown in Table 3.

We note first of all that the mean exceeded 3.5 for all questions, indicating that consciousness had been raised compared to before the course. The most popular answer to Question 1 (8 students) was “I’ve become interested”, followed by “I’ve become extremely interested” (6 students). The mean value rose from 3.652 to 4.609. For Question 2, the most popular answer (13 students) was “I’ve become interested”. For Question 3, however, no students responded “I’ve become extremely interested”; for this Question, although the mean rose from 2.217 before the course to 3.870 afterwards, the post-survey mean was lower than any of the other Questions. In Question 4, too, the mean was 4.652, the most popular answer being “I intend to install them on a regular basis”.

### Table 3. Post-survey (survey of changes in attitudes)

(1) How have your attitudes towards computer networks changed compared to before this course?
(2) How have your attitudes towards Linux changed compared to before this course?
(3) How have your attitudes towards server construction changed compared to before this course?
(4) In future, how do you think you will respond to Windows updates or Linux security patches?

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</table>

1: I don’t have any intention of installing them; 2: I probably won’t install them; 3: I don’t particularly feel like installing them; 4: I’ll probably install them; 5: I intend to install them on a regular basis; 6: I’m determined to be assiduous about installing security updates.
up from 2.739 before the course. From these results, we can say that students’ consciousness of computer networks has risen after the course, but that students still view server building as difficult.

8.2. Survey of students’ understanding
We conducted a survey of students’ self-reported understanding of lesson content; the results are shown in Table 4.

For all questions, the mean result is higher than 4.000. With the exception of Question 10, the most popular answer was “I was able to understand”. Thus, it appears that students were able to reach a high level of understanding of the content covered in the course.

8.3. Other surveys
We also polled students on their feelings regarding working on servers or networks in educational institutions and their interest in studying the subject further. These results are shown in Table 5.

The most popular answer to Question 1 (6 students) and the mean, at 3.478, was below 3.5. We can see from this that, even if students have learned the basics from the course, actually building or maintaining a server is seen as a burden. In actual fact, most information teachers find server-related work to be a burden, and it is perhaps to be expected that students would be no different in this respect. For Question 2, the mean exceeded 5.0, with “extremely interested” being the most popular answer (10 students), suggesting that the course was successful in stoking students’ interest in networks and servers and related topics.

Table 5. Post-survey (other items)

(1) In the future, how do you feel about engaging in work in educational institutions connected with building servers or networks?

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1: I think that would be a big burden; 2: I think that would be a burden; 3: I think that might be a bit of a burden; 4: I think that might be interesting; 5: I would like to try that; 6: I would definitely like to do that.

(2) How interested would you be in learning further about server construction or networks?

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<td>5.043</td>
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</table>

1: definitely not; 2: no; 3: I don’t think so; 4: a little interested; 5: interested; 6: extremely interested

Finally, we required students at the end of the course to submit a report. This report was to include a “results” section, and in this section we observed comments such as the following:

- I managed to complete the installation successfully, and I was able to install X Linux.
- I am very satisfied because I managed to install an OS for the first time.
- As I input commands, I felt that, although gradual, I was getting real experience of building a server.
- Because we gradually built up from simple commands, we learned how the various

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Table 4. Understanding of lesson contents

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<td>(1) Installing Linux</td>
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<td>(2) Using the text editor gedit</td>
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<td>(3) Moving and deleting files, etc., with the command line</td>
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<td>4.957</td>
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<td>(4) Using absolute and relative paths appropriately</td>
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<td>(5) Changing permissions</td>
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<td>(6) Setting access restrictions using TCPwraper</td>
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<tr>
<td>(7) Installing and uninstalling software</td>
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<td>4.261</td>
</tr>
<tr>
<td>(8) Philosophy of server administration and the importance of security</td>
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<td>4.739</td>
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<tr>
<td>(9) Domain name servers and the importance of dynamic DNSs</td>
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<tr>
<td>(10) How to build various kinds of servers</td>
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1: I was not able to understand at all; 2: I was not able to understand; 3: I was not able to understand slightly; 4: I was able to understand slightly; 5: I was able to understand; 6: I was able to understand extremely.
commands are connected.

- There were lots of detailed specifications and settings [which were difficult to master], but we somehow managed to build a server and try accessing other students' servers.
- I had always thought that building a Web server was a terribly difficult thing to do, but I learned that with a thorough explanation it is quite possible.
- Building a server is a complex and difficult process, but I found that following the correct procedure made it easier than I expected.
- Working with the command line, I found that, although it took some time, I was able to successfully move files around and perform other simple operations.
- I was able to build an FTP server, and upload and download files to and from a file server.
- It was difficult, but I was able to do the FTP portion on my own.
- I was able to build an FTP server and to confirm that file transfer had taken place.

From these comments, we can see that students did acquire a portion of the skills necessary to administer a server. They were also able to carry out the tasks in Part 4: Command and Paths, and we consider that our course did make a meaningful contribution.

9. CONCLUSION

In this study, we created teaching materials and designed a course—and conducted an evaluation of both—with the aim of educating information teachers with the skills and knowledge required to run servers in educational settings. After clarifying the nature of the necessary skills and knowledge, we created a textbook containing the necessary items, and devised a curriculum and teaching plan using these materials. From the surveys conducted to judge the success of this project, we conclude the following:

1. The course made a major contribution to raising students' awareness and fostering their interest in servers and networks.
2. Likewise, the course was successful in awakening an interest in learning more about these topics.
3. In addition to raising interest and awareness, the course made substantial contributions to actual knowledge. We made a strong effort to ward off confusion students by avoiding overuse of technical vocabulary and by copious use of visual aids, and the results suggest that these policies were successful. We also believe that our choice of the comparatively stable and easy-for-beginners Vine Linux distribution contributed to the smooth progress of the course. Student comments after the course suggest that they judged the course successful. Comments such as “My understanding and interest in servers and networks have deepened” and “This has been one of my most rewarding courses” were particularly heartening. On the textbook, encouraging comments included “Material was organized in an easy to understand way and explanations were clear” and “The lack of technical terms meant that we were able to follow along without confusion”.

Version numbers of server OSs and the like could be problematic in connection with future implementations of this curriculum. In the present study, since the hardware was rather old, we used the likewise rather old Vine Linux 3.2. Since server environments change on a day-to-day basis, upgrades will be necessary, and with these upgrades may come changes in the exact applications used and in directory structures, amongst other changes. Thus, we consider regular upgrades of the teaching materials and curriculum to be important tasks in the years to come.

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