Selection of Server-Side Technologies for an E-Business Curriculum

J. Christopher Sandvig
Department of Decision Sciences
Western Washington University
Bellingham, WA 98225, USA
csandvig@wwu.edu

ABSTRACT

The rapid growth of e-business and e-commerce has made server-side programming an increasingly important topic in information systems (IS) and computer science (CS) curricula. This article presents an overview of the major features of several popular server-side programming technologies and discusses the factors that influence the selection of server-side programming for teaching e-business curriculum. The factors include the capabilities of the technology, its complexity, infrastructure requirements, fit within the broader curriculum, market share, employer demand, and the availability of supporting resources such as books and on-line help. It concludes with a brief description of the decision-making process at Western Washington University (WWU).

Keywords: Server-Side Programming, Curriculum, E-commerce, Web Development, Database

1. INTRODUCTION

The term e-business includes a broad range of business activities that are conducted via electronic communication. It is an umbrella term that includes e-commerce as well as many facets of business operations that utilize digitally transmitted information (Robinson, Tapscott, and Kalakota, 2000). Both e-business and e-commerce are transaction-oriented activities that utilize electronic communications, usually Internet technologies. While e-business has existed for decades using proprietary technologies, the Internet has greatly lowered the cost and expanded the scope of e-business activities.

High market demand for e-business skills has motivated many Management Information Systems (MIS) and computer science (CS) programs to develop an e-business component within their curricula. This trend has been further encouraged by surveys of MIS employers and alumni who have identified e-business and Internet application-development skills as a valuable niche area for graduates (Ehie, 2002; Mitchell and Strauss, 2001). The high value that MIS employers place on programming skills (Chrysler and Van Auken, 2002) has also encouraged inclusion of server-side programming in many e-business curricula.

A typical e-business transaction involves a customer (client) using a computer and a web browser to communicate via the Internet with a web server. The web server hosts the applications that are responsible for conducting e-business. These responsibilities include providing the site's navigation and interface, listing product information, providing a shopping cart, collecting customer and order information, validating user inputs, maintaining security, enforcing business logic, processing payments and other critical business functions. The focus of this paper is on the technologies that support e-business on the web server.

Four major server-side technologies are needed to support Internet-based e-business: a web server to handle requests from the Internet, a server-side programming technology for managing the user interface and business logic, a database application, and a server operating system (Figure 1). The following steps outline the basic steps of handling a web request:

- The process is initiated when a user's (client's) browser sends a request to view a web page. The request is transmitted via the internet to the appropriate web server.
- The web server retrieves the file associated with the request from the server's file system (Note: In the interest of simplicity more advanced topics such as security, authentication, caching are omitted from this overview).
- If the request is for a static HTML (Hypertext markup language) page, the web server sends the file to the client, and the process is finished.
- If the request is for a dynamically generated page, the web server passes the file to the programming engine. Here the programming code and database queries are executed and a response is created. The response consists of HTML, text, and possibly other client side scripts such as JavaScript and VBScript. The response is passed to the web server, which then sends it to the client via the Internet.

Specific combinations of server technologies are typically bundled together. For instance, a popular open-source technology combination is known as the LAMP (Linux, Apache, MySQL, PHP/Perl/Python) stack. This combination utilizes the Linux operating system, Apache web server, MySQL database and PHP (or Perl or Python) server-side programming technology. Similarly, Microsoft's technologies are also usually bundled with other Microsoft products. A common combination is the Windows operating system, Internet Information Server (IIS) web server, ASP (Active Server Pages) or ASP.NET programming technologies, and Access or SQL Server databases. While the protocols between the different technologies are largely standardized, allowing the possibility of many "non-standard" combinations, the benefits of using standard configurations include easier installation, more extensive documentation, and a wider selection of on- and off-line documentation. An overview of major features for over two dozen web servers is available at www.serverwatch.com.
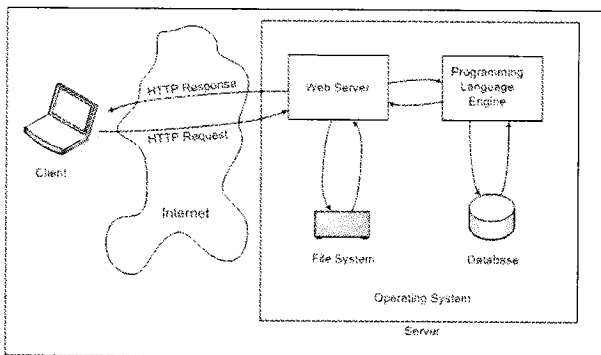

Figure 1: Process for handling a HTTP web request.

With such a large selection of web server technologies available, it is difficult for instructors to know which ones are best suited to their teaching needs. This paper focuses on the selection of a server-side programming technology for teaching e-business. It overviews the major features of several popular server-side programming technologies, estimates their relative market share, and examines the market demand for skills. It concludes with a description of the process used for selecting the technologies used at Western Washington University.

2. LITERATURE REVIEW

A variety of server-side programming technologies and languages has been used to teach e-business. This section reviews several recent articles that have used server-side programming to teach e-business (in chronological order). Although a few papers mention the reason that a particular technology was selected, no previous articles have focused specifically on the criteria used to select server side technologies.

McCubbrey (1999) describes a masters-level Electronic Commerce curriculum at the Daniels College of Business at the University of Denver. JavaServer Pages (JSP) was used because the curriculum covered object-oriented programming concepts. Denton (2000) describes the use of web-based projects in a systems design and development course that used the Visual Basic (VB) programming language and CGI (common gateway interface) to interface with the internet. Denton observes that this is an unusual combination of technologies, but states that "The choice of Visual Basic is logical for a business school environment..." (Denton, 2000, pg. 86).

During 2002, three articles described the use of server-side technologies for teaching e-business. The first, by Cao et al. (2002), described the use of Microsoft's ASP to teach information security concepts. ASP was selected because the authors felt that the code was more readable. The second article, by Lim (2002), describes the evolution at Illinois State University from using Visual Basic and CGI in 1997 to JSP in 2002. Visual Basic was originally used because many of the students knew VB prior to taking the e-commerce course. It was later replaced with the newer and more efficient JSP technology. In the third 2002 article, Lomerson (2002) describes the use of ASP to process HTML forms created by students in a beginning HTML course. He selected ASP because it is widely used and available on campuses, and the scripts are easily managed by the course instructor.

Ingram and Lunsford. (2003) describes how e-business concepts were taught by having students use ASP to develop a web-based sales order system. ASP was chosen primarily for its "robust data access support" (pg. 141). In a second 2003 article, Wang (2003) describes the use of JSP to teach E-business. JSP was selected because of its popularity in the marketplace.

In the first of two articles published in 2004, Chopoorian and Wang (2004) describes a course in which students are responsible for obtaining hosting through a commercial Web service provider that supports either Perl or Java. The instructors then provide pre-written code that students modify. The most recent article, by Yue and Ding (2004), describes the evolution of a web development course that has been taught since 1996. At various times the course has used CGI-Perl, ASP, Cold Fusion, J2EE/JSP, and ASP.NET. Currently it employs ASP.NET, J2EE/JSP, and Perl, since they represent "the three major platforms of web development" (Yue and Ding, 2004. p. 24).

A summary of the server-side programming technologies described in the recent literature is shown in Table 1.

Internet technologies have evolved rapidly, and a technology that was a good choice for a particular purpose a few years ago may not be a good choice now. For instance, Microsoft's popular ASP technology is currently being eclipsed by the newer ASP.NET technology. Although the names are similar, ASP.NET is a considerably more complex technology than ASP and may not be as appropriate for beginner programmers.

A review of the literature finds that there is not an obvious technology choice for teaching e-business. ASP and JSP are the most popular, but Perl/CGI and ColdFusion have also been used. Surprisingly, no authors report using PHP, which is a popular, low-cost, and relatively easy to learn technology.

The following sections overview the features of the most popular technologies being used today and estimate market share for several technologies.

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Author(s)	Server-side Programming Technology Used	Reasons Cited
McCubbery 1999	Java	Object-orientation.
Denton 2000	Visual Basic with CGI	Many business students know VB.
Bartholome and Olsen (2002)	ASP.NET and Perl	No reasons cited.
Cao, Davis, Bai, Katter 2002	Active Server Pages	Readability, easy for students to learn.
Lim 2002	Java Server Pages	Commonly used in practice.
Ingram and Lunsford 2003	Active Server Pages	Robust data access support, price.
Rob 2003	Active Server Pages	No reasons cited.
Wang 2003	Java Server Pages	Popular choice for building interactive e-Commerce applications to replace CGI programs.
Chopoorian and Wang 2004	Perl & Java	Students learn Java in previous programming course. Inexpensive hosting is available for these technologies.
Yue and Ding 2004	ASP.NET, J2EE/JSP, Perl	Represent the three major platforms for web development.

Table 1. Server-side Programming Technologies used in published cases

3. SERVER-SIDE TECHNOLOGY OPTIONS

All of the major server-side technologies have the ability to support e-business. They differ from each other in terms of ease of use, scalability, features, languages, price, support, and degree of integration with other products. This section first reviews server-side programming languages and operating systems, followed by brief overviews of several popular programming technologies.

Every server-side programming technology supports at least one programming language, and some technologies support multiple languages. Java Server pages, as its name implies, supports only the Java language, while ASP.NET supports over 24 languages (StartVbDotNet.com, 2006). Several server-side technologies have their own languages, such as PHP's PHPLanguage and Python's PythonLanguage. An advantage of utilizing a server-side technology that employs a popular programming language, such as Java or Visual Basic, is that students may already know the language and the language skills that they learn can be applied to other, non-web programming tasks. The advantage of technology-specific languages is that they are often tailored to the unique needs of web programming and are easier to use. Table 2 lists more popular server-side programming technologies and their vendors.

The major operating systems used in E-business are Linux, Windows, Unix, FreeBSD, OS/2, and Solaris. Most server-side technologies can run on any of several different operating systems. PHP, for instance, may be installed on the Linux, Unix, Windows, Mac, Solaris, OS/2, and several other operating systems. In contrast, ASP and ASP.NET are Microsoft products and are designed to run primarily on the Windows operating system, although third-party and open-source versions of the .NET Framework are available for Linux and other operating systems.

The major features of several popular server-side programming technologies are described below (in alphabetical order):

Active Server Pages (ASP) – Microsoft released ASP in December 1997 as a feature of its Internet Information Server (IIS) web server. Since IIS was bundled with most versions of the Windows operating system, ASP was widely available and soon gained a large market share. ASP is a scripting language that intersperses server-side programming code with HTML. It supports two scripting languages, VBScript and JScript (Microsoft's version of JavaScript), and seven server-objects for tasks such as communicating with the client and the server. It runs primarily on the Windows operating system, but third-party vendors have created versions for other operating systems. ASP is often used in conjunction with Microsoft's Access and SQL Server databases. It has a reputation for being relatively easy to learn and use.

ASP.NET – In 2002 Microsoft released the .NET framework, which included ASP.NET for developing web-based applications. The .NET framework supports several object-oriented programming languages, including VB.NET, C# (similar to C), and J# (similar to Java). In addition, third parties have developed compilers for many other languages (StartVbDotNet.com, 2006). The .NET class library includes over 5,000 classes, providing many advanced features and tight integration with the Windows operating system (Sandvig, 2004). While Microsoft's version of ASP.NET runs only on the Windows operating system, the framework is designed to be platform independent, and third parties have developed versions for other operating systems. An open-source version has been developed for the Linux operating system through the Mono Project (www.mono-project.com). The .NET framework is a free download from Microsoft's web site (www.asp.net). It is typically used in conjunction with Microsoft's Access and SQL Server data-

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Technology	Vendor/Sponsor	Supported Languages
ASP	Microsoft	VBScript, JScript
ASP.NET	Microsoft	VB.NET, C#, J# & others.
ColdFusion	Macromedia	ColdFusion Markup Language (CFML)
JSP/J2EE (open source)	Sun, IBM, BEA and others	Java
Perl/CGI (open source)	The Perl Foundation	PerlLanguage
PHP (open source)	The PHP Group	PHPLanguage
Python (open source)	Python Software Foundation	PythonLanguage
Ruby (open source)	Yukihiro Matsumoto	RubyLanguage
Smalltalk (open source)	SmallTalk.org	Smalltalk Language

Table 2. Selected server-side programming technologies

bases, but supports Oracle and other OLEDB compliant databases.

ColdFusion – Macromedia's ColdFusion Markup Language (CFM) was introduced by the Allaire Corporation in 1995 and gained popularity because it was supported by Allaire's popular HomeSite HTML editor. It is a scripting language with a reputation for being easy to learn and use. Allaire is now part of Macromedia, and ColdFusion is supported by Macromedia's popular DreamWeaver editor. Versions are available for the Windows, Linux, and Unix operating systems. Macromedia's list price for the Standard edition is $1,299 per server, with discounts for educational users.

JavaServer Pages (JSP) – JSP is the component of Sun's J2EE (Java 2 Platform Enterprise Edition) open-source specification. Implementations include IBM's WebSphere, BEA's WebLogic, Sun's Java System Application Server, and JBoss (Bond et al. 2002). JSP allows server-side Java code to be embedded in static content, in a manner similar to PHP and ASP (Bai, 2003). It uses the object-oriented Java programming language, making it more abstract and complex than procedural languages such as VBScript or PHPLanguage. Open-source and commercial implementations are available for all major operating systems. Sun's implementation is a free download from Sun's web site (java.sun.com/j2ee).

PHP Hypertext Preprocessor -- PHP is an open-source scripting technology that intersperses server-side code with HTML. PHP is one of the most popular web programming languages used today. Like ASP, it is powerful and easy to learn. A significant advantage of PHP is that it is multiplatform, with versions available for the Windows, Linux, UNIX, and other operating systems. PHP uses PHPLanguage, which is derived from a mixture of C, Java, and Perl syntax. It is the most popular of the scripting languages included in the LAMP platform, and is available as a free download from www.php.net.

Python and Perl – Both Python (named after the British comedy "Monty Python") (Python.org, 2005) and Perl (practical extraction and report language) are open-source programming languages that pre-date the Internet. Early web programmers often used these languages in conjunction with CGI to create dynamic web pages. They are supported, along the PHP, by the LAMP stack. The popularity of these languages for web development is difficult to estimate because they do not have a distinctive file extension (although the scripts are often located in CGI directories).

In addition to the server-side programming technologies listed above, there are many other technologies available. Table 2 includes a more extensive, but not inclusive, list of technologies.

4. TECHNOLOGY SELECTION CRITERIA

The decision of which technology, or technologies, to employ in an e-business curriculum is influenced by many factors, including:
- market share
- labor market demand for skills
- effectiveness at conveying the concepts being covered in the e-business curriculum
- complexity and difficulty of learning the technologies
- fit with other technologies used in the curriculum
- Instructors' teaching philosophy
- student background and career aspirations
- availability of integrated development environments (IDEs)
- database tools
- cost of deployment and maintenance
- availability of books and on-line help
- open source verses commercial

Each of these factors is discussed in the following sections. The relative weight of each factor is influenced by the goals of the e-curriculum, the time and resources available for teaching e-commerce and the background and goals of the students and instructors.

4.1 Market Share
The popularity of a web technology reflects the independent decisions of thousands of developers. Their decisions are likely to be influenced by many of the same factors that make the technologies desirable to teaching e-business. These factors include reliability, security, ease-of-use,

maintenance, acquisition cost, maintenance requirements, efficiency, features, and the quality of the support available from books and on-line help.

Market share is difficult to estimate for web programming technologies. Many of them are free Internet downloads, and since they run on the server, it is not always possible to tell by looking at a web page which technology generated it.

Two recent surveys have counted the number of servers using specific technologies. The first was by Port80 Software in August 2006 (Port80 Software, 2006). It surveyed the technologies used by the public web sites of Fortune 1000 corporations. The survey found that Microsoft technologies (ASP and ASP.NET) were the most popular at 48.4% market share, followed by Java Platforms (J2EE, JSP, WebLogic, WebSphere, Tomcat) at 12.7%, PHP at 5.4%, ColdFusion at 3.1%, Perl at 2.2%, and Python at 0.1%. The remaining 28.1% of servers are not configured to support any server-side programming technologies.

A second survey, by Netcraft.com (2004), counted the number of IP addresses using Macromedia's ColdFusion, Microsoft's ASP.NET, Sun's JSP, and IBM's Lotus Notes. The market share between these products was 38%, 27%, 26%, and 9%, respectively. The report noted that ASP.NET showed very strong growth, with a 224% increase in usage during the prior year. Netcraft.com does not, unfortunately, specify how the IP addresses were selected or why the survey excluded popular technologies such as ASP and PHP.

One limitation of counting web servers is that many servers are used for "parking" domain names and other uses that can give a distorted view of market share. ServerWatch.com estimates that 90 percent of all web sites are orphans with little content and no links from other sites (ServerWatch, 2005). Clearly, such sites should not receive the same weight as servers that host large web sites. Therefore the author does not consider the NetCraft survey data to be very reliable.

4.2 Labor Market Demand for Skills

College graduates entering the labor market with proficiency in high-demand server-side programming technologies may enjoy significant advantages in the labor market. Market demand for technology skills is influenced by the popularity of the technology among employers and the technology's growth rate. Skills in new technologies with high growth rates are likely to be in greater demand than skills in mature technologies for which there may be a surplus of programming talent.

Two recent surveys examined demand for technical skills. The first is conducted monthly by TIOBE Software (TIOBE 2006). The "TIOBE Programming Community Index" utilizes hit counts from the Google, MSN and Yahoo search engines for the search term "xxx programming" where "xxx" is a particular programming language. Unfortunately the TIOBE survey includes only programming languages and not server-side programming technologies such as ASP.NET or PHP.

A second technology skill survey counted the job postings for various technical skills on Monster.com and HotJobs.com (Liu et al. 2003). The survey only included one server-side technology in their survey, ASP, for which it reported high demand. Unfortunately this result does not help us determine the relative popularity of server-side programming technologies.

Given the lack of published information on the relative popularity of server-side programming technologies, the author conducted a survey similar to that of Liu et al. focusing specifically on server-side programming skills. The survey was conducted on three large employment web sites, Monster.com, CareerBuilder.com, and Dice.com. Monster and CareerBuilder list all types of jobs while Dice specializes in technical jobs. The survey was conducted on June 24, 2006 and the results are shown in Figure 2. The searches were restricted to the Seattle metropolitan area due to the limitation that Monster.com reports a maximum of 1,000 listings for each search. Given that there may be regional differences in job demand for particular server-side technologies it is recommended that instructors conduct searches for the geographical areas where many of their graduates seek employment.

It is interesting to note that the Port80 survey of usage by Fortune 1000 companies ranks the technologies in the same order as the job survey shown in Figure 2. Both rank the technologies in the order:

1. ASP/ASP.NET
2. JSP
3. PHP
4. ColdFusion
5 CGI (Perl/Python)

This result may be due to the fact that Fortune 1000 companies are also large employers.

One interesting result is the high demand for ASP.NET skills (Figure 2). This may be due to the high growth rate for this technology, as noted by Netcraft.com and two other recent articles (Savvas, 2004; Zeichick, 2004). At the other extreme is the low demand for Classic ASP skills despite the large number of ASP pages deployed. It may be that organizations are switching from Classic ASP to ASP.NET and have a surplus of programming talent in the older technology.

4.3. Effectiveness at Conveying E-Commerce Concepts Covered in the Curriculum

A major reason for teaching server-side programming in an e-commerce curriculum is to improve student comprehension of e-commerce concepts. E-commerce is a broad topic and different academic programs may emphasize specific topics such as security, usability, database integration, object-oriented programming concepts, modeling, program architecture and marketing. The specific focus of an academic program may influence the selection of a server-side programming language. For instance, if the primary focus is on interface design, it may be preferable to use a relatively easy to learn technology such as PHP or Coldfusion. Conversely, if the focus is on program architecture or object-oriented programming concepts, a fully object oriented technology such as ASP.NET or JSP would be more appropriate.
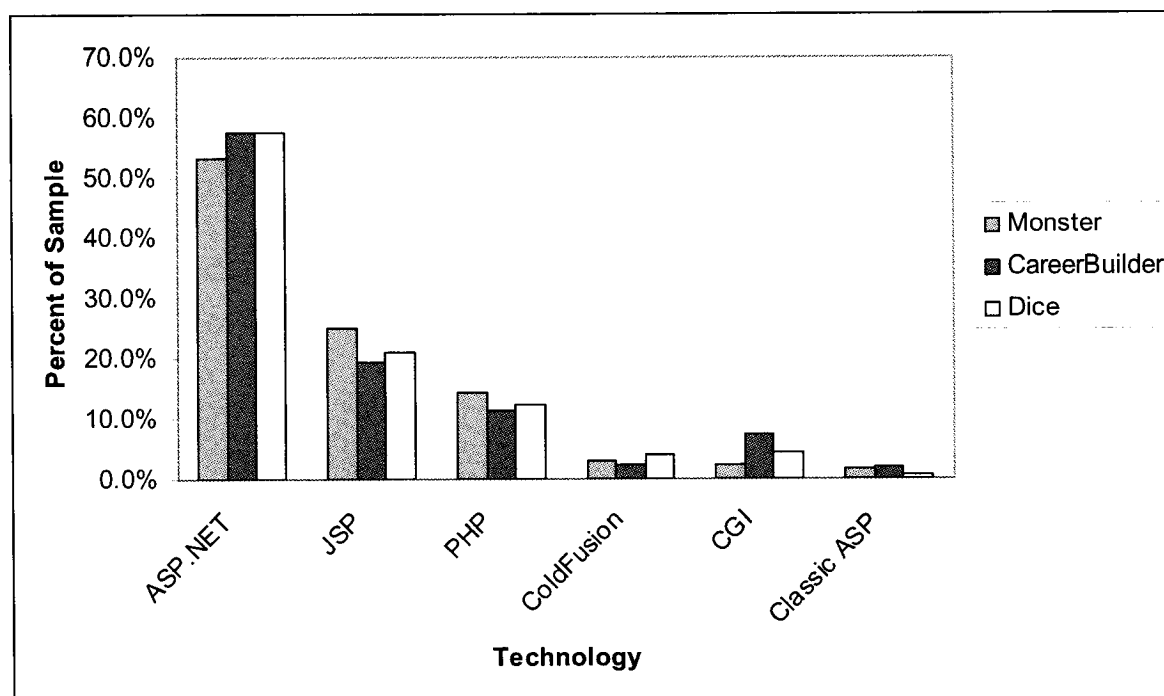
The total number of jobs returned was 485 on Monster.com, 161 on CareerBuilder.com and 300 on Dice. All searches were restricted to a single metropolitan area (Seattle) since unrestricted searches exceed Monster.com's maximum of 1000 jobs per search.

Figure 2. Positions listed on Monster.com, CareerBuilder.com and Dice.com

4.4. Complexity and Difficulty of Learning the Technologies

Technologies that are feature-rich tend to be more complex and difficult to learn. For instance, ASP and PHP are relatively easy to learn but do not provide rich support for web services, error trapping, security tools, multi-tier architecture, and other advanced topics. In contrast, ASP.NET and J2EE implementations such as WebSphere, WebLogic, and JBoss are considerably more complex to learn but provide full support for almost every advanced programming topic. Given that most e-business curricula are severely time-constrained, instructors must often make a tradeoff between teaching e-business concepts verses teaching the programming tools that are used to implement the tools. If the course goals are to illustrate simple concepts such as retrieving data from a web form and writing it to a database, a less complex technology may be the best choice. However, if the course covers more advanced e-business topics, a more full-featured and complex programming technology may be needed.

4.5. Fit with Other Technologies Used in the Curriculum

E-commerce programs are frequently offered within a broader curriculum, such as an undergraduate computer science degree, a management information systems degree or a specialty a track within an MBA program. The background of the students and the technologies covered elsewhere in the curriculum are likely to influence the selection of server-side programming technologies. For instance, if the students have learned Java programming as a prerequisite to the e-commerce course(s) it may be preferable to leverage this knowledge and use JSP in the e-commerce curriculum.

Conversely, if students have had little programming experience it may be preferable to use a less complex technology such asp PHP.

4.6. Instructors' Teaching Philosophy

The teaching philosophy of the instructors or program is also a factor. Some instructors prefer a more technical approach that emphasizes advanced programming concepts such as object-oriented programming, n-tier program architecture, inheritance, generics and code reusability. Other instructors prefer to focus more on e-commerce concepts less on programming skills. Instructors with a "programming focus" will likely prefer to use an object-oriented programming technology while instructors with an "application" focus are likely to prefer a scripting language.

4.7 Student Background and Career Aspirations

The background and career aspirations of the students are also an important consideration in the selection of server-side programming technologies. Students with a strong technical background are less likely to be intimidated by complex technologies. They are also more likely to pursue careers where knowledge of these technologies is likely to be advantageous. Students who are less technically-oriented may be better served with less-complex technologies that allow them to learn e-commerce concepts without incurring the overhead of learning complex programming technologies.

4.8. Availability of Integrated Development Environments

Integrated development environments (IDEs) can reduce the

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time it takes to write programs by providing features such as drag-and-drop coding, WYSIWYG (what you see is what you get) editing, automatic code completion and debugging tools. IDEs can reduce the learning curve for writing code by providing assistance with syntax and other tedious programming details. Proficiency with IDEs can also be advantageous to students looking for employment.

The downside of IDEs from a teaching perspective is that they can automate so many programming tasks that students may not understand the code they produce. For instance, Visual Studio provides a WYSIWYG editor that allows database connection objects and server controls to be dragged from the toolbox onto the work surface and it provides wizards to guide the process of configuring them. The resulting code works properly, but the high amount of automation provided by Visual Studio the many steps handled internally by the controls hides much of the underlying code. While such approaches are appropriate in a production environment, in a teaching environment they can hide important implementation details. Some instructors may prefer a less automated programming approach. Another option is to allow students to use an IDE but prohibit the use of high-level objects that can be configured using wizards.

IDE's are available for most, if not all, programming technologies. Macromedia's popular Dreamweaver MX support both PHP and ASP.NET. Microsoft offers the free "Visual Web Developer" IDE, which is a simplified version of Visual Studio, while Java programmers may use the free and open-source Eclipise IDE. A complete overview of IDEs is beyond the scope of this paper, but many product reviews are available on-line. A recent survey by Evans data found that Visual Studio is the most popular IDE, followed by Adobe/Macromedia Studio 8 (i.e. Dreamweaver) and Eclipse (Kerner 2006).

4.9. Database Tools
Relational database design and SQL (structured query language) are essential topics in an e-commerce curriculum. The differences in core functionality between different relational database products are fairly minor, but there are significant differences between database interfaces.

Most popular programming languages and databases are compliant with ODBC (open database connectivity) standards and can communicate with each other. There are, however, advantages to using specific language-database combinations. One significant advantage is that many programming technologies include native support (through specialized class libraries) for particular databases. Native language support typically provides improved performance and extra features that are non-ODBC. Examples of common language-database pairs are PHP-mySQL, PHP-Oracle, .NET-SQL Server, and .NET-Oracle.

Another second advantage of using popular language-database combinations is the availability of books and on-line documentation. For instance, Most PHP books use mySQL, while most ASP.NET books use SQL Server or Access.

Most databases applications run on the server. Students require an interface to access the database. This can be either a desktop application (such as SQLyog, SQL-Server's Enterprise Manager, Visual Studio or Eclipse) or a web interface (such as phpMyAdmin). Regardless of the access method, each student must be provided with an account on the database and granted specific database permissions.

Microsoft Access is a significant exception. It is essentially a user interface for creating database files and queries. Access uses the built-in database functionality of the Windows operating system (i.e. Microsoft's Jet Database Engine) to execute queries. Programming technologies running on the server can also use Window's built-in database functionality, eliminating the need to install a database application on the server. This eliminates the need to create and administer student database accounts on the server.

Access can also be used as a desktop interface to access non-Microsoft database applications, thanks to the flexibility of ODBC drivers. For example, Access can be used to provide a rich interface to mySQL, including the ability to write SQL queries using Access's drag-and-drop query builder.

Before selecting a database product, instructors should work with the available interfaces and decide with will work best within the context of their curriculum, students and computer facilities. The selection of a database product will have a major influence on the "bundle" of server-side technologies used in the curriculum.

4.10. Cost of Deployment and Maintenance
Most open-source products are free and many commercial vendors offer substantial educational discounts on their products. Consequently, the costs of IT support personnel are likely exceed those of software licenses and hardware. IT support costs can be minimized by using server technologies that are compatible with the skill-set of the existing IT support staff. Given the limited resources of many educational institutions, support costs could be a significant factor into the technology selection decision.

It is a good practice to use dedicated "teaching" servers for student server accounts. Student code frequently contains infinite loops and other problems that can affect the performance of the server. Student-written code can also create substantial security risks for other users on the server.

4.11 Availability of Books and Online Help
Selecting a well written and appropriate textbook is likely the most important single decision that an instructor makes in designing a course. This is particularly true in technical courses where some students may need to be exposed to the material several times to learn how the pieces fit together. Fortunately there are many excellent books available for popular server-side programming technologies. The author has found that the trade books available from publishers such as O'Reilly, SAMS, and Wrox are often better and less expensive than the textbooks available from traditional college publishers. However, many trade books are written for experienced IT professionals so the instructor must be careful to select one that is appropriate to students who may be less experienced. Before making a final decision on server-side technologies it is prudent to examine the textbooks available. Popular technologies will afford a wide selection, but the options may be quite limited for new or obscure technologies (i.e. Lasso or SMX).

On-line help is also extremely important for teaching programming. There are dozens of web sites that provide tutorials and discussion forums for popular programming and database technologies. Students find these web sites extremely helpful for looking up syntax, debugging, finding code snippets and learning material that is not covered in their textbook. Again, popular technologies will have more on-line help than less-popular technologies.

4.12 Open Source verses Commercial

Some students, faculty and IT support personnel have an almost religious-fanaticism regarding the relative superiority of open-source products verses commercial software products. These opinions can be so strong that the vice-president of marketing for MySQL, Zack Urlocker, stated at a forum on open source software, "We're not a religion, we're not a cult, we're not a charity. We're a business," (Krill, 2004). His need to clarify the role of open-source software is indicative of the passion many people have on this issue.

The author's opinion is that students' best interests should take priority over the instructors' personal ideology. The selection criteria described earlier in this paper are the factors that should be considered.

5. MAKING THE TECHNOLOGY SELECTION DECISION

There are no simple formulas that can be applied to the technology-selection decision. Each e-business program needs to evaluate these factors within the context of its curriculum, faculty, technical resources, students, and labor market. In some situations there may be a single factor that trumps all others, while in many cases the instructors will have to weigh all the factors and select a technology that best satisfies as many criteria as possible.

Not only is the decision difficult, but it must be reevaluated frequently. Web technologies and their application to e-business problems are evolving rapidly. While curricula cannot chase every technology fad, Internet technologies are still relatively immature and are continuing to evolve in fundamental ways. As an indication of how rapidly web technologies are evolving, only eight months elapsed between the coining of the term AJAX (Asynchronous JavaScript and XML) and Microsoft's inclusion of the technology as a major new feature of ASP.NET 2.0 (Mangalindan and Buckman, 2005). This rapid technology evolution is likely to continue for many years, requiring that e-business curricula be frequently revised to stay current with e-business technologies and practices.

This paper has discussed many factors that need to be considered when selecting a server-side technology. Given all the factors involved and the tradeoffs, how does an instructor put it all together to make a decision? The next section illustrates the decision-making process for selecting server-side programming technologies at the author's institution, Western Washington University.

6. SELECTION OF SERVER-SIDE TECHNOLOGIES AT WWU

E-business at Western Washington University is part of series of six web development courses that cover web technologies ranging from basic HTML to advanced security, programming and architecture concepts. The e-business curriculum is open to all WWU students, although most are pursuing bachelors degrees in either business or computer science. Three of the courses are taught by computer science faculty and three are taught by business faculty. In 2006 the first four courses focus on learning specific technologies (HTML, CSS, DHTML, JavaScript, server-side programming, databases), tools (Dreamweaver, Visual Studio, Photoshop) and concepts (e-commerce, usability, security, program architecture, debugging, object-oriented programming). The fifth course covers a variety of technical and e-commerce concepts such as e-marketing, security, SSL, web services, search engine optimization, server configuration, user tracking, advanced database concepts). The sixth course is a practicum or internship where the students work either individually or in teams to build a e-commerce site for a company or organization. The first four courses all include laboratories and weekly programming assignments. The third and fourth courses include significant projects where individual students build e-commerce sites complete with product catalog, shopping cart and checkout process.

When the e-business curriculum at WWU was originally conceived in the late 1990's, web technologies were relatively simple and WWU's e-business curriculum emphasized "softer" skills such as project management, e-business concepts, and teamwork. However, web technologies evolved quickly and by the year 2001 e-commerce web sites were increasingly utilizing server-side programming to generate dynamic, database-driven pages. It was apparent that the curriculum needed to be redesigned to include more server-side programming and database skills. This motivated a comprehensive review of server-side technologies. The choices quickly narrowed down to two very popular and easy-to-use scripting technologies, PHP and ASP.

We selected ASP after carefully weighing the factors discussed earlier in this paper. Major considerations that influenced this decision were: high demand by local employers for ASP skills, relative ease of use, ability to convey e-commerce concepts covered in the course, the availability of a Windows server, available of excellent textbooks, and extensive on-line help. Another important factor was ASP's compatibility with Microsoft's Access database, which was already installed in all University computer labs. Access's user-friendly graphical interface and its integration with ASP made it a good product for teaching database concepts. Disadvantages that we recognized with using ASP were that it runs only on Windows servers and it made our curriculum almost 100% Microsoft-based.

The inclusion of server-side programming into the curriculum created the opportunity to introduce several new concepts and tools. We added database creation and normalization, SQL, regular expressions, data validation, and security concepts to the curriculum. Each of our e-commerce

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courses include substantial projects (usually on-line storefronts) that help the students understand how the technologies and concepts learned in the courses are integrated to create realistic web sites (course syllabi are available on line by Googling the author's name). These changes were very popular with students who could see the high value of learning these skills.

Web technologies continued to quickly evolve and by 2002 we saw a need to incorporate more advanced programming tools into the curriculum such as object-oriented programming, web services, caching, error-trapping, and application configuration. We again evaluated several technologies and narrowed the choices to the recently-released ASP.NET and the more mature J2EE/JSP. After again weighing the factors discussed earlier, we selected ASP.NET. The primary two factors tilting the decision were its ease of use relative to J2EE/JSP and our expectation that many companies that employ our graduates would eventually migrate from ASP to ASP.NET. In 2002 we introduced ASP.NET into our intermediate level course (which follows the introductory ASP course) and removed a client-based project. The change has been very popular with students, particularly those who are more technically inclined.

Since the adoption of ASP.NET in 2002, the e-business curriculum has continued to evolve towards more technical topics, reflecting the increasing sophistication of web development technologies. The e-business curriculum now includes object-oriented programming concepts, security concepts, data validation using check-sums and regular expressions, data structures, stored procedures, XML, web-services, SSL (secure socket layers), CSS (cascading style sheets), DHTML (dynamic HTML), program architecture, server and application configuration, SQL Server, and Visual Studio.

Since introducing ASP.NET to the curriculum in 2002 our students have been learning ASP in the introductory server-side programming course and ASP.NET in the intermediate and advanced courses. Despite the similarity in the names, the two technologies are much different. ASP has proven to be a very effective technology for providing students with a gentle introduction to server-side programming and excellent preparation for learning ASP.NET. Employer demand for ASP skills remained strong in our area until early 2006 when it dropped sharply. The introduction of ASP.NET 2.0 in late 2005 may have convinced companies that Microsoft was committed to the newer technology and that it had reached a level of maturity that it was safe to adopt it in favor of ASP.

The sharp drop in demand for ASP skills and Microsoft's focus on ASP.NET motivated a reevaluation of ASP's inclusion in the curriculum. One option was to replace ASP with ASP.NET in the introductory course and cover more advanced ASP.NET and e-commerce topics in the two advanced courses that follow it. Another second option was to replace ASP with another scripting language in the introductory course. Advantages of the second option are that: a) scripting languages are considerably easier for novice students to understand and apply, and b) students would continue to get exposure to more than one server-side programming technology. It has been the author's experience that exposure to more than one technology dramatically

improves student understanding of fundamental programming and e-commerce concepts.

After careful consideration and discussions with current and former e-commerce students we decided to replace ASP and Access in the introductory course with PHP and MySQL starting in the Fall of 2006. The factors that we considered are summarized in Table 3. As a scripting language, PHP will provide our students with a solid and gentle introduction to server-side programming. As a side benefit, adopting open source products will diversify our Microsoft-heavy curriculum. While this has never been an issue with the faculty, some students have criticized our curriculum for being too Microsoft-centric. The change to PHP and MySQL will require no hardware changes since we will use the Windows-based versions of the products. Our technical support people are experienced with open source products and expect that it will not be difficult to support the new technologies.

Other significant changes made to the curriculum in 2006-2007 academic year were to incorporate the new features introduced in version 2.0 of ASP.NET as well as greater integration of Visual Studio 2005. Both of these products experienced major revisions in the previous academic year. The changes made to Visual Studio, such as a secure, built-in local web server, made it much more practical to use in an academic environment. The curriculum will also be modified to incorporate greater use of the C# programming language, which is quite popular with local employers.

Server-side technologies and e-commerce practice will continue to evolve at a rapid pace. We will continue to reevaluate the technologies used in e-business curriculum and revise the curriculum to reflect current technologies and best-practices. This is a very time-consuming endeavor, but one that is necessary to keep the curriculum responsive to student and employer needs.

7. CONCLUSIONS

The selection of a server-side programming language for use in an e-business curriculum has important implications for many aspects of the curriculum. The article has provided an overview of several popular server-side technologies and discussed the factors that need to be considered in selecting them.

The factors and decision-making process described in this paper have been used successfully at WWU since the e-business curriculum was launched in 2000. The feedback on the curriculum from both graduates and employers has been consistently positive and many of the program's graduates are now working as professional web designers and programmers.

Developing and maintaining an e-commerce curriculum requires an extraordinary amount of faculty effort. In the short span of six years WWU's program has undergone several substantial revisions and there is little sign that the pace of change is decreasing. While time consuming for the faculty, it is also very exciting for both students and faculty to be involved in such a dynamic and interesting area.

Criterion	ASP.NET	PHP
Market share	Low overall market share but high among Fortune 1000 companies which hire many of our graduates.	Very high overall market share but low market share among large companies.
Employer demand for skills	Very high employer demand (see Figure 2)	Low employer demand (see Figure 2). However, quite popular for internships.
Effectiveness of conveying e-commerce concepts	Low - Complexity of learning technology will likely detract from coverage of e-commerce concepts.	Excellent – PHP's ease of use allows more time to be spent on e-commerce concepts
Complexity and difficulty of learning technology	Complex object-oriented technology. May be difficult for novice programmers to grasp.	Easy to learn scripting language. Similar to ASP which worked very well in this course.
Fit with other courses in curriculum	Good – many of our students have used Microsoft's development tools	Good – Diversifies curriculum by including open-source products.
Instructor's teaching philosophy	Instructor is concerned that complexity of ASP.NET will detract from coverage of e-commerce concepts	Less abstract technology provides a gentle introduction to programming
Student background & career aspirations	Poor fit for students with no prior programming experience and for those that do not aspire to be professional programmers.	Good technology for beginning programmers and for students who do not expect to be professional programmers.
Availability of IDE	Excellent – Visual Studio and Visual Web Developer are popular products and are free for educational use.	IDE not needed. Simple syntax allows the use of a basic text editor. Several IDEs are available for students who prefer to use them.
Database tools	Typically used with either Access of SQL Server. Both have easy to use graphical interfaces.	Typically used with MySQL, a powerful database product. Several interfaces are available, including Access.
Cost of deployment and maintenance	Low –Windows-based teaching server is available the department receives free educational software via Microsoft's MSDN Academic Alliance program.	Low – Open source products are free and will be deployed on existing Windows server.
Availability of teaching resources	High – Many good ASP books and web sites are available.	High – Many good PHP books and web sites are available.
Open source vs. proprietary	Employers tend to use commercial products	Some students prefer open-source products

Table 3. Criteria considered in selection of server-side programming technologies for introductory server-side programming course at WWU in 2006

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AUTHOR BIOGRAPHY

J. Christopher Sandvig is an Associate Professor of Management Information Systems at Western Washington University. He teaches web development and e-commerce courses using PHP, mySQL, ASP, ASP.NET, SQL Server and Visual Studio. Dr. Sandvig has published articles on the topics of MIS curriculum design, B2B e-commerce, web site navigation, inventory management, new product development and technology transfer. Current research topics include web navigation design and human-computer interface design.

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