Web-Network Technology Curriculum Development for Computer Science

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Abstract

This paper describes our National Science Foundation (NSF) Advanced Technology Education (ATE) project entitled "Web-Network Technology Curriculum Development for Computer Science", the new Web-Network Technology (Web-Net Tech) Certificate Program being developed as part of the project, distinctive features of the program, innovative teaching/learning strategies being incorporated into the program, and first year accomplishments and results.

The Web-Net Tech Program is being developed by Erie Community College in collaboration with the University at Buffalo, guided and supported by education-industry partners. This NSF project (Jeanette Neal, PI; Peter Scott, Co-PI) is designed to assist industry to meet its needs for a well-trained Information Technology (IT) workforce and prepare students for professional careers in IT, focusing on the high-demand area of web-network technology. We define web-network technology to be the design, deployment and administration of network-based computing content and resources. The primary target population for the new Web-Net Tech Program includes industry personnel in need of IT skills training or upgrading, students in academia, and persons desiring to join the IT workforce. In addition, this project will provide professional development and collaboration opportunities for college/university faculty, industry representatives, and high school teachers to enhance their own IT knowledge and skills. Outreach to high school students and other industrial organizations will further serve to inform and attract new students and faculty into IT programs and training opportunities.

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1 Introduction and Project Overview

The Web-Net Tech Program is being developed by Erie Community College in collaboration with the University at Buffalo, guided and supported by education-industry partners. This NSF project is designed to assist industry meet its needs for a well-trained information technology (IT) workforce and prepare students for professional careers in IT, focusing on the high-demand area of web-network technology. The primary target population for the new Web-Net Tech Program includes industry personnel in need of IT skills training or upgrading, students in academia, and persons desiring to join the IT workforce. In addition, this project will provide professional development and collaboration opportunities for college/university faculty, industry representatives, and high school teachers to enhance their own IT knowledge and skills.

Outreach to high school students and other industrial organizations will further serve to inform and attract new students and faculty into IT programs and training opportunities.

Distinctive features of our project and approach include:

- Development of the new Web-Net Tech Certificate Program and courses to provide innovative training in state-of-the-art web-network technology, covering the complete end-to-end spectrum of web-network development and programming, from multimedia user clients to back-end information servers for intranets, internets, and extranets. Program coverage will include network fundamentals, client-server architectures, interactive dynamic multimedia, human-computer interfaces/presentations, and development tools and languages. The courses comprising the Certificate Program are described in Section 3.
- Industry-academia collaboration via our Web-Net Tech Advisory Council, National Visiting Committee, External Evaluator team, and special derivative activities.
- Infusion of workplace realism into the program courses regarding industry practices, procedures, tools, issues, environments, and tasks. The infusion is being accomplished through the use of real world industry examples, case studies, collaborative projects, virtual environments, and guest lecturers, among others. This topic is discussed further in Section 4.
- The Web-Net Tech web site consisting of four major parts: Information Center, Course Materials Hosting, Virtual Workplace Laboratory, and Technology Showcase. This web site is being designed and developed to support the program, permit a "hands on" software development experience, provide students with a showcase for their efforts, and promote the program to potential students and partners. The web site is discussed further in Section 4.5.
- Development of two Train-the-Trainer workshops in the next two years of the project. These workshops will target secondary and postsecondary academic instructors as well as industrial instructors. The first Train-the-Trainer workshop will focus on current real workplace issues, applications, case studies, and projects and how to integrate them into educational courses. The second Train-the-Trainer workshop will train instructors from diverse disciplines to modify the Web-Net Tech materials and web site capabilities to produce modules, applications, and facilities to enhance the courses that they teach.

2 Goals and Objectives

This section describes the major national and regional problems that motivated and shaped the design for this project.

1. There is a shortfall of skilled personnel to fill the large and growing demand for computer scientists and programmers that have skills in web and network development. According to the "Occupational Employment Projections to 2010" of the U.S. Bureau of Labor Statistics published in November 2001 [7], employment in professional and related occupations is projected to grow faster and add more workers (7 million) than any other major group. Furthermore, the report says "Computer and mathematical occupations are projected to add the most jobs, 2 million, and grow the fastest among the eight professional and related occupations subgroups… The demand for computer-related occupations will continue to increase as a result of the rapid advances in computer technology and the continuing demand for new computer

applications, including those for the Internet and intranets." It should be noted that these optimistic predictions well post-date and have been adjusted for the changed market conditions following the technology sector economic contractions of mid-2000 to mid-2001.

Additionally, the Occupational Outlook Quarterly of the U.S. Bureau of Labor Statistics for Winter 2001-2002 states that of the projected 20 fastest growing occupations, 9 are computer related, including the 7 fastest growing ones. Fast-growing computer industries and the increasing importance of computers and computer networks in nearly every industry will sustain the rapid growth in these occupations through 2010 [30].

Although the marketplace has changed, including the demise of many dot.com companies and the inability of many successful high-tech companies to continue their short-term growth rates, the demand for IT workers in the New Economy remains strong according to an April 2001 report of the Information Technology Association of America (ITAA) [13]. This is because the vast majority of IT employment is outside of the IT industry. The report states that "Despite the experience of individual companies, the U.S. requirement for a steady supply of new IT workers continues. While the current economic slowdown has diminished demand, such demand for new talent persists. Indeed, this new study by the Information Technology Association of America (ITAA) finds a national IT workforce of 10.4 million. Add to this total an additional 900,000 workers that companies say they hope to hire this year. Of this total, 425,000 positions will go unfilled because of a lack of applicants with the requisite technical and non-technical skills."

The enormous growth of the Internet, the World Wide Web (WWW), and company intranets has created a high demand for personnel with skills in web-network technology. This demand will continue as internets and intranets continue to grow. Among the most "in demand" IT personnel are those with web-related training (13 percent of all IT positions) [10] and those with the skills to support wide area networks (WANs) and local area networks (LANs), develop competitively capable web sites, and develop and support network applications [12]. Joyce Plotkin, Executive Director of the Massachusetts Software Council, was quoted as saying that the Internet is the most important factor in the increased need for software professionals [12].

2. Aggressive efforts and large sums from national, state, and private sources are being invested to grow the IT [22, 23, 24] and Bioinformatics [25, 26, 27] industries in Western NY. The ability of these endeavors to attract and develop a critical mass of well-trained personnel has been identified as a potential limiting factor in the success of these critical initiatives [22, 27].

3. The continuing development of new innovative technology and applications makes technical skills ephemeral, frequently outmoded in five to seven years [11], and requires continual training and skills upgrading of the IT workforce [12, 28]. Education must also be provided both in the foundational theory and problem solving areas that will enable workers to adapt to a rapidly changing work environment. Certificate programs, with their shortened durations relative to degree programs, are ideally suited to deliver this education and reintroduce the student to the workplace while her skills are still critically needed. While there is a proliferation of proprietary certification programs in the networks and web programming areas, these tend to be vendor-specific, covering one product line only. Students seeking to insulate themselves from the branding fickleness of the marketplace are thus often forced to choose between overly-specific vendor certification and overly-long degree programs.

4. Unfortunately, a common complaint about four-year schools is that they are disconnected from the real world [11] and, as a result, students lack exposure to real workplace issues, practices, problems, and applications in college and university IT programs.

3 Curriculum Overview

The Web-Net Tech Certificate Program consists of five required courses and an optional internship. The courses are:

CS 211 Computer Networks and Internetworks: A study of how computer networks and internets operate, from the lowest level of data transmission and wiring to the highest level of application software communication over the network infrastructure. Topics will include exploration of networks and their management in the web environment, the OSI model, data and packet transmission, topologies, hardware, client-server systems, internetworks, simulation and management tools, e-commerce, and security. Prerequisite: C or C++ programming knowledge, or CS121 Computer Science I, or permission of the instructor.

CS 215 Web Development and Programming: This course is the first course of a two-semester sequence covering the development of web-based software for intranets and internets. The two course sequence will cover end-to-end development, including both the client-side and server-side development. Topics include design of a web site and web pages, Hypertext Markup Language (HTML), style sheets, scripting languages, dynamic web pages, database connectivity, web servers, basic server side programming, and the Extensible Markup Language (XML). Modern development tools will be used. Prerequisite: CS 121 Computer Science I, or working knowledge of a programming language including methods/functions/procedures, parameter passing, and arrays.

CS 216 Advanced Web Development and Programming: This course is the second course of a two-semester sequence covering the end-to-end development of web-based software for intranets and internets. This course emphasizes server-side development of enterprise applications. Topics include web servers, distributed network-based computing, handling client requests, server-side services, transmitting data using HTTP, database connectivity, security, and e-commerce. Programming languages and tools will be among the most significant such as Java, servlets, JavaServer Pages, Active Server Pages, .NET, XML, among others. Prerequisite: CS 215.

CS 209 Programming in Java: A study of the Java programming language for students who already have programmed in another language. Major topics include syntax, applets and applications, object-oriented programming, control structures, graphical user interfaces (GUIs), graphics, files and streams, exception handling, web-based client programs. Prerequisite: CS 121 Computer Science I or permission of instructor.

CS 220 Advanced Programming in Java: This course is a continuation of CS 209 Programming in Java. Topics include advanced topics in object-oriented programming, advanced graphical user interfaces (GUIs), multithreaded programs, networking, database connectivity, structured data types, reusable integrable components, among others. Prerequisite: CS 209 or permission of instructor.

CS 290 Computer Science Internship. This course is intended to provide the student with real world experience in the area of Computer Science. The student will be assigned a project that will entail hands-on experience in the software development process, including problem definition, requirements specification, design, implementation, testing and debugging, and documentation. The student will typically be working with an external organization, such as a local company, to address real world problems. Prerequisite: Two Computer Science courses such as CS 121 Computer Science I and CS 132 Computer Science II or higher, or by permission of the department. Note: This course is optional.

4 Teaching/Learning Strategies

The primary teaching/learning strategies being employed in the certificate program are the infusion of workplace realism into the courses, "hands on" experience for participants, team projects, and the development of real products that will become part of an established not-for-profit public service web site with high visibility.

4.1 Workplace Realism, Examples and Case Studies

The motivation for infusing workplace realism into the courses is to shape learning towards practical preparation for the IT professions that the students have chosen and to increase students' learning motivation by enabling them to see more easily the value and application of what they are learning [14]. This approach has similarity to the contextual learning approaches being applied in programs such as the School-to-Work Programs sponsored by the School-to-Work Opportunities Act of 1994 [9].

The infusion of workplace realism is comprised of several components. An important aspect of workplace realism is to expose students to the principles, projects, tools, and concerns of industry. This includes insight into representative projects performed in industry, how they are conducted and managed, the tools used, and concerns such as security, ethics, and privacy.

Another aspect of the infusion of workplace realism is the use of examples and case studies from industry to provide concrete instantiations of the topics covered in class. The software solutions represented by the examples and case studies are examined for strengths, weaknesses, logical next steps, open issues, and lessons learned. Examples or case studies may be presented by industry personnel who were an integral part of the example project development. The suite of realistic workplace projects will be updated each year to track changes in the environment.

The infusion of workplace realism into our courses is supported by the industry members of the program Advisory Council. These industry representatives are an important resource for the program, providing information, guidance, guest lectures, and collaboration. Core program faculty are working with industry representatives in designing projects and virtual workplaces.

4.2 Collaboration

Reports from industry [12, 11] and research in higher education [1, 2, 19, 31] have shown the need and benefits of collaborative learning. Participation by students in collaborative team projects with industry is also another component of workplace realism in our Web-Net Tech Program. Collaboration is being accomplished through class projects and through internships. A

major innovative collaborative project that is part of the Web-Net Tech Program is the development of the History/Architecture of Western New York (HAWN) web site, discussed below.

4.3 Hands-On Exercises and Projects

Since the importance of active student participation in creative learning activities is well recognized [3, 4, 8, 17], the Web-Net Tech courses include "hands-on" student projects. Hands-on experience is an integral part of all the Web-Net Tech courses through lab session exercises and assigned projects. Lab session exercises consist of students performing short structured lab exercises that explore topics covered in the lecture sessions. The lab exercises are performed in the college computer lab under the guidance of the instructor. Assigned projects entail larger software development efforts that typically include the design, implementation, and testing of software solutions.

4.4 Collaborative Development of the HAWN Web Site with Real-World Value

Finally, perhaps the most interesting of the teaching/learning strategies currently being used in the Web-Net Tech Program is the collaborative development of products with real world value. The product being developed during this Spring 2002 semester is a web site on the History/Architecture of Western New York (HAWN). The HAWN web site will become part of an established not-for-profit public service web site with high visibility. The idea is to develop a site with sub-sites for historical/architectural attractions that do not have web sites and cannot afford web sites. Candidate attractions for inclusion in the HAWN site include the Guaranty Building, built in 1895 by Dankmar Adler and Louis Sullivan, which pioneered the use of the all steel frame making it one of the world's first "skyscrapers", grain elevators invented in Buffalo by Joseph Dart in 1842, St. Paul's Cathedral constructed in 1849 by English architect Richard Upjohn, and the site of the border crossing of Underground Railroad, among others. The HAWN site will include links to the already established web sites of other more major historical attractions.

Development of the HAWN site is being performed as a project of the Web-Net Tech program with collaborative support from a local company that is an Internet service provider (ISP) and web development company. The finished HAWN web site will be showcased by this local company as a feature of Online Buffalo. The site will be a public service to the people of WNY and will help promote tourism in the region.

The majority of the HAWN development is being performed by students in the Web Development course, Spring 2002. The overall process for developing the site has been broken down into a sequence of smaller well-defined student projects for this course, planned so as to culminate in a finished web site. Students in the course are working in small teams, each focused on developing a subsite for a different particular historical attraction. The sequence of projects includes, for example, outlining the subsite using storyboards, defining how visitors will interact with the site, defining the information that is to be included or available on every page and the media used to present the information, incremental implementation of a prototype of the site, periodic testing with different browsers and platforms, obtaining periodic review feedback from experienced professionals and targeted users, and refinement of the prototype based on the periodic testing and review feedback until a final version is achieved. The course will culminate in the deployment of the student-developed HAWN site on the professional public Online

Buffalo web site. Highlights will also be posted to the Showcase section of the Web-Net Tech web site, along with additional student narrative describing the process by which they developed these materials.

Additional teaching/learning strategies used in this course include the use of a goal-driven approach. The students have been provided with exemplars of elegant well-designed sites as the type of end product to achieve. Another strategy used in the course is to not expect the students to develop the entire web site from scratch. Instead, for example, the faculty developed the main entry "splash" page for the HAWN site (with links to the students' subsites) and provided examples of candidate components that could be adapted and used in the subsites (e.g., nested tables for organizing layout, dynamic components such as buttons and navigation bars). The faculty also provided "skeletal" or "starter" versions of some components to be completed and used by the students.

4.5 Web-Net Tech Supporting Web Site

The Web-Net Tech Web Site, mentioned in other sections of this paper, will be developed and used as part of the Program to better prepare current industry personnel, non-traditional adult students, as well as traditional students for the high demand areas of web-network technology. The web site is intended to provide online course materials; simulated real workplace situations, projects, and case studies; interactive tutorials; and support for information sharing, communication, and collaborative educational team projects with industry participation [5, 16, 32, 28]. The use of the web site to support education-industry collaborative student projects will become increasingly important as software engineering in industry becomes increasingly a web-based virtual enterprise performed by remotely distributed teams [6]. The web site will also be used to help meet the increasing need for non-traditional educational approaches and learning resources. These needs are becoming more severe because of factors such as the non-traditional adult-age cohort being the fastest growing student segment at the postsecondary level [28].

5 Accomplishments

Accomplishments of the first year of our NSF project include:

- Established the industry-academia project Advisory Council and National Visiting Committee; held periodic meetings and developed a good working relationship with the Advisory Council.
- Identified the External Evaluator for the project and jointly formulated an evaluation plan and schedule
- Developed the definition and description of the Web-Network Technology Certificate Program.
- Developed the syllabi for the four new courses of the six that comprise the Certificate Program.
- Developed course materials for two of the new courses including handouts, lab exercises, and projects for use in the Spring 2002 semester.
- Developed course materials for the infusion of workplace realism into the courses.
- Developed collaborative projects with industry including the HAWN website development project.

- Developed portions of the Web-Net Tech web site, particularly in the Information Center and Course Materials Hosting Center of the web site.
- Performed recruitment tasks, including a hardcopy and electronic mailing in advance of the Spring 2002 semester.
- Initiated the offering of the Web-Net Tech program in the Spring 2002 semester; offered three of the courses in the Spring semester, two of the new courses and the existing Java course.
- Consulted with the grant project External Evaluator on the development of the evaluation plan, instruments, and procedures. Assisted with the application of the evaluation procedures and instruments.

6 Evaluation

Evaluation of the project accomplishments is being conducted using several methods across the three years of the project. This evaluation is consistent with the general principles described in the professional literature [18, 21]. Project evaluation is being performed by a three-member External Evaluator team that had no prior contact or relationship to the Grant Project team members and is from outside of the western New York area.

The evaluation plan targets the main categories of project objectives or activities: (1) industry needs; (2) development of the Web-Net Tech Program and courses; (3) course materials development, including the Web-Net Tech web site; (4) infusion of workplace realism, collaboration, and hands-on experience into the courses, (5) training the trainer, and (6) fostering closer ties between ECC, industry, and other academic institutions.

The evaluation of some of the items on the grant project timeline are being accomplished by determining whether they were done or not. ECC is providing evidence to the External Evaluator that these items were accomplished. Examples of these are the items and activities associated with the Project Advisory Council, the National Visiting Committee, and the Industry Needs Assessment. Similarly, ECC is providing evidence to the External Evaluator that the Web-Net Tech Program and courses have been created and that the college has started to offer the courses.

The External Evaluator will evaluate each of the courses and the course materials based on a review of course objectives; review of course outlines and syllabi; review of course materials, handouts, assignments, etc.; review of web site pages/materials; administering course evaluation student questionnaire forms; course evaluation possibly using student focus groups; reviewing samples of student work such as completed tests, assignments, projects; and course evaluation by instructor via questionnaire form.

The plan for evaluating the grant project and its products will also include Advisory Council focus groups conducted in conjunction with the March meeting.

Although not available at the time of writing of this paper, the evaluation results for the first year of the project will be presented as part of the conference presentation. Lessons learned from this first year of the Web-Net Tech Program will also be included as part of the conference presentation.

7 Conclusion

IT training is in crisis in the United States. It is imperative that new and innovative approaches be developed to enable current workforce personnel to retrain or upgrade their skills to meet the demands of the IT workplace, to prepare non-IT persons to join the IT workforce, and to prepare traditional post-secondary students for jobs in IT. Current shortages, particularly in high-demand areas such as web-network technology, are straining the system, slowing growth and encouraging importation of large numbers of foreign workers. Projections to the year 2010 by the U.S. Bureau of Labor Statistics indicate that the growth in such high-demand areas for trained personnel will exacerbate the problem. One dimension of response to this crisis is the design of community-college-based certificate programs promoting IT skills upgrading, rapid retraining of current non-IT workers, and the timely education of traditional students in high-demand technology areas. The Web-Net Tech program discussed in this paper is in this context. The central role of industry-academia collaboration, infusion of workplace realism throughout, and a dedicated website are key strategies for the success of this program.

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