The Doctor of Professional Studies in Computing:
An Innovative Professional Doctoral Program

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Abstract

This innovative degree program addresses the inflexibility of traditional doctoral programs for working professionals. Unlike traditional doctoral programs that are often narrowly focused, this program emphasizes integrated study among the computing disciplines as well as applied research in one or more of them. The Doctor of Professional Studies in Computing (D.P.S.), while advanced in content and rigorous in demands, can be distinguished from the Doctor of Philosophy (Ph.D.) in that its focus is the advancement of the practice of computing through applied research and development. The Doctor of Professional Studies is a professional doctorate that integrates academic and professional cultures. The program enables computing and information technology professionals to earn a doctorate in three years through part-time study while continuing in their professional career. The program uses a team approach to both teaching and learning, and combines monthly face-to-face weekend meetings with asynchronous distance learning via the Internet.

Keywords: professional doctorate, computing, part-time doctoral study, asynchronous learning

1. INTRODUCTION

In the fall of 1999, the School of Computer Science and Information Systems (CSIS) of Pace University initiated an innovative doctoral program that enables computing and information technology professionals to earn a Doctor of Professional Studies in Computing in 3 years through part-time study. The project was announced in 1995 (Merritt, 1995), planned and then proposed in 1997 (Merritt, 1997), and approved in 1999 (Merritt, 1999) . It was presented at Snowbird in 2000, (Merritt, 2000).

The Doctor of Professional Studies in Computing (D.P.S.) is an innovative post-master's doctoral program that is structured to meet the needs of the practicing IT professional (Pace University 2001). Unlike traditional doctoral programs that are often narrowly focused, this program emphasizes integrated study between the computing disciplines as well as applied research in one or more of them. It is an intensive, part-time doctoral program designed for completion in three to four years. The program uses a team approach to both teaching and learning, and combines monthly face-to-face weekend meetings with asynchronous distance learning via the Internet.

Several other universities offer doctoral programs that permit part-time study. For example, Robert Morris College in Pittsburgh, PA offers a Doctor of Science in Information Systems and Communications that is a three-year program (Caputo, 2000; Robert Morris College, 2001). New Jersey Institute of Technology offers a Collaborative Doctorate for mid-career professionals who want to pursue a doctorate while continuing full-time employment (New Jersey Institute of Technology, 2001). The Graduate School of

Computer and Information Sciences at Nova Southeastern University has a doctoral program that combines on-campus/online formats that enable professionals to pursue doctoral degrees without career interruption (Nova University, 2001). However, none of these programs addresses the issues of professional doctoral education in computing as comprehensively as the Pace program does.

This innovative degree program addresses the inflexibility of traditional doctoral programs for working professionals. The Doctor of Professional Studies in Computing, while advanced in content and rigorous in its demands, can be distinguished from the Doctor of Philosophy (Ph.D.) in that its focus is the advancement of the practice of computing through applied research and development. The Doctor of Professional Studies is a professional doctorate that integrates academic and professional cultures.

2. THE CHALLENGE

As we at Pace University's School of Computer Science and Information Systems were planning how to add doctoral education in computing to our graduate degree offerings, one thing was clear from the beginning: we wanted to provide a program that was innovative and responsive to what we believed were the heretofore unsatisfied needs of a substantial group of computing professionals. The vast majority of our master's degree students pursue their graduate studies on a part-time basis and many over the years have asked for the opportunity to pursue part-time doctoral study. It seemed obvious that our program should directly serve this cohort, at least. There are virtually no longer any local doctoral programs that permit part-time study, and the few that do permit part-time doctoral study do not distinguish between the full-time and part-time student. The Council of Graduate Schools reports that full-time study is the norm for doctoral study, especially in the sciences (Syverson, 1999). Although the part-time/full-time issue was one of the major concerns, we decided to address the entire doctoral education paradigm as we created the design of our new program.

Time to Completion
The number of years required to complete a U.S. research doctorate varies by subject as well as by the distinction between total elapsed time and the time during which a student was registered. "The Survey of Earned Doctorates" (NSF et al., 1999) provides the data given in Table 1. The median number of registered years for all fields is just over 7 years. This means that, when added to the average of 4-5 years for a bachelor's degree, U.S. citizens who earn an American research doctorate have spent around 11 or more academic years in school as full-time students and researchers. We believe that this is neither necessary nor good for the student, and our doctoral program is, among other things, designed to address and remedy this time-to-degree issue.

Table 1.
Median number of years from baccalaureate to doctorate by broad field for selected years 1974-1999

Field	1974	1979	1984	1989	1994	1999
All Fields						
Total	8.6	9.1	10.0	10.6	10.8	10.4
Registered	6.0	6.2	6.9	7.0	7.2	7.3
Physical Sciences (includes math and computer science)						
Total	6.9	6.9	7.3	7.5	8.5	8.0
Registered	5.7	5.9	6.0	6.2	6.7	6.8
Engineering						
Total	7.7	7.6	8.0	8,2	9.0	8.7
Registered	5.7	5.7	5.9	6.1	6.4	6.6
Life Sciences						
Total	7.3	7.4	8.3	9.2	9.5	9.0
Registered	5.6	5.9	6.3	6.7	7.0	7.0
Social Sciences						
Total	7.9	8.5	9.8	10.5	10.4	9.9
Registered	5.9	6.3	7.1	7.5	7.5	7.5
Humanities						
Total	9.4	10.43	11.6	12.6	12.0	11.7
Registered	6.7	7.6	8.3	8.5	8.5	8.9
Education						
Total	12.5	12.9	14.8	17.3	19.7	19.9
Registered	6.3	6.7	7.7	8.3	8.1	8.2

Professional/Other						
Total	10.0	10.9	12.3	13.3	13.5	14.0
Registered	6.0	6.3	7.2	7.6	7.5	8.0

The Professional Doctorate

The best-known research doctorate title awarded in the United States is the Doctor of Philosophy (Ph.D.). However, there are a number of other doctoral titles that enjoy the same status and represent variants of the Ph.D. within certain fields (U.S. Department of Education).

> …………………………..
> Doctor of Forestry (D.F.)
> Doctor of Geological Science (D.G.S.)
> Doctor of Industrial Technology (D.I.T.)
> Doctor of Music (D.M.)
> Doctor of Public Administration (D.P.A.)
> **Doctor of Professional Studies (D.P.S.)**
> …………………………..

A professional doctorate is aimed at practicing professionals who wish to acquire formal qualifications in recognition of research and research-related activities that they carry out in their work. Technological, economic and societal changes contribute to the changing nature of professional practice. Professionals must be able to keep up with the state of their practice by playing a role in the development, management and evaluation of professional activity; and responding creatively to the challenges of change. This is especially true in the emerging computing and information technologies.

For some professionals, it is appropriate to undertake the study of specific topics in depth, with the intention of contributing new theoretical knowledge and methodological approaches. There are many doctoral programs that offer the opportunity for this kind of study leading to a Ph.D. However, other professionals want to develop a different expertise and contribution. Their concerns focus on being able to

- develop knowledge and expertise in relation to different forms of research and research topics
- learn how to enhance their practice through varied but systematic research inquiry
- appreciate how policy-making and management may be furthered through research activity
- develop the knowledge and skills required to support the research of others
- disseminate research findings, theirs and others, to professional and research audiences

We have designed a professional doctorate with these goals that also fosters explicit links between research and professional practice and development. The D.P.S. in Computing at Pace University provides a framework in which significant applied research is integral to all coursework in the curriculum. Moreover, we treat

All of them have similar content requirements. The following is a subset of the degree titles that the U.S. National Science Foundation (NSF) recognizes as research degrees that are equivalent to the Ph.D. The complete list is in given in the "Report on Postsecondary Education" (U.S. Department of Education).

> …………………………...
> Doctor of Fine Arts (D.F.A.)
> Doctor of Health and Safety (D.H.S.)
> Doctor of Library Science (D.L.S.)
> Doctor of Modern Languages (D.M.L.)
> Doctor of Public Health (D.P.H.)
> Doctor of Science (D.Sc./Sc.D.)
> …………………………...

doctoral education holistically. We serve the total learning needs of the doctoral student.

3. THE STRATEGY AND IMPLEMENTATION

Many of the difficulties that students face in the doctoral education experience affect both full-time and part-time students. However the effect on the part-time student is generally much greater. Full-time students often perceive that they are isolated from their student peers and the faculty, but for part-time students this is usually a reality. Full-time students complain about the amount of work and study time. But for the part-time student who is maintaining a professional career and a family life, finding the necessary time for serious doctoral study can be insurmountable. For a part-time student, the time-to-completion is an even greater issue than it is for the full-time student.

As we considered strategies for overcoming these difficulties, we quickly recognized that many of the things that can interfere with successful study in a full-time doctoral program can be turned into benefits in a properly designed program for the part-time student who is a full-time employed computing and IT professional. The goal was to provide an intellectually stimulating learning environment in which the cutting-edge and emerging computing and information technology can be discussed, debated and researched by all students and faculty.

The D.P.S. program exploits the rich diversity in student backgrounds and professional experience of the doctoral student body. Students in the program have deep expertise in specialized areas of computing and IT as a result of their professional lives. The program utilizes team-teaching/team-learning supported by an intellectually nourishing learning community. Community building begins with the first on-site session

and continues to grow throughout the program. We attribute the program's virtually100% retention to this strong and supportive community of students and faculty. (One student in each of the first two classes withdrew early in the first semester due to excessive professional and personal demands.) The community operates as an open society in which everything is shared, assignments and presentations are published on the web and are available to all. Students and faculty are encouraged to share everything that they do or think about.

In order to maintain this learning environment, the program depends heavily upon the Internet, building upon the experience of the School of Computer Science and Information Systems (Blum and Sachs, 1999; Merritt, 1999) We utilize various software and communication modes to support the necessary student-student and student-faculty interaction. The main courseware for the program is CourseInfo (now Blackboard 5 http://blackboard.com). For information dissemination and general asynchronous discussion we use a number of listservers. For synchronous discussion we use Blackboard chat and Instant Messaging (AOL AIM). One of the most successful modes for asynchronous discussion is the "wiki". A wiki is a completely interactive web site at which any visitor can edit any page. Such a site can be used to broadcast information to students, to permit threaded discussions on line, and to get anonymous feedback from students throughout the course. Wiki (wiki wiki web -- a play on quick web) was invented by Ward Cunningham. The premier site is at http://c2.com/cgi/wiki. This is the world wide virtual meeting place of the patterns community.

The D.P.S. in Computing program admits part-time students who wish to participate in doctoral study while maintaining a professional career. We seek students who can devote frequent and substantial time to doctoral study, who have an independent learning style, and who are self-motivated and self-disciplined. Students are required to have earned a master's degree in computing/information technology, or a master's degree in a closely related field and have very strong technical professional computing experience. Generally our students are required to have 5 or more years of advanced professional information technology experience.

Each fall we admit a class of about 20 students who are expected to graduate as a class after three years. To emphasize that this is a three year program, we identify and refer to a class by its expected graduation date, e.g., the class that entered in fall 1999 is referred to as the "class of 2002". Each class proceeds through the program as a cohort in lock-step fashion. There is an online orientation for new doctoral students before classes begin and an initial on-site 4-day first week (including a weekend) to get things started. Regular on-site sessions occur monthly, five times a semester, on Friday evenings and all day Saturday. In between the on-site sessions, students and faculty interact energetically over the Internet.

Research and the Dissertation

Traditionally, the single most important and difficult component of doctoral study is the dissertation. The long times-to-completion are primarily due to a student not being able to complete the research in a timely manner. Both full-time and part-time doctoral students suffer from the "All But Dissertation (A.B.D.)" syndrome. We have addressed this issue and believe that we have a solution. D.P.S. students focus on research beginning with the first semester of study with the guidance of an advisor and through the research seminar. The primary purpose of the five-semester Research Seminar sequence is to prepare the students for their doctoral research. The seminar sequence begins with a gentle introduction to what research in computing and information technology is about, utilizing examples of different kinds of computing research and methodologies presented by faculty and /or invited researchers. The seminars progress by having students investigate various research areas of their own interest, ultimately culminating with a dissertation proposal draft by the end of the second year of study. An important ancillary benefit is that as the students progress through the seminars, they are exposed to important emerging issues in computing and information technology.

These seminar courses provide the student with an opportunity to get to know and interact with the Pace CSIS faculty. To facilitate the dissertation process, this research seminar helps students develop skills that can be used in the dissertation process, such as information gathering, problem identification, investigation and analysis, effective documentation, planning, and management. In many cases, these research seminars help lay a direct foundation for a dissertation or indirectly stimulate interest in an area that ultimately leads to a dissertation. Thus the program has built-in coaching and mentoring by faculty advisors and most importantly, by the students themselves.

4. STUDENTS

There is a great deal of professional diversity among the D.P.S. students. The organizations that employ our students include Bell Atlantic, IBM, Lucent, Hyperion Solutions, Computer Associates, Met Life, New York Life, Chase, Philips Research, AT&T, AARP, E*Trade, Oracle, U.S. Military Academy (West Point), PriceWaterhouse-Coopers, and AXA. The average professional computing and IT experience is about 18 years and ranges from 6 to 43 years. Students' professional activities include software development, telecommunications management, data management, and e-commerce, and the job titles include CIO, Vice President, and Director of e-business.

Many of our D.P.S. students live and work in the extended New York metropolitan area, but we have students who travel from California, Washington D.C., Philadelphia and Boston. Geographic distribution is a goal, facilitated by the use of the Internet and scheduling strategies.

Women make up 20% of our first two classes. This matches the U.S. average as given in (Caputo, 2000 & NSF et al., 1999). However, our new class of 2004 will have 50% women. The race/ethnic breakdown in our first two classes is shown in Table 2 in comparison to U.S. doctoral student data provided in the "Survey of Earned Doctorates" (NSF et al., 1999)

Table 2
U.S. citizen/permanent resident doctorate recipients by race/ethnicity, 1999

Field for Doctorate	Total	Asian	Black	White	Hispanic
Computer Science	385	74	10	288	13
Information Systems	81	12	8	60	1
Telecommunications	18	4	1	11	2
Computer Engineering	92	31	5	56	0
Management Information Systems	57	6	2	47	2
Total	6333	127	26	462	18
U.S. %		20%	4%	73%	3%
Pace D.P.S. in Computing (combined classes 2002 & 2003)		18%	28%	51%	3%

The dissertation areas in which the students in the class of 2002 are working include: Data Warehousing, Patterns and Pattern Languages, Visualization of Data, Genetic Algorithms, Distributed Systems Architecture, Software Component Integration, Website Personalization and Privacy, Buyer and Seller Recommender Systems, Software Testing and Quality Assurance, Data Security, Web Content Management Strategies, Web Services for Businesses, and Broadband Wireless Network Access Services.

5. CURRICULUM STRUCTURE

The D.P.S. in Computing is a 48-credit program, which assumes the prior completion of a master's degree in computing or a closely related discipline. Research commences in the first year when students begin an 18-credit integrative core, and continues through the 12-credit advanced elective sequence in the second year. A 12-credit dissertation completes the program.

The **first year** (fall, spring and summer) integrated core curriculum is designed to provide an understanding of computing as a coherent discipline and the environments in which computer-based systems operate. In the **second year** (fall and spring), students pursue elective study in selected areas that support the projected dissertation research. Students devote the **third year** to completing their research and writing the dissertation.

Students participate in a Research Seminar sequence during each of the five semesters of the first two years of study (including summer between the first and second years). These seminar courses introduce the student to the various methods and styles of computing research. Students will identify new computing research problems and formulate research proposals in preparation for their dissertation research. These courses provide the student with an opportunity to get to know and interact with the CSIS faculty.

Course Descriptions
First Year of Study
Software Design and Implementation DCS 801, 802, 803   2 credits each
These courses address the environment in which software systems are built and used. Critical and emerging issues in computer science and their relationship to software development and design provide the major theme. These courses are project based, and students develop a substantial project working in small teams. The project is coordinated with the DCS821, 822, 823 courses. The project development explores cutting edge object-oriented software development methodologies such as extreme programming (XP), open source and mob software, and is implemented in Java. Pattern-oriented software architecture as an approach to software development is explored.
Topics include:
Object-oriented development and Java; design patterns; Unified Modeling Language (UML); GUI programming; computer ethics and social values; human computer interaction; software standards; distributed systems; client server computing; Internet programming; emerging software methodologies.

Systems Development–Analysis, Design, and Engineering DCS 821, 822, 823 2 credits each
These courses are project based. Students develop a substantial project working in small teams coordinated with the DCS801, 802 and 803 courses. The project development explores cutting-edge software systems development methodologies. Contact is practice-oriented software engineering and information systems, and is representative of the real-world environment with which practicing computer professionals interact -- tool-rich working environments, team development efforts, cost performance trade-offs in business contexts, and expenditure of considerable effort on tasks other than source-code development.
Topics include:
Problem solving paradigms; the software engineering problems of scale, cost, schedule, quality and consistency; software development process; organizational patterns; analysis patterns, design patterns and generic models; object-oriented architectures; object-oriented analysis & design; software process – processes, projects, process improvement; software process assessment – capability maturity model (CMM), ISO 9001; software quality assurance; project management; risk management; user-interface design issues; GUI design; software maintenance; software reuse.

Data Communications, Networking, and Internet DCS 833, 834, 835 2 credits each
This course sequence progresses from the basics of data, signals and information transmission to principles of computer networking and the operation of current and evolving Internet protocols and applications. Material provides a foundation for planning and management of network facilities and design and implementation of Internet-based applications. The first course establishes a foundation in data communications as a major component of current and evolving telecommunications systems and the Internet. Students see Internet-related examples. The second course builds upon the first, examining in detail the issues and techniques for computer networking emphasizing LANs, internetworking via TCP/IP, and the Internet. The ISO Reference Model and the TCP/IP protocols form the framework for introducing Internet facilities, services and applications. In the third course, students examine current and emerging Internet services, protocols and applications. Students investigate and report new network technologies and applications in small team projects. Concepts related to Internet-based applications and the Web are applied in the core-curriculum software development project.
Topics include:
Models of communications and layered architectures; analysis of data, signals and transmission capacity; digital voice and video; link protocols and error control; multiplexing and statistical sharing of network resources; probability models of network traffic; LAN strategies and standards such as shared and switched Ethernet, FDDI and ATM; LAN internetworking using

bridges and routers; routing strategies and congestion in networks; the IP protocol; transport layer strategies and the TCP and UDP protocols; HTTP and the WEB; Domain Name System, FTP, and SNMP; security and e-commerce; multicasting, multimedia, quality of service (QOS) protocols; Internet telephony (VOIP).

Research Seminar DCS 891A, B, C, D, E[*] 1 credit each (* 2 credits)
Students are introduced to the methods and styles of computing research through presentations by faculty and industry professionals and by studying selected research documents. Students see a variety of methods and styles of computing research. Students learn to identify new computing research problems and to formulate research proposals in preparation for dissertation research.

Second Year of Study
Topics in Computing and Information Technology DCS 860, 861 2 or 3 credits each (6 per semester)
These courses consist of topics of current interest to students. Cutting edge issues and emerging information technology areas are explored. Students register for two or three topics per semester. The topics for these courses are in large part selected by the students. A major goal for these courses is to understand the technological life cycle, the various emerging information technologies covered, their issues and potential impact. The program calls on the computing community of the nation for visiting experts who discuss their current research and development activities.
Topics include:
Small computing devices – communicating with computers in human modalities, pen computing and handwriting recognition, speech recognition techniques and applications; data security – cryptography, intrusion detection, corporate vital defense strategy; Internet performance and high-volume web serving technologies; data mining and data warehousing; e-commerce issues; pervasive computing and m-commerce, XML, VoiceXML, WML and WAP, human computer interaction, and natural language processing; emerging telecommunication technologies; distributed components and middleware; user interface development environments and tools;
artificial intelligence, and virtual reality.

Third Year of Study
Dissertation for Doctor of Professional Studies in Computing DCS 990, 991 6 credits each
The dissertation is an original, rigorous, independent applied research product that may advance knowledge, improve professional practice, and/or contribute to the understanding of computing. Research methods used depend upon the nature of the research: controlled experiment, project development, empirical studies, theoretical analyses, or other methods as appropriate. The dissertation must be of sufficient strength to be able to distill from it a paper worthy of publication in a

refereed journal or conference proceeding, or to use it as the basis of a monograph. Although publication is not a requirement for completing the doctoral degree, students are required to prepare a paper to submit for publication.

6. PROGRAM ASSESSMENT

The traditional doctorate presumes full-time study, emphasizes specialization, aims to create theoreticians, and almost always engenders feelings of personal antipathy. Our program strives to be dramatically different. It is designed for the working professional, emphasizes study across the disciplines of computing, aims to cultivate applied expertise, and is committed to both responsiveness to students and timely student graduations. Furthermore, it is more interactive than traditional programs and relies upon online courseware and the Internet.

Because the program is at the educational frontier, assessment is critical. Objective data needs to be collected to verify the program's efficacy. Novel ideas that are working need to be recognized and cultivated. Shortcomings need to be pinpointed and addressed before too much learning time is lost or students experience angst.

Three substantial assessments are performed at the end of each semester: (i) individual course evaluations, (ii) an extensive survey with both closed-ended and open-ended questions about overall program experiences, and (iii) an in-depth questionnaire for teaching faculty. In addition, special activities and events such as the summer workshop on Java, an evening of semi-formal and informal interaction between the students and the entire CSIS faculty aimed at building dissertation committees, and retreats where students receive help with their dissertation research formulations are promptly followed by assessments.

The assessment results have been strongly favorable, which is consistent with our virtually one hundred percent student retention rate. The ultimate program assessment will come between June and December of 2002 as we see whether or not students are completing their dissertations within the intended timeframe and whether their work is met with external commendation.

7. CONCLUSIONS

During the course of this doctoral program, we have found that the students:
- expand their knowledge base across applied computer science, information systems, software engineering, telecommunications and emerging information technologies
- develop solid, working relationships with other students from a wide range of computer-related backgrounds

- integrate the academic and professional aspects of computing
- apply what they learn to their professional environment and to their aspirations for the future

We are finding that all of these accomplishments enhance their marketability as highly skilled and experienced IT professionals, and, upon completion of this journey, we anticipate that our students will emerge as leaders in the IT fields.

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