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The Doctor of Professional Studies in Computing:
An Innovative Professional Doctoral Program
was presented at ISECON 2001 in Cincinnati, Ohio

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A Research Doctorate for Computing Professionals – A Ten Year Experience

Fred Grossman, Charles Tappert, Joe Bergin, Susan M. Merritt

The Doctor of Professional Studies (DPS) in Computing at Pace University provides computing and information technology (IT) professionals a unique opportunity to pursue a doctoral degree while continuing to work full time. It supports interdisciplinary study among computing areas and applied research in one or more of them, and thereby provides a background highly valued by industry. It is an innovative post-master’s doctoral program structured to meet the needs of the practicing computing professional. The DPS in Computing, while advanced in content and rigorous in its demands, is distinguished from the Doctor of Philosophy (PhD) by focusing upon the advancement of the practice of computing through applied research and development. It is designed specifically for people who want to do research in an industrial setting.

The DPS program provides an intellectually stimulating learning environment in which emerging computing and information technology can be discussed and researched in an open forum. Students and faculty are encouraged to share their experiences and ideas with everyone in the program.

While a PhD advances knowledge in the discipline of study and a professional doctorate advances the practice, in computing there can be a fuzzy distinction between the two concepts. Successful professional doctoral students will demonstrate that they have effected the practice as well as effected deeper and broader understanding of the practice through research. Our students regularly have the opportunity to put their learning into practice. This is particularly true because they hold senior positions and are able to effect change in their organizations. There is value added by practicing computing and studying at the same time.

The DPS in Computing admitted the first class of twenty students in the fall of 1999. To qualify for admission, students complete a master’s degree and have a minimum of five years’ professional experience in computing and information technology, although typically our students have 10 to 20 years of experience. Each class brings professional expertise in specialized areas of computing to the learning community. The class proceeds through the program as a cohort, and is expected to graduate together after three years.

The program is unique in its design and methodology. The motivation for the program, its structure, and early experiences were described in a paper written as the program was ending its second year, when the initial class had completed its coursework and was embarking upon the dissertation.[13] Another paper, focusing on assessment, written at the end of the fifth year[14] looked at how the dissertations compared to doctoral dissertations from traditional programs, considering the significance of the problems studied, the investigative methodology, readability and the dissertation completion rate.

The DPS in Computing is now in its eleventh year. Through the class of 2008 (the cohort who matriculated in 2005), 52% of the 118 students who entered the program, have graduated. The average time in the program for the 62 graduates is three years and two months between matriculation and the successful dissertation defense. The shortest completion time is two years and six months, and the longest, five years and ten months. According to the fifth-year assessment, the quality of the dissertations is on a par with those from traditional PhD programs.[14]

What kind of doctorate to offer?
It is useful to make the distinction between a professional doctorate in computing and a research doctorate for computing professionals. The professional doctorate is often perceived as different from and not a substitute for a research doctorate, most often, the PhD. There has been increasing interest in professional doctoral programs[6, 15] But reports cited indicate that there is confusion about what is desirable in a professional doctorate. Should there be a research dissertation requirement as in the PhD, or should there be a significant contribution to practice requiring some demonstrated practical action that produces change or development in a community of practice or in an organization? We set our doctoral program apart from both the professional doctorates and from the academic research doctorate (PhD). It is neither one nor the other, but a synergistic integration of the two.

We had to choose what the degree designation would be -- PhD, DPS, or some new designation, e.g., Doctor of Computing. The last choice was ruled out because the New York State Education Department does not recognize such a designation. Pace University pioneered the professional research doctorate when it introduced the Doctor of Professional Studies (DPS) in Business in the early 1970s. In 1999 we launched the DPS in Computing, a doctoral program that integrates computing and professional cultures. The DPS has been considered by the National Science Foundation “to be a research doctorate equivalent to the PhD.”[16, 17]
The profession of computing

At the time the DPS in computing was in development in 1998, the notion of computing as a profession was garnering interest. Peter Denning published his essay about the nature of the emerging “Profession of Computing” and its relation to the computing disciplines -- computer science, software engineering, software architecture, and other IT areas of specialization.[8] In addition to a shared body of knowledge and skills, a profession has a responsibility to the community – its effect on the community is for the good – and a professional must understand how the profession and the external community affect each other.[1,12] Peter Denning proposed an answer: “Who Are We?”[9]

The computing professionals who comprise our applicant pool are the set of people who work with computing technologies. But what are these computing technologies? We need to understand what we mean when we call the degree Computing. What should be in the curriculum? What are appropriate areas for dissertation research? What backgrounds do we look for when admitting students?

The academic view of computing is that it is primarily composed of the disciplines of Computer Science (CS), Information Systems (IS), and Software Engineering (SE), and further specialized by the research topics, approaches and methods found in each of these disciplines.[10, 11] Another perspective is that it is defined by industry computing needs and functionality. We embrace both views of computing as we characterize our program curriculum, philosophy and dissertation research areas.

In our domain, computing involves the interaction among computer-based methodologies with other disciplines so that we can:
- explore the many uses of computers;
- elicit meaningful problems/applications that can benefit from computer-based solutions;
- suggest unsolved computing research questions;
- study how people interact with computer-based applications and the effects;
- pursue research challenges coming from applications and other disciplines.

Addressing the research challenges from non-computing domains can involve computing research applied to those domains or applied to one of the computing disciplines. An important aspect of computing research is that it is interdisciplinary and may depend upon the synergy of more than one discipline, i.e., where neither computing nor another discipline alone can create new knowledge. Because of their professional backgrounds, our students tend to think about research in an interdisciplinary manner. This stimulates their ability to bring to light new problems that neither discipline alone would recognize, and that can often lead to fundamentally new ways of thinking about problems. This might include the implementation of known computing solutions to applications in new ways, or the development of new tools and techniques and theories to solve new problems or to solve known problems in better ways. The contribution might be to computing or to the practice in an application domain or both. Much of the research that our students do has immediate effect because they are working in and with other disciplines.

Our students

Our students have been educated in and are professionally involved in an extremely diverse set of computing areas and applications. The DPS in computing attracts and thrives on a professionally diverse student body. Entering students’ careers extend from 5 to 33 years, with an average among students of thirteen years. Professional activities include software development, project management, telecommunications and network design, education and training, IT management, data management, and Internet engineering with employers such as Verizon, IBM, MetLife, Dannon, USA, JPMorgan Chase, AT&T, E*Trade, Brookhaven National Labs, Oracle, Museum of Natural History, Pfizer, and Sothebys. Their job titles include CIO, CTO, vice president, director, consultant, senior technical staff, project manager, software architect, data administrator, professor. Many of our DPS students live and work in the greater New York metropolitan area, but others travel from Massachusetts, California, Illinois, Pennsylvania, Washington, DC, and Canada.

Our faculty

Unlike traditional doctoral programs with a focused area of interest, e.g., computer science, information systems, or data communications and networking, our doctoral faculty need to have broad multidisciplinary interests and experience in order to support and facilitate the spectrum of dissertation research topics. This works for us at Pace University because we have an extremely diverse and eclectic faculty. We are also fortunate to be able to reach out to external professionals and researchers to complement our own faculty as needed, typically from the students’ employer contacts and faculty colleagues.

Faculty time commitment may tend to be greater than what is normally expected in traditional doctoral programs; this is because our faculty act as research and learning facilitators in addition to being instructors and dissertation advisors. They are part of the teaching-learning community of support and actively interact with all the students, not just advisees. All members of the community – students and faculty – are proactive in supporting and encouraging the dissertation progress of every student in the class. This is particularly apparent in the doctoral symposium-like third-year class meetings.

The program

Each September, a new class of 15 to 20 students matriculates, and classes move through the program as a cohort. 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.

A special strength of the program is the specialized technical knowledge and expertise embodied in the students’ professional computing and IT experience. A learning-teaching community is created at the very beginning which draws upon this expertise and strengthens the collaborative skills of the students.

Every indicator confirms that a high level of cohesion grows quickly and persists. In fact, this strong community may be
credited for the retention of students some of whom feel overwhelmed by the pressures of school and work.

We do not require additional computing and workspace resources because our students have their own laptops and except for the time they are onsite (once a month) they work in their own space.

**Curriculum content and delivery**

Because students come with different computing and professional backgrounds and experience, we do not assume specific prerequisite knowledge in the same way that we might, for example, in a CS degree. We do not use a compartmentalized course structure that is traditional in graduate education. We have some courses that fit that structure, but these, too, have an “open” component, i.e., team projects where teams select the specific area of study with faculty approval and guidance to enhance the total learning experience of the class.

The challenge is what to choose for the curriculum. We cannot assume common prerequisites in a class with diverse computing backgrounds – CS, IS, software engineering, telecommunication and networking, MIS, various business or social science areas. The program is about computing.

We chose a program in “computing” as different from CS, or IS, or any other specific computer related discipline for a doctorate serving computing professionals. A specifically focused program is not as relevant to seasoned computing professionals who already understand that computing is an integrated (synergistic) discipline. Students come from various and widely diverse application areas – health, education, business, engineering, data management. They appreciate how the ideas, principles and practices that they learn can be used among many applications, sometimes in the same way and sometimes in different ways.

One chief educational objective is that practicing information technology professionals will encounter and develop insights into recent developments within the fields contributing to applied computing; and they do so, in an educational and research setting. One goal is that students will be able to apply some of what they are learning immediately on their job. Sometimes the utility is concrete; other times it is more abstract, for example, in the way they think about a problem. The other chief objective is that each student will become able to undertake the creation of new knowledge and to report research results to academic and professional audiences. Rather than lecture, we more often use Socratic challenges. Students read, write and discuss while faculty (and eventually the students) challenge assumptions and conclusions. Throughout we posit that the process is more important than the product, at least in the educational arena.

We start close to the frontier of computing knowledge and practice and look back to understand how we got there, as opposed to starting at the beginning and trying to get to the frontier. Because of the diversity in academic and professional experience, every student’s distance to the frontier is different, and we depend on the teaching-learning community to provide some normalization. For example, one of the software development areas that we have been studying and experimenting with is dispersed and distributed agile methodology. A student working at a major corporate research facility has been exploring these emerging software development methodologies and practices, and was able to share some experiences with the DPS community.

**First year of study**

For the first year, we chose three major areas of study that every computing professional should know in professional and academic experience -- software, computer communication and networking, and the Internet.

It is in the software curriculum area that we are the most adventurous and unique, including such topics as modern software development methodologies, patterns, cyber ethics, retrospectives. There is a strong focus on agility, with an emphasis on first being agile, and then doing agile. The students read the seminal authors, e.g., Beck, Cockburn, Highsmith, Coplien, Cohn, Poppendieck, and meet some who are invited to spend a weekend with the class. There is an agile software development project in which the students work in dispersed (virtual) agile teams. We view agility in a broad sense, based on a set of fundamental principles, not limited to software development. Of all the areas studied, the focus on agility has had the greatest impact on dissertation research as well as on effecting change in work environments. Agility, perhaps above all, characterizes our program.

A second area in which we are innovative is the study of patterns. Our students study and use software design patterns in the agile project. They also study organizational patterns and pedagogical patterns. Our students have been able to make changes in their professional work by using organizational patterns and patterns for introducing change.

A pattern provides a structurally simple way of describing an expert solution to a recurring problem. It captures an “essence” of a context, problem and solution. Patterns can provide a better means of understanding and communicating. Software and Organizational patterns have become an important driving force in the industry, transforming both software production and the organizations that produce it. Learning how to mine and write patterns helps the student to recognize and document the essence of their research.

In our program, students are encouraged to think and write holistically. We introduce them to “object think”, not to become object oriented programmers, but to change the way they think about things and the way things interoperate. Thinking in terms of patterns, and in terms of objects, have commonalities. Jim Coplien said it this way[4]:

"I like to relate the definition of patterns to dress patterns. I could tell you how to make a dress by specifying the route of a scissors through a piece of cloth in terms of angles and lengths of cut. Or, I could give you a pattern. Reading the specification, you would have no idea what was being built or if you had built the right thing when you were finished. The pattern foreshadows the product: it is the
rule for making the thing, but it is also, in many respects, the thing itself.

A pattern involves a general description of a recurring solution to a recurring problem replete with goals and constraints. But a pattern does more than identify a solution, it explains why the solution is needed. [3]

A “retrospective” is typically not included in a computing degree program. While a project retrospective is an important component of modern software development, we utilize the practice more generally. It has proven to be an area that many of our students have successfully introduced into their professional work. A retrospective helps facilitate process improvement and enables team learning. Since our program is heavily dependent on team and community, we hold periodic retrospectives of the program itself with the students.

Other software related topics studied in the first year include open source, ethics and technology, privacy-security, and the impact of tools on software development.

Second year of study
During the second year, we explore cutting edge issues in emerging information technology. The following are examples of what we have studied. Depending upon the interest and importance to the DPS community at the time, some of these topics constitute an entire semester course, and others are modules in Topics in Emerging Information Technology courses.

- Small computing devices – pen computing, handwriting and speech recognition
- Data security and information assurance
- Artificial intelligence and genetic algorithms
- Pattern recognition – visual patterns, speech, biometrics
- Internet performance and high-volume Web serving technologies
- Data mining, data warehousing and data modeling
- Pervasive computing
- Distributed components, middleware, Web services
- Patterns – software, organizational

Research seminar sequence
The purpose of the Research Seminars is to prepare the students for doctoral research. The seminars are what enable completion of the degree in 3 years. The seminar sequence begins in the first year of study with an introduction to what research in computing is about, utilizing examples of different kinds of computing research and methodologies and presented by faculty and invited researchers. In the progression of seminars students investigate research areas; the goal is a dissertation proposal draft by the end of the six-semester seminar sequence.

By the end of seminar 3 (summer of year 1) students select a research area and have a draft of an idea paper. This is a working document that grows to include the research approach and plan, and eventually to the final dissertation. We recommend that students choose an area of research in which they have prior knowledge and expertise. This is possible because all DPS students are mature computing professionals with a minimum of five years of experience in industry. Most students of traditional doctoral programs matriculate directly from the BS or MS degree and must get “up to speed” in an area; our approach can save several years of effort.

In seminars 4 and 5 (fall and spring of year 2) we use the Socratic method, asking questions and challenging what is said. Initially this is managed by the faculty, but the students learn to question and challenge, and quickly become Socratic. They are exposed to new ideas and ways of thinking. They learn abstraction, and see patterns and models of inquiry and discovery that they can apply to their own ideas. Students connect with an advisor in the spring of the second year. The DPS student owns the research and is immune from committee or advisor changes.

The dissertation process
Unlike many other programs, Pace DPS students focus on research beginning in the first semester of study under the guidance of faculty advisors. As they progress through the program seminars, readings, and discussions, they are exposed to emerging issues in computing and information technology. In most cases, the research seminars lay a foundation for a dissertation or indirectly stimulate interest in an area that leads to a dissertation. The program has built-in coaching and mentoring by faculty advisors and, most importantly, by the students themselves.

The DPS dissertation is a rigorous, original, independent applied research product that may advance knowledge, improve professional practice, contribute to the understanding of computing. It is a disciplined and systematic inquiry for the purpose of discovery, establishing or extending the field of study. The dissertation must be of sufficient strength that the student is able to distill from it a paper worthy of publication in a refereed journal or conference proceeding.


Students are encouraged to choose research in areas closely linked to their professional experience. Unlike most students in traditional full time doctoral programs our students are formed in the profession and use their experience and knowledge as a platform for their research. Also, because of their senior positions in the work environment, they are able to manage and control studies and empirical research that would otherwise be difficult or impossible. This is an important strength of the DPS in computing.

The dissertation seminars in the third year are run very much like doctoral symposia at the major computing conferences, except that there are six of them throughout year 3 (the dissertation year). They provide fora for doctoral students to present their research and get detailed feedback and advice. All
the students and faculty advisors are present so that the advice spectrum is broad. The main objectives are:

- to allow students to practice early writing and effective presentation of their research progress;
- to provide a supportive setting for constructive feedback about students' current research and guidance toward future research directions;
- to offer fresh perspectives on students' work from faculty and students outside the research area;
- to promote the development of a supportive community of scholars and a spirit of collaborative research.

The student will give a presentation of 15-20 minutes followed by 15-20 minutes of questions and feedback. The experience is meant to mimic a "mini-" defense. Aside from the actual feedback, this helps the student gain familiarity with the style and mechanics of such a presentation. We use the Socratic method of clarification through confrontational dialogue. This forces the student to think independently and to vigorously defend a position.

**Agile approach to the dissertation process**

Since the agile methodology and the concept of being agile are important topics in the DPS program, it seemed only natural to approach the dissertation process in an agile manner. Typically the dissertation process is "waterfall-like" with heavy upfront planning and little writing. The main deliverable of the dissertation process is the dissertation manuscript. Before we adopted the agile approach, our students, too, looked at the dissertation as a very large task that was overwhelming.

What it means to be agile is defined in the Agile Manifesto for software development. [2] There is a set of important principles behind the agile manifesto. We have adopted some that we found to be the most important for our process:

- Early and continuous delivery of valuable product;
- Welcoming changed requirements, even late in development;
- Delivering working product frequently, from a couple of weeks to a couple of months, with a preference for the shorter timescale;
- Measuring progress primarily through useful deliverables;
- Using agile processes for sustainable development, enabling sponsors, developers, and users to maintain a constant pace indefinitely;
- Valuing simplicity as the art of maximizing the amount of work not done.

We had been using the agile approach in the later stages of the dissertation process with success. We are now starting to use it early in the process beginning with the idea paper and all the way through to the defense. We use some of the eXtreme Programming (XP) - like practices with descriptive terminology adapted for this non-software use:

- Communicating closely between advisor and student;
- Doing the simplest thing that will work with what you know now;
- Short time-boxed iterations of work;
- Continuous integration of accepted new work product;
- Pairing;
- Sustaining pace;
- Refactoring – restructuring and reorganizing.

We suggest a three-week iteration cycle. For each iteration there is a planning session during which the dissertation short-term deliverables ("stories") to be done are discussed and estimated. The stories are written by the student and/or the advisor. Every story has a written deliverable. These may be annotations of readings or parts of the final dissertation manuscript. The stories are simple, focused and small.

Once the stories are estimated by the student, the student and advisor together select which stories to complete in the current iteration. Each iteration has a "velocity," which is a measure of how much work that is completed and accepted can be done. The velocity of the next iteration is set to be the amount of work accepted in the prior iteration. This maintains a sustainable pace that the student is comfortable with and supports continuous delivery of quality product.

There is continuous communication between the student and the advisor; if the student determines that it will not be possible to complete all the stories for the iteration, then together they decide what to drop. Only completed and accepted work is integrated into the dissertation product. If the student finishes the stories before the end of the iteration, more stories are selected based upon their value and the velocity remaining in the iteration. Even though it might appear to be proscribed and overly structured, this process actually promotes creativity and helps many students finish in a shorter time period.

As the dissertation product grows it is re-factored; parts can be discarded or changed and new stories written. The dissertation is usually considered to be done when the advisor and student agree that there is enough value to satisfy the requirement for a dissertation.

**Success stories – student testimonials**

Several students offer testimony to the impact of the DPS on their work practices and functionality:

Three students who work for a multinational computer technology and consulting corporation:

"I chose to look into Agile Software Development methods as my area of research. I'm clearly helping to shape how software is developed across the corporation by taking a leadership role in promoting, using and lecturing about agile methods."

"Throughout the program, I was exposed to the latest software methodologies and technologies, and was able to capitalize on my own experience and the experience of other professionals; and I was able to witness and participate in innovative research... My own dissertation offered my employer the opportunity to witness groundbreaking research in a real world situation and reap the benefits of the experimentation when it proved successful."

"Working within a major technology company, I was constantly encountering topics and situations that revolved
around new and emerging technology. ...I applied the learning from the DPS program immediately. It allowed me to more fully and more quickly understand the evolving technology.I encountered and added tremendous value to that technology by more effectively applying my background in financial services.”

A student who is a senior vice president of a large insurance company:

“...In the program we are surrounded by experts in many computing areas such as programming, engineering, teaching, management and others all united by common interests in conducting top-quality research in the world of computing. ... As a practical matter, I was able to use my research in Agile Development Methods to manage an enterprise-wide project, completing it on time and on budget. This success led to increased responsibilities and more visibility by top executives at my firm.”

A student who is the CIO of a major food manufacturing company:

“...My Doctor of Professional Studies (DPS) in Computing will help me grow my company. How do you prepare for large-scale technological change on a national and global level? My DPS is helping.... I’m using skills I gained from my studies to drive the notions of “Fearless Change,” “Agile,” and “Retrospectives” with my IS/IT department. The Pace DPS program is one of the few doctoral programs for working professionals. It is the one that I needed.”

**Completion and retention rate**

Every doctoral program will have students who have completed all but the dissertation (ABD); some say it is the nature of the beast. [7] What matters is how the program manages the ABD issue. It is ultimately the doctoral student’s responsibility to complete the dissertation. Even after the official matriculation for coursework has ended (in our case after the third year), it is still the responsibility of the program to make every effort to get a student through.

Why do some students drop out? The watch phrase in the DPS program is “life gets in the way.” We cannot help that, but we can provide a support group to help. We schedule sessions to bring the community back together to re-energize. If a student needs to take a leave due to work or personal issues, the community of support and the team structure of the work permit the student to defer study and rejoin a new class. This is why our retention rate is over 90%.

A summary of the program’s completion rate is given in Table 1 and Figure 1. Table 1 gives the completion rate for each of the classes – class of 2002 (the first class that started in 1999) through class of 2008 (with the class of 2009 completing as this is being written). This does not completely reflect the status of the dissertations. We never give up on a student. However we have lost a few, 7 to be exact who we believe will never go beyond ABD. But we have many more who are close to finishing and others who are making regular progress as shown in Table 1.

<table>
<thead>
<tr>
<th>Class</th>
<th>Number Completed</th>
<th>Number Expected to Complete within 6 months</th>
<th>Number Making Progress</th>
<th>Number Permanent ABD</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>15 of 20</td>
<td>2 of 20</td>
<td>1 of 20</td>
<td>2 of 20</td>
</tr>
<tr>
<td>2003</td>
<td>6 of 17</td>
<td>4 of 17</td>
<td>6 of 17</td>
<td>1 of 17</td>
</tr>
<tr>
<td>2004</td>
<td>11 of 16</td>
<td>1 of 16</td>
<td>3 of 16</td>
<td>1 of 16</td>
</tr>
<tr>
<td>2005</td>
<td>11 of 18</td>
<td>0 of 18</td>
<td>5 of 18</td>
<td>2 of 18</td>
</tr>
<tr>
<td>2006</td>
<td>6 of 16</td>
<td>2 of 16</td>
<td>8 of 16</td>
<td>0 of 16</td>
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<td>2007</td>
<td>8 of 16</td>
<td>2 of 16</td>
<td>5 of 16</td>
<td>1 of 16</td>
</tr>
<tr>
<td>2008</td>
<td>5 of 15</td>
<td>3 of 15</td>
<td>7 of 15</td>
<td>0 of 15</td>
</tr>
<tr>
<td>Totals</td>
<td>62 of 118</td>
<td>14 of 118</td>
<td>35 of 118</td>
<td>7 of 118</td>
</tr>
<tr>
<td>Total%</td>
<td>52%</td>
<td>12%</td>
<td>39%</td>
<td>6%</td>
</tr>
</tbody>
</table>

Figure 1 compares our completion rate against the traditional PhD rate recently compiled by the Council of Graduate Schools PhD Completion Project.[5] Traditional doctoral programs often take students fresh from BS degrees, so it is understandable that the completion rate is spread out over a longer time interval than ours. The “DPS + 2 years” curve in Figure 1 shows how it compares with the traditional completions when shifted 2 years to consider the time from BS to MS. While we are doing better than the national average, we are always trying new methods to improve the completion rate and the dissertation quality.

![Percent Dissertation Completion by Year](image)

**Conclusion**

Our approach to doctoral education is non-traditional mainly because we do not serve traditional doctoral students. Providing a superior doctoral experience for a diverse group of senior computing professionals for whom traditional programs are not possible or appropriate presents many challenges. While traditional doctoral study is a process of formation, the DPS in computing enhances and extends professionals who have already formed a professional identity, and empowers them to do greater things in their organizations and their future professional lives. The program exploits the depth and breadth
knowledge and experience that our students have in computing as a result of their professional experience, and takes a crosscutting approach to curriculum, embracing such areas as agile software and non- software processes, networking and the Internet, design and organizational patterns, and security.

We believe that a student cohort is required. We learned early that more important than a cohort is a teaching-learning community. Students contribute their own knowledge and background experience to the learning of others. Faculty members act more as research and learning facilitators than instructors and traditional dissertation advisors. They are part of the teaching-learning community of support, and they actively interact with all the students, not just their advisees. All members of the community — students and faculty — are proactive in supporting and encouraging the dissertation progress of every student in the class. The synergy of diverse multidisciplinary yet deep individual knowledge and experience provides a support structure for timely completion.

We believe that we are creating a new class of scholarly professionals, who, acting as stewards of the computing discipline, are capable of critically evaluating new ideas and transforming and interacting with interdisciplinary professionals. They recognize the importance of representing and communicating ideas effectively, and thus effect immediate knowledge transfer to make significant changes in the way organizations function.

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Abstract

Pace University’s Doctor of Professional Studies in Computing program, a fusion of academic and professional cultures, started as a venture into largely uncharted educational territory. One part of the mission was and remains a one hundred percent student retention rate, with each student successfully defending a dissertation with original research in three years. Yet, throughout, the students retain full-time employment as high-level computing and IT professionals.

Another part of the mission is to provide breadth and currency across the computing disciplines (specifically, computer science, information systems, and telecommunications) as well as depth in annually selected areas of emerging technology. This is in a context in which entering students have masters degrees and generally at least five years of professional experience in diverse computing-related areas and therefore lack a common foundational background.

As a new program at the University and in the country, penetrating assessments have been conducted each semester. This report describes the assessments, the anticipated and unanticipated challenges, and the steps that have made the evolutionary development of this program successful.

1. Introduction

The Doctor of Professional Studies in Computing (D.P.S.) can be distinguished from the Doctor of Philosophy (Ph.D.) in that it focuses on the advancement of the practice of computing through applied research and development, promotes study of the computing disciplines in an integrated manner, and is structured for completion by working IT professionals in three years of continuous, part-time study. 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. Each September, beginning in 1999, a new class of approximately twenty students matriculates. Classes move through the program as a cohort.

The chief educational objective is that practicing information technology professionals will encounter and develop insights into recent developments within the fields contributing to applied computing, in an educational and research setting. One goal is that students will be able to apply some of what they are learning immediately on their job. Sometimes the utility is concrete; other times it is more abstract, for example, in the way they think about problems. The other chief objective is that each student will become able to undertake the creation of new knowledge and the know-how to report research results to academic and professional audiences.

The D.P.S. in Computing admitted its first cohort class of twenty students in the Fall of 1999. Residency consists of five consecutive semesters of coursework: the fall, spring and summer semesters of one year, and the fall and spring of the following year. Thereafter, energies are applied to the dissertation. During residency, on campus classes are held roughly once a month, on a Friday evening and all day Saturday. When students are not on campus a great deal of activity takes place through Internet courseware (Blackboard), email lists, the Wiki Wiki web, instant messaging, and, when needed, telephone conferences.

A special strength of the program is the specialized technical knowledge and expertise in the students’ professional computing and IT experience. A learning-teaching community is created at the very beginning which draws heavily upon this expertise and strengthens the collaborative skills of the students. These abilities and skills are harnessed for collective advantage in three ways:

i. At orientation and onward, it is emphasized that the spirit of the program is one of community and mutual assistance, not competition. Each class moves through the sequence of courses as a cohort that is expected to remain intact.

ii. Every opportunity is used to promote student-student, student-faculty, and faculty-faculty congeniality and students are encouraged to post technical questions on things that came up on the class email lists.

iii. A team-based software development project comprises a substantial part of the class work during the first two semesters.

Every indicator confirms that a very high level of cohesion grows quickly and persists. In fact, this strong sense of community may be credited for the retention of several students who, at different points, felt overwhelmed by the pressures of school and work.
A full discussion of the beginnings of the Pace University DPS in Computing, its curriculum, and mission may be found in [1]. As of this writing, the sixth entering class is beginning its first year, and three classes have completed their third year milestone, when dissertations were to have been defended. The basic student demographics, the curriculum, and the structure of the program have not changed. Yet, there were issues to be addressed as the program moved along and adjustments were made accordingly. This paper describes some of these and the assessment tools and procedures that enabled this to happen.

2. Five Thrusts of Assessment

Assessment involves empirical investigation into the effectiveness of a goal-oriented activity and using the results to enhance procedural efficacy. As a form of social research, an investigation's conduct depends upon how much is understood about what is going on. When an activity's mechanisms are well understood, the operative variables and their relationships are known. This makes possible short-answer questionnaires. In contrast, open-ended techniques are needed for trailblazing into the factors that promote or inhibit the activity's success. Items that elicit prose are used for evoking insightful reflection. Many short-answer and open-ended instruments were created for assessing the DPS. Because the students are stake holders in the program, and are articulate, their best efforts as survey participants could be relied upon.

Course Evaluations
An opinion survey is administered in every course at the end of a semester. This includes the usual complement of queries on the clarity of course objectives, the fairness of work evaluation, and the appropriateness of the workload. Customized items pertain to whether appropriate content was selected for emphasis, whether coverage was at the appropriate depth, and whether students felt adequately prepared. Other customized items pertain to the value of collaborative work and the courseware. With thoughtfulness primed by over twenty short-answer items, students are asked to remark on what they found most valuable about the course and for suggested improvements.

Semester Reflections on the Program as a Whole
The first two years of the program has a mix of courses and objectives that give each semester a distinctive flavor. Object technology and emerging software design and development methodologies (e.g. agile programming) figure prominently in the first semester. Milestones associated with the dissertation become overriding concerns in later semesters. These milestones include drafting an idea paper, performing a review of the literature, devising a method of investigation, and selecting an adviser. A thorough look at the satisfactions and frustrations of studentship along with the program's content, structure, and procedures needs to reach beyond the individual courses. Thus, at the end
of each semester, students receive an open-ended questionnaire on their progress. The faculty members are queried on the same concerns with a questionnaire that takes their perspective.

Special Purpose Questionnaires
Student progress is accelerated by procedures intended to facilitate processes that are slow moving in traditional doctoral programs. The process of locating a dissertation adviser, for instance, is streamlined by a number of mechanisms, including events where faculty members introduce themselves and their research interests. Inventive procedures invariably look promising, but a factual answer is needed to the question of how well do they really work. If a procedure works, it should be replicated. What can be done to improve its effectiveness? Will a follow-up be planned, and, if so, what form will it take? Questions like these are the subject of specially focused assessments.

Examinations of the Dissertation Process
The dissertation process includes all activities during the five semesters of residency that cultivate an understanding of research, lead to the formation of a committee, and establish a plan of action for the third year. It includes all activities during the third year that contribute to progress, such as the three class meetings during the fall semester and the three class meetings during the spring semester at which each student presents a progress report and receives both support and constructive criticism from peers and faculty. The dissertation process also includes the continuous communication offered to students who have missed the three year completion date but continue to work on their research (in some cases, slowly). One of the program's objectives is that there will be no ABD's. We consider a student as to be ABD when she or he is no longer actively working on the dissertation. Efforts are expended to prevent this.

Numerous special assessments have been conducted on the dissertation process. One is on whether students are, in fact, leaving the fifth semester with preparedness to complete. Another addresses the schedule slippage occurring during the summer trailing the end of residency. A series of questionnaires adduced data on the kinds and amounts of interaction taking place between students and dissertation advisers.

Evaluations of Dissertation Quality
Academic quality is a transcending issue. The value of a degree to a student, the value of an education to a sponsoring organization, and the value of a program to a university depend upon it. One might legitimately wonder how credible the dissertations produced by working professionals within three years of entering a doctoral program (albeit a post-masters program) appear to faculty accustomed to Ph.D. theses from traditional programs. To this end, objective reviewers were selected and asked to evaluate the meaningfulness of the problem, the methodological strength of the investigation, and the readability of the presentation.

Findings from assessment investigations are put to three uses: program improvement, "real-time" quality control, and accountability. Program improvements are adaptations that will strengthen the curriculum, its delivery, procedures, and the success of future students. An example is the Java workshop offered as a free option ahead of the first semester. "Real-time" quality control refers to remedies that compensate for faults effecting students within the program; a problem is identified and a correction is installed before the problem results in an immutable diminishment. Accountability pertains to findings that substantiate the program's value. Holding these uses in mind when reviewing a report helps to clarify expository intents that may be murky.

The dissertation is what distinguishes a research doctorate from other graduate degrees. It is the program's capstone and also the greatest challenge for the students [2]. Therefore, findings pertaining to the dissertation process and the quality of dissertations emerging from the D.P.S. are described here in some detail.

The Dissertation Process

For each class up through the class that started last fall (Fall 2003), the retention rate through the five semesters of coursework has been just one or two students shy of 100%. As of September 2004, defenses are emerging from the third entering class (the cohort that started in 2001). Because Pace University's D.P.S. in Computing is unique and new, no baselines exist for pronouncing the dissertation completion rate to be high or low. For the first class, from which graduations began in May 2002, 13 (65%) of the 20 students who originally matriculated have received diplomas; five of the seven who did not graduate report that efforts are continuing.

Although a graduation rate of 65% within five years may be commendable, it is disappointing that 35% of those with the diligence to complete the coursework failed to complete within two years beyond the targeted three-years. To obtain a thorough understanding of the obstacles, and why different ones pose problems to particular students, a sweeping investigation was conducted in May 2004 involving all who graduated, all who did not graduate within four years (we term this aggregate the non-graduates), all those in the midst of their third (or fourth) year, and all dissertation advisers.

Apart from job stress, job loss, or illness; the problem identified as most severe by both the faculty and the non-graduates was leaving for the summer, following the five years of residency, without a clearly defined research topic. This could happen in two ways. There may be an explicit void, of which the student is only too aware; or the student might believe an agreement on the problem and the methodology that exits with the adviser, in fact, does not.
All respondents believe that more needs to be done, earlier, to steer students in the
direction of individually suitable research topics. Sufficient time needs to be available
for false starts and for putting the research on a solid footing before residency elapses.
This was apparent before its objective confirmation by the latest assessment and, already,
an attempt has been made to improve the program. The dissertation "idea paper," a semi-
formal proposal, is now due during the third term of residency (i.e. the summer between
years one and two) instead of during the fourth term.

It had been thought, when the program was under development, that dissertations
would be rooted in students' professional background and practice. When this is the case,
students tend strongly to be successful in completing their research expeditiously.
However, for more than half of the students, this is not the case, and both finding a topic
and bringing the research to a successful conclusion is more difficult. An impediment to
pursuing research matched to one's background may be the disinclination of advisers to
extend themselves as partners, studying and working along with the student. A faculty
member contributed this observation. It was echoed by students who felt that feedback
was slow in coming and of limited utility when the research was in an area that did not
coincide with the adviser's. A step toward improvement may be increasing the number of
faculty members actively engaged in the program to enlarge the domain of faculty
interests. Yet benefits are seen to accrue when students are relatively autonomous, such
as able to change advisers (even quite late in the work) with no ill effects.

Student after student reports on the value of subdividing research and dissertation
work into manageable pieces. One faculty member has adopted a strategy of
"encouraging the student to produce a paper for publication, even if only for an internal
workshop, soon after obtaining preliminary results." This provides a foothold into
describing the problem, the research method, and the findings. It would seem that
encouraging students to establish a sequence of achievable milestones promotes success.

Graduates credit their resolve, above all else, with the successful completion of
their dissertation. Perhaps this is key inasmuch as a non-graduate warns of "getting
cought going back to our regular lives and not being able to spend enough time on the
research." Faculty members similarly warn of the slow drift that can carry students away.
The cohort completing its third year (i.e. the class beginning in September 2001) kept up
its resolve and morale with online chats. Discussion focused on writer's block, progress
reports along with research hints (e.g. "What worked for me...."), and useful URLs.
Staying in touch, the positive tone, and smatterings of humor helped to counter feelings
of being overwhelmed and alone.
Evaluations of Dissertation Quality

A rigorous inquiry on dissertation quality substantiates their caliber. Evaluators with standards normed to programs conferring Ph.D.s rated those dissertations considered best to be as fine as theses seen anywhere. The dissertations representative of the spectrum's bulge in the middle were unquestionably worthy. The dissertations considered weak were likewise branded as weak (although acceptable), substantiating the investigation's validity. On a four-point scale with the highest mark being a 4.0, dissertations rated as follows:

• significance of the problem -- 3.4.
• strength of investigative methodology -- 3.3.
• readability -- 3.5.

The comments rightly note that DPS dissertations carry a decidedly applied orientation. For example, a dissertation on building artificial neural networks for analyzing turbulence in fluid flow through pipes dwelled more on the construction and efficacy of the new technology than on abstract characteristics of dynamic (nonlinear) systems. This is expected and understandable inasmuch as the D.P.S. is oriented toward the concerns of practitioners, which are more likely rooted in application than theory.

By the end of May 2004, the cohort that had begun in Fall 2001 had defended a total of six dissertations with the following titles:

Optimized Software Component Allocation on Clustered Application Servers

Measuring Usability: Categorically Modeling Successful Sites Using Established Metrics

Stego-Marking Packets to Control Information Leakage on TCP/IP Based Network

Solving a Class of Time-Dependent Combinatorial Optimization Problems with Abstraction, Transformation and Simulated Annealing

Solving Optimization Problems Using Genetic Algorithms with Multiple Genome Coding

Architectural Solutions to Agent-Enabling E-Commerce Portals with Pull/Push Abilities

4. Conclusion

A cliché of today might be that assessment is a journey, not a destination. The process is never done. Subsequent to an improvement, a study is needed of its efficacy and unanticipated effects in search of the next improvement. Or, another concern emerges as a priority. The point is that each improvement is provisional (or assumed to be one in a sequence), and no one improvement brings program scrutiny to a close. This is a benefit because no program repair or upgrade needs to be without fault.

A danger of describing a program by way of assessment is that a focus on improvements made and still needed highlights defects more than strengths. By all indicators, Pace University's D.P.S. in Computing at five years of age is a success. That a full class is admitted each year from a growing pool of applicants, confirms that it is meeting a need. That students are graduating, and their dissertations are good, confirms the effectiveness of the processes. A robust sense of community is a source of program strength and a special asset for all involved. Students work proactively with each other, and with faculty, and faculty work with each other, to achieve success for all students. Alumni speak of having formed life-long friendships and have maintained professional relationships with the faculty and the School. They continue to co-author papers with faculty members. They serve on dissertation committees. They teach for Pace as adjuncts. They attend the annual DPS picnic. And they contribute generously to the School's scholarship fund.

5. References


8
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>
<thead>
<tr>
<th>Table 1.</th>
<th>Median number of years from baccalaureate to doctorate by broad field for selected years 1974-1999</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Fields</td>
<td></td>
</tr>
<tr>
<td>Total Registered</td>
<td>8.6</td>
</tr>
<tr>
<td>Physical Sciences (includes math and computer science)</td>
<td></td>
</tr>
<tr>
<td>Total Registered</td>
<td>6.9</td>
</tr>
<tr>
<td>Engineering</td>
<td></td>
</tr>
<tr>
<td>Total Registered</td>
<td>5.7</td>
</tr>
<tr>
<td>Life Sciences</td>
<td></td>
</tr>
<tr>
<td>Total Registered</td>
<td>7.7</td>
</tr>
<tr>
<td>Social Sciences</td>
<td></td>
</tr>
<tr>
<td>Total Registered</td>
<td>7.3</td>
</tr>
<tr>
<td>Humanities</td>
<td></td>
</tr>
<tr>
<td>Total Registered</td>
<td>5.6</td>
</tr>
<tr>
<td>Education</td>
<td></td>
</tr>
<tr>
<td>Total Registered</td>
<td>12.5</td>
</tr>
<tr>
<td>Registered</td>
<td>6.5</td>
</tr>
</tbody>
</table>
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.)

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 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.)

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 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 virtually 100% 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 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

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

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 DCS 801, 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
refueed 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:

- 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.

8. REFERENCES

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