An Agile Approach to Doctoral Research and Dissertations

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Abstract
As with any industry, higher education institutions must remain current in order to attract quality students to their programs. At the undergraduate and masters level, online courses and degrees are becoming increasingly popular, especially for those individuals who are geographically separated from their institution or interest or who work a full-time job and are unable to attend locally. While we have seen growth of these types of programs, doctoral programs have remained relatively traditional. Most doctoral programs are designed for students who have just recently finished a master’s degree and are able to enroll full-time in a residential program. We feel that this focus on recruiting this type of student does prevent individuals with years of professional industry experience from not only earning a doctoral degree, but bringing their talents to the institution. Our research sets out to compare traditional doctoral programs and their respective dissertation processes with the Agile professional studies doctoral program. The research compares and contrasts traditional and Agile dissertation methods as well as discusses core differences between the two program types. It also summarizes enrollment and completion rates from various private, public, and online institutions and ends with a summary and ideas for future work.

1. Introduction
Advances in science, technology, engineering and mathematics have been largely attributed to the international academic industry that provides necessary funding and resources for basic research and development programs which, in turn, contribute to global economic expansion via business and technology innovation. The program structures, along with the research practices and methodologies, employed at participating academic universities is the day-to-day foundation that enables students, practitioners, and scientists to embark upon a field of study of their choosing. Although there are inherent differences, traditionally, all university-led research programs devote a percentage of resources to the attainment of a doctoral-level degree, which affords both student and university with what can be considered leading-edge research. This research thus becomes a vital and continuous source of funding for universities due to the reputation gained of discovering, sharing, and creating real-world solutions, and which can be measured via various metrics such as student enrollment, graduation and retention rates, reputation, endowment, number of patents, and number of university-sponsored entrepreneurial ventures.

Given the breadth, depth, and successes of ongoing doctoral-level research programs, interest has arisen in discovering a better understanding as to which components in these respective research programs are responsible for the tremendous value that continues to be attributed to university-led doctoral research. In this paper, we will examine the historical make-up of non-agile doctoral-level research programs with a focus on U.S. universities that offer degrees in information technology, information systems, computer science and engineering, and computational and computing disciplines such as informatics and information theory.

The common framework and practices in these programs will be discussed and analyzed, and the paper will further compare and contrast these non-agile programs which employ a top-down, approach of directed research from theory to applications, with those programs that adopt an Agile-based approach to research and doctoral-level studies i.e. a bottom-up, practitioner-led research based on experience with real-world solutions and applications.

The study is organized as follows: Section 2 presents the non-agile Doctoral dissertation process used by most universities. Section 3 presents the Agile Doctoral dissertation process used at Pace University. The methodology used in this study by a cohort of 14 Pace University Doctoral candidates is discussed in section 4. Section 5 presents the results of the study: Section 5.1 compares the non-agile and Agile dissertation processes through matrix comparisons of the program characteristics, general dissertation process details, and current examples from public, private, and on-line universities. University statistics for non-agile and Agile doctoral completion are presented in Section 5.2. Section 6 presents the conclusions and proposed future work.
2. Overview of the Non-Agile Approach to the Dissertation Process

2.1. Parts of the Non-Agile Process

The typical research process in a non-agile approach that consists of the following steps:

1. Planning the Study
2. Literature Review
3. Study Implementation and Data Gathering
4. Analysis and Interpretation
5. Reporting

The approach reflects a step-by-step methodology for developing and delivering a dissertation report. Each step can be viewed as dependent or serial set of activities where each one needs to be completed to advance to the next. This is akin to the typical non-agile model present in many software development life cycles (SDLC). In software development, the non-agile model can be defined as a sequential process where progress is tracked from:

1. Conception
2. Initiation
3. Analysis
4. Design
5. Construction
6. Testing
7. Implementation
8. Maintenance

This model was born from the manufacturing industries and may be quite suited for that type of product delivery. However, a particular weakness with the model is that it is not adaptable to change. This becomes problematic, for example, during a relatively long project, or as in the case of a doctoral dissertation, which is usually a 4 - 5 year program, the student dissertation life cycle (SDLC) and development of the dissertation is dynamic and will undergo many changes. The non-agile model’s not being “flexible to change” will increase the completion times and graduation rates for doctoral students. The statistics section of this report (Section 5.2) will show this dramatic difference between both models and demonstrate why a non-agile model is probably not the best approach as a dissertation process model for a doctoral student in a research program.

2.2. Non-Agile Research Cycle

The non-agile doctoral research approach recommends:

1. Begin with the problem
2. Research defines the goals

3. Overview of the Agile Approach to the Dissertation Process

Agile software development is a practice where groups of software development methods that are based on an iterative and incremental approach are used to promote frequently deliver of a quality product. The approach is adaptive to change in requirements and is flexible enough to evolve solutions through a collaborative and self-organizing team(s). The Agile approach is outlined in the Agile Manifesto [1]. The spirit of the Agile process is captured in the quote, “frequent delivery of quality products”.

With that definition in mind we can now examine the Doctor of Professional Studies (DPS) process used by Pace University. This process makes it possible for most DPS students to complete their dissertation within the three-year and ½ year time frame. Although some students complete the process in May/June of their third year, the end of the summer of the third year is the actual three-year marker.

3.1. Agile Methodology Applied to DPS

Doctoral students and faculty in the Pace University DPS program participate in an Agile educational environment. DPS students are established professionals in their respective field, and have experience with identifying root cause problems, and finding innovative solutions. The Pace DPS program applies Agile software development concepts to dissertation “development”, and in many cases application of these concepts allow a large percentage of students to complete their dissertations, to maintain a sustainable pace during dissertation research, and to have a completed dissertation sooner.

The important Agile principles for the Pace dissertation processes include [5]:

- 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.

In the context of the dissertation, the “product” is finished, written pieces added to the dissertation framework, not just ideas and conversations about the topic. “Valuable” product are meaningful pieces of written research, survey data, calculations, etc. which directly contribute to the goals of the research. “Early/Continuous/Frequent delivery” should be a written draft every three to four weeks, to be discussed with the cohort and faculty at the on-site class meetings, starting at the end of the second semester.

Research and dissertation seminars are the vehicle where DPS students “deliver” their thesis product each month, starting after the second semester, and feedback from the seminar discussions help students determine what is “valuable” in their research so far. Starting in the first semester, DPS students participate in research seminars where they learn the depth of commitment and rigor required for doctoral research through monthly seminars from experienced faculty and guest lecturers in new and innovative computing fields. They also study and practice established research techniques, including searching on-line database reference and critical reading of journal articles. This experience sets up the second year research seminars and third year dissertation seminars, where dissertation topics are discussed, debated, refined and affirmed with other students and with faculty.

Sustainable development is a critical contribution of the Agile methodology to writing a DPS dissertation. In contrast to the non-agile dissertation method of filling in a prescribed outline by the end of five or six years, students and advisors communicate often to write “user stories” – short-term deliverables, which are discussed and estimated. Students and advisors then agree which stories can be done in an iteration, based on the Agile concept “do the simplest thing that will work with what you know now”. The stories completed in the first few iterations will establish a “velocity” – a measure of how much work can be completed and accepted per iteration. The practice of assignment of stories per iteration based on estimation and velocity help to define a sustainable pace – what can be finished without excessive overtime. The velocity of a working professional will be different than that of a full-time student, so this estimation is critical for the success of DPS students. Close communication between students and advisors, short, time-boxed iterations, and continuous integration of new work bring the advantages of the Agile process to dissertation writing.

When DPS students apply the Agile concept of “simplicity - maximizing the amount of work not done”, they focus their time and energy on the essential parts of their thesis. To successfully defend a dissertation topic in the research and dissertation seminars and at the dissertation defense, students need to be prepared to explain all research decisions and results. So throughout the research process students remove any non-value added processes from their research methodology, and break down the rest into simple, well-understood tasks, which become stories [9]. Documentation of processes that the student decided not to implement can be included in the dissertation, to set boundaries for the research scope. Applying the concept of simplicity can help the student finish their dissertation sooner, by removing unnecessary work and narrowing the scope of research.

3.2. Team and Cohort Groups

Each DPS class is divided into teams for team projects and other team assignments. Working in teams enhances learning, creating an "active learning process", and is particularly effective when the team members actually need each other to complete a project. It is the norm for employees to work in teams, and teams are used in all kinds of organizations, such as in industry, education, and government.

DPS students’ larger group of classmates (cohort year group) contribute frequently by making helpful suggestions in the research seminar meetings and by helping to find relevant literature and related material. This is an important part of the Agile DPS dissertation process and all students are expected to participate and help their colleagues. The power of the community is strong.

3.3. Research Seminar Sequence

Beginning with Research Seminar 3 we use the Socratic method of clarification through confrontational dialogue. This forces the student to think for him/herself and to vigorously defend their position. Because this method works best when the student is adequately prepared, it is strongly advised that students put substantial effort and thinking into their preparation. We find that the better the student is prepared, the more the student benefits from these interactions. From the Wikipedia the Socratic method is, "... asking a series of questions surrounding a central issue, and answering questions of the others involved. Generally this involves the defense of one point of view against another and is oppositional."
4. Methodology Used in This Study

The DPS 2016 cohort comprising 14 Doctoral students conducted the following study. As described in section 3, team organization, support, and cooperation are essential to an Agile DPS process, and those team dynamics were applied to this study. The cohort operated on the Agile practice of “frequent delivery of quality product” by setting up a framework for the study paper and matrices, which were filled in as drafts of sections were completed. The Agile practice “do what you can with what you know now” was applied to the research process. Teams 1, 2, and 3 in the cohort each made phone calls and emails to universities and searched websites to find programs descriptions and statistics for Computer Science and Information Technology Doctoral programs. Research was focused on answering these questions for public, private, and on-line doctoral programs:

- The number of applicants
- The number of acceptances
- The number of students who have passed the written qualifying exam
- The number of students who have passed the oral qualifying exam
- The number of graduates
- The length of time that it took these students to complete their studies
- The number of students leaving the program ABD (All But Dissertation)
- If this could be broken down by gender, and race
- And if possible, by year

A core team of representatives from the three cohort teams built the matrices and statistics tables as results were provided. The cohort was asked for their input on the conclusions.

5. Results

Section 5 presents the results of the study: Section 5.1 compares the non-agile and Agile dissertation processes through matrix comparisons of the program characteristics, general dissertation process details, and current examples from public, private, and on-line universities. University statistics for non-agile and Agile doctoral completion are presented in Section 5.2.

5.1. Non-Agile versus Agile Research Program Characteristics

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Non-agile Research Program</th>
<th>Agile Research Program</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of Student</td>
<td>Generally young Masters degree graduates with little to no experience.</td>
<td>Seasoned professionals. (Agile teams hire those with strong skillsets.)</td>
</tr>
<tr>
<td>Lifestyle of Student</td>
<td>Usually residential, full-time, and inflexible schedules. Students are usually not permitted to have full-time jobs outside of program.</td>
<td>Students are fully employed in the area of their studies in order to develop professionally.</td>
</tr>
<tr>
<td>Community Support</td>
<td>Tends to be isolated. Students work alone on their research with little community support.</td>
<td>Cohort-based. Students support each other and the community’s goals. Students work together on teams (pairing) to accomplish milestones in the program.</td>
</tr>
<tr>
<td>Dissertation Methodology</td>
<td>Dissertations must be proposed in a large formal planning process and drafts are reviewed only occasionally.</td>
<td>Dissertations are designed briefly and evolve over the lifetime of the document. Regular check-ins (frequent iterations) ensures the product is of high quality without waste.</td>
</tr>
<tr>
<td>Time to Completion</td>
<td>5+ years</td>
<td>~3 years</td>
</tr>
<tr>
<td>Format</td>
<td>Individual, in person</td>
<td>Cohort, hybrid</td>
</tr>
<tr>
<td>Teaching Experience</td>
<td>Most students teach as part of their program.</td>
<td>No teaching required.</td>
</tr>
<tr>
<td>Examinations</td>
<td>Comprehensive examinations</td>
<td>No comprehensive examinations.</td>
</tr>
</tbody>
</table>

5.1.1. Non-Agile versus Agile Research Program

<table>
<thead>
<tr>
<th>Process</th>
<th>Non-agile Approach</th>
<th>Agile Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dissertation development</td>
<td>Mostly individual with guidance from a dissertation advisor</td>
<td>DPS candidate can work with both an advisor, input from other DPS students and teachers and colleagues from work.</td>
</tr>
<tr>
<td>Qualifying Exams</td>
<td>Must pass all qualifying exams in order to qualify to continue with your dissertation</td>
<td>No qualifying exams</td>
</tr>
<tr>
<td>Internal Review Boards</td>
<td>Required for all dissertations conducting human research</td>
<td>Required for all dissertations conducting human research</td>
</tr>
<tr>
<td>Course Work completion</td>
<td>All course work must be completed prior to defense</td>
<td>DPS is now requiring Idea Paper at the end of the first year of program. There is</td>
</tr>
<tr>
<td><strong>Document name</strong></td>
<td>Dissertation proposal</td>
<td>Idea Paper</td>
</tr>
<tr>
<td>-------------------</td>
<td>-----------------------</td>
<td>------------</td>
</tr>
<tr>
<td><strong>Document length</strong></td>
<td>Dissertation proposal average length is 30-50 pages long</td>
<td>Idea paper is 7-10 pages</td>
</tr>
<tr>
<td><strong>Document scope</strong></td>
<td>Non-agile approach</td>
<td>Idea paper is created using Agile methodology to deliver a working idea paper developed frequently and at a sustainable pace. The idea paper is continually honed and focused during the second year. The focus of the idea paper is presented and reviewed in an iterative style in class.</td>
</tr>
<tr>
<td>(Research Approach and Plan)</td>
<td>dissertation proposal is created to cover the entire proposal in an all or nothing approach. The full thesis proposal is required by doctoral committee</td>
<td></td>
</tr>
<tr>
<td><strong>Dissertation idea</strong></td>
<td>Can be chosen by advisor</td>
<td>Can be an idea that you are interested in.</td>
</tr>
<tr>
<td>(Research Area)</td>
<td>Average student takes 8.2 years to complete</td>
<td>Average Agile DPS is 3.2 years</td>
</tr>
<tr>
<td><strong>Average Time to completion</strong></td>
<td>Required</td>
<td>Required</td>
</tr>
<tr>
<td><strong>Oral defense / dissertation defense</strong></td>
<td>Student reviews literature relevant to the problem.</td>
<td>Student reviews literature relevant to the problem.</td>
</tr>
<tr>
<td><strong>Literature Review</strong></td>
<td>Meet regularly with your advisor to discuss your research idea and progress. No recommended amount of meetings</td>
<td>Regularly scheduled meetings, usually with PowerPoint presentations, includes:</td>
</tr>
<tr>
<td><strong>Dissertation Status Sessions</strong></td>
<td>Completed thesis is given to advisor for final approval, prior to the oral defense.</td>
<td>Brief Elevator description of your research problem</td>
</tr>
<tr>
<td><strong>Dissertation Manuscript</strong></td>
<td>at least another year of classes.</td>
<td>What you did since the last meeting.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>What you are currently doing.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>What you intend to do by the next session.</td>
</tr>
</tbody>
</table>

### 5.1.3. Current University Dissertation Program Characteristics

Our study sampled Computer Science and Information Technology related doctoral programs from public, private, and online universities. Descriptions of the doctoral programs show that the characteristics of these programs usually follow the non-agile doctoral process described in section 5.1.2. Common characteristics of the programs researched include:

- Ph.D. students are full-time, on-campus: Indiana, Stanford, Penn State, University of Virginia, UCLA, Virginia Tech, Rutgers
- Teaching Assistantship or Research Assistantship required: Stanford, Penn State, University of Virginia
- Ph.D. students must pass all qualifying exams and course work in order to start on a dissertation: Indiana, Stanford, Penn State, University of Virginia, UCLA, Rutgers
- The full dissertation proposal is submitted after passing qualifying exams in that subject area: Indiana, Stanford, University of Virginia
- A Reading Committee, including the primary thesis advisor, supervises dissertation research, advises the student, and evaluates the student’s progress. No formal input from other students: Stanford

There are exceptions where non-agile programs do incorporate some Agile characteristics:

- On-line universities allow students to attend self-paced, evening and weekend courses
- George Mason admits part-time Ph.D. students and provides late afternoon and evening classes
- Stanford has a first year research seminar similar to that of the Pace DPS program.

Pace University DPS program characteristics are presented and compared with non-agile program characteristics in section 5.1.2, the “Agile Approach” column in the matrix.

University programs researched for this study were:

- **Private**
  - Indiana University – School of Informatics and Computing
  - Stanford University – Engineering Computer Science
  - Pace University – Doctor of Professional Studies in Computing

- **Public**
  - Penn State University – College of Information Science and Technology
  - University of Virginia – Computer Science and Engineering
  - University of California, Los Angeles – Computer Science
  - Virginia Tech – Computer Science and Information Technology
5.2. Graduation and Completion Statistics

The research team compared graduation and completion statistics (where available) with the Pace DPS. Figure 1 below shows the mean time to completion for traditional public, traditional private, online, and the Pace DPS programs.

Figure 1. Mean Time to Completion for Researched Institutions.

Figure 2 provides data for percentage of candidates who complete a program per year for different traditional Ph.D. degree types and the Pace DPS.

Figure 2. Percentage vs. Years to Completion for Multiple Disciplines and Pace DPS.

The figure above shows a higher level of completion for Pace DPS students in the first three to five years of study, while some of the other programs do not show their students completing until the six to eight year mark. While Pace DPS students tend to complete their degree earlier as compared to traditional programs, the Pace faculty are always trying new methods to improve the completion rate and the dissertation quality [5,7].

5.3. Pace DPS Statistics

The Pace DPS students and faculty provide active support to keep students in the program through successful completion of their dissertations. In addition to support through the dissertation seminars, students who need to take a leave for work or personal reasons can defer and join a new class. Table 1 gives the completion rate for each of the classes – class of 2002 (the first class that started in 1999) through class of 2012. Many students are making regular progress or close to finishing.

<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>8 of 17</td>
<td>4 of 17</td>
<td>5 of 17</td>
<td>1 of 17</td>
</tr>
<tr>
<td>2004</td>
<td>12 of 16</td>
<td>1 of 16</td>
<td>2 of 16</td>
<td>1 of 16</td>
</tr>
<tr>
<td>2005</td>
<td>14 of 18</td>
<td>0 of 18</td>
<td>2 of 18</td>
<td>2 of 18</td>
</tr>
<tr>
<td>2006</td>
<td>8 of 16</td>
<td>2 of 16</td>
<td>6 of 16</td>
<td>0 of 16</td>
</tr>
<tr>
<td>2007</td>
<td>10 of 16</td>
<td>2 of 16</td>
<td>3 of 16</td>
<td>1 of 16</td>
</tr>
<tr>
<td>2008</td>
<td>7 of 15</td>
<td>3 of 15</td>
<td>5 of 15</td>
<td>0 of 15</td>
</tr>
<tr>
<td>2009</td>
<td>6 of 15</td>
<td>8 of 15</td>
<td>1 of 15</td>
<td>0 of 15</td>
</tr>
<tr>
<td>2010</td>
<td>5 of 14</td>
<td>7 of 14</td>
<td>2 of 14</td>
<td>0 of 12</td>
</tr>
<tr>
<td>2011</td>
<td>5 of 14</td>
<td>5 of 14</td>
<td>5 of 14</td>
<td>1 of 14</td>
</tr>
<tr>
<td>2012</td>
<td>5 of 14</td>
<td>8 of 14</td>
<td>3 of 14</td>
<td>0 of 14</td>
</tr>
<tr>
<td>Totals</td>
<td>93 of 175</td>
<td>40 of 175</td>
<td>35 of 175</td>
<td>8 of 175</td>
</tr>
<tr>
<td>Total%</td>
<td>53%</td>
<td>23%</td>
<td>20%</td>
<td>4%</td>
</tr>
</tbody>
</table>
6. Conclusion and Future Work

We found that because the Pace DPS program leverages professional experience in the program, this enables quicker completion whereas traditional programs spend anywhere from three to five years preparing students with basic coursework before they even begin the dissertation process.

When speaking with several of the traditional institutions, we also found that they seek and attract a much different type of Ph.D. candidate. Most institutions would not allow students to have careers or full-time jobs, required residential status, and required students to teach during their program. Moreover, the dissertation process was mostly self-guided, instead of a true collaborative work as it is in the Pace DPS. Some of the institutions we spoke to also advised us that several of their students do not finish their doctoral work because they are hired by outside firms before they have a chance to complete. Pace DPS students are grounded in their careers and are not subject to this same issue.

There are two major areas for future work. If there were more time, the researchers would have liked to be able to construct a survey tool that could be sent out to all DPS students asking them about their satisfaction with the program, if they would suggest the program to other perspective students, and suggestions for possible improvement of the DPS program.

Another great extension of this study would be in the area of graduation, and attrition statistics. Due to the lack of response from many of the researched institutions, it was difficult to obtain a consistent set of statistics across the board from public, private, and online institutions. Online universities were happy to share their retention rates, as they were very high. Traditional programs at private institutions were less willing to share this information without significant documentation on how this research was going to be used. The research team did not have sufficient time to follow up with many of these institutions.

7. References

Appendix

Table 1: CRA Survey Data for Ph.Ds. in Computer Science—Ph.Ds. awarded and progress toward completion

<table>
<thead>
<tr>
<th>Academic Year</th>
<th>PhDs Awarded</th>
<th>PhDs to be Awarded Next Year</th>
<th>Passed Written Exam</th>
<th>Passed Thesis</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011-2012 Public Univ.</td>
<td>1177</td>
<td>1326</td>
<td>1395</td>
<td>1064</td>
</tr>
<tr>
<td>2011-2012 Private Univ.</td>
<td>443</td>
<td>471</td>
<td>389</td>
<td>254</td>
</tr>
<tr>
<td>2010-2011 Public Univ.</td>
<td>1062</td>
<td>1260</td>
<td>1367</td>
<td>899</td>
</tr>
<tr>
<td>2010-2011 Private Univ.</td>
<td>395</td>
<td>426</td>
<td>360</td>
<td>278</td>
</tr>
<tr>
<td>2009-2010 Public &amp; Private Univ.</td>
<td>1501</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>2008-2009 Public &amp; Private Univ.</td>
<td>1473</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>2007-2008 Public &amp; Private Univ.</td>
<td>1597</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Table 2: Cumulative Ten-Year Completion Rates by Program, Broad Field, STEM v. SSH Overall

Table 3: CRA Survey Data for Ph.Ds. in Computer Science—Total Enrollment

<table>
<thead>
<tr>
<th>Academic Year</th>
<th>Total PhD Enrollment</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011-2012 Public &amp; Private Univ.</td>
<td>13105</td>
</tr>
<tr>
<td>2010-2011 Public &amp; Private Univ.</td>
<td>N/A</td>
</tr>
<tr>
<td>2009-2010: Public &amp; Private Univ.</td>
<td>12590</td>
</tr>
<tr>
<td>2008-2009: Public &amp; Private Univ.</td>
<td>12370</td>
</tr>
<tr>
<td>2007-2008: Public &amp; Private Univ.</td>
<td>12260</td>
</tr>
</tbody>
</table>

Table 4: Summary for the public universities program capturing enrollment period, headcount, number of degree awarded and years to complete.

Table 5: Below is the summary for the online Doctoral programs capturing the graduation rate, attrition rate and year to complete percentage.

Computing Research Association Taulbee Survey

“The Taulbee Survey is the principal source of information on the enrollment, production, and employment of Ph.Ds. in computer science in North America. Conducted each fall since 1974, the survey in general covers the preceding academic year. The survey has always had an excellent response rate—a fact which we believe lends great credibility to the result.” [3] This is an excellent source of up-to-date statistics— in 2011-2012, for example, Computer Science departments from 152 public and private schools responded to the survey.