Stevens Institute of Technology

School of Business

**AACSB
ASSURANCE OF LEARNING PLAN**

**Doctor of Philosophy in**

**Data Science**

 **(Ph.D.)**

April 30, 2022

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# Introduction: PhD Assurance of Learning Plan

The interdisciplinary Ph.D. in Data Science prepares inquisitive students to become pioneers in this space through a rigorous curriculum emphasizing mathematical and statistical modeling, machine learning, computational systems and data management. The program is administered through both the Schaefer School of Engineering and Science and the School of Business at Stevens, ensuring a diverse curriculum that responds to demand for data scientists with extensive knowledge of the theories, techniques and applications associated with data and artificial intelligence. Graduates become research leaders in academia or industry, where they lead the organization’s forays through the data revolution and into the age of A.I. and machine learning.

Given the rapid evolution of emerging A.I. concepts like machine learning and language processing, Stevens worked with industry to develop four curricular threads that ensure mastery of the most important principles in this discipline. These areas represent the greatest needs for tomorrow’s data scientist.

1. Machine learning and artificial intelligence. Explores statistical learning, A.I., machine learning and financial analytics.
2. Mathematical and statistical modeling. Covers multivariate analytics, financial time series and dynamic programming techniques.
3. Computational systems. Explores advanced algorithm design, distributed systems and cloud technologies.
4. Data management at scale. A deeper dive into data technologies, mobile systems and data management.

The student will take at least one course, and no more than three courses, in each of the four core areas, working with an advisor to select the best portfolio for career interests. Students who demonstrate competency in a particular subject area may waive the related core course.

**Core Area 1: Mathematical and Statistical Modeling**

* BIA 652 Multivariate Analysis
* FE 542 Time Series with Applications in Finance
* MA 661 Dynamic Programming and Reinforcement Learning

**Core Area 2: Machine Learning and Artificial Intelligence**

* BIA 656 Statistical Learning and Analytics
* CS 541 Artificial Intelligence
* CS 559 Machine Learning: Fundamentals and Applications
* FE 690 Advanced Financial Analytics

**Core Area 3: Data Management at Scale**

* BIA 678 Big Data Technologies
* CS 522 Mobile Systems and Applications
* CS 609 Data Management and Exploration on the Web

**Core Area 4: Computational Systems**

* BIO 668 Computational Biology
* FE 595 Financial Systems Technology
* CS 549 Distributed Systems and Cloud Computing
* CS 600 Advanced Algorithm Design and Implementation

**Ph.D. Required Courses**

All doctoral candidates at Stevens take the following courses to prepare them for the rigorous research involved in the dissertation process.

* PRV 961 Doctoral Signature Credit Seminar
* MGT 719 Research Methods

**Concentrations**

Students in the Data Science program choose one of the available concentrations or, working closely with their faculty advisor, create a custom concentration of their own.

**Concentration 1: Financial services**

This concentration prepares students to lead forays into areas such as financial innovation, high-frequency trading, large-scale portfolio optimization, automated investment systems, financial data mining and visualization, and trade surveillance and financial fraud detection. These topics will be covered with emphasis on practical solutions to the challenges facing investment banks, hedge funds, mutual funds, exchanges and regulators.

* FE 546 Optimization Models and Methods in Finance
* FE 545 Design Patterns and Derivative Pricing
* FE 550 Data Visualization Applications
* FE 610 Stochastic Calculus for Financial Engineers
* FE 635 Financial Enterprise Risk Engineering
* FE 680 Derivatives
* FIN 638 Corporate Finance
* FIN 628 Derivatives
* FE 655 Systemic Risk and Financial Regulation
* FE 670 Algorithmic Trading Strategies
* FE 621 Computational Methods in Finance
* FIN 703 Microeconomic Theory
* FIN 704 Econometrics
* FIN 705 Asset Pricing Theory and Applications

**Concentration 2: Life sciences**

This concentration prepares you to pursue advanced research topics, such as computational modeling in biology and biomedical science, bioinformatics, computational and medicinal chemistry, and biomedical data reduction. Statistical modeling, data management and machine learning techniques will help you identify trends in healthcare data and direct research in the pharmaceutical industry, in government or at hospitals.

* CH 644 Computer Methods in Chemistry
* CH 760 Chemoinformatics
* CHE 660 Advanced Process Control
* CHE 661 Design of Control Systems
* CPE 610 Introduction to Bioinformatics Engineering
* CPE 686 Software Tools in Bioinformatics
* CS 544 Health Informatics
* CS 691 Introduction to System Biology
* CS 694 Advanced Computational Modeling in Biology and Biomaterials Science

**Stevens School of Business and PhD Vision Statements**

**School of Business Vision**
We will be leaders in the creation and dissemination of knowledge that drives successful innovation in products, processes and businesses.

**PhD in Data Science (PhD) Vision**The interdisciplinary Ph.D. in Data Science prepares inquisitive students to become pioneers in data science through a rigorous curriculum emphasizing mathematical and statistical modeling, machine learning, computational systems and data management.

Ph.D. PROGRAM LEARNING GOALS

The program’s objective is to prepare students to pursue an academic or industry research career that is increasingly global in nature.

To improve the program’s competitiveness, we added several specific competencies, detailed the indirect measures to assess the competencies and specified how to track these when we outline the goals. Moreover, we incorporate more explicit focus on ethics and global threads so that our students will be better prepared for embracing global challenges we face today.

The course work introduces students to the foundations of research related to innovation and technology in organizations and equip them with the knowledge required to conduct independent research with ethical expectation in perspective. In today’s business and academic environment, global context and orientation have become more important than ever before as research is generating much broader impact in the society. Therefore, we aim to infuse research ethics and global perspectives as an integral part of our learning goals.

The courses, with their domain-specific origins, are differently positioned to develop skills in understanding and analyzing as well as in creating and applying.

# PhD Learning Goals

The Learning Goals for the PhD program are listed in Table 1. Note that the first goal (written and oral communications skills) is same as for other graduate degree programs; the remaining two learning goals (as listed above) are specific to the PhD program.

Table 1: PhD Learning Goals

|  |
| --- |
| Learning Goals/ Skill Sets |
| PhD 1: Students can communicate effectively in written and oral presentations and structure research papers.  |
| PhD 2: Ph.D. graduates master the core knowledge and research tools in their major field of study.  |
| PhD 3: Ph.D. students demonstrate capacity to identify and develop a research project for their dissertation in a timely fashion.  |

While achieving the learning goals defined above, we also aim to incorporate ethical discussions and the global perspective of the learning into different aspects of the program activities. These efforts are manifested through ethics training in course content, exams and academic activities, and at the same time all the learning activities have also considered with a global perspective so that our students will be equipped to address global problems and be ready to engage global academic community. We considered them as the “Ethics Thread” and the “Global Thread” on top of the explicitly defined learning goals.

# PhD Assurance of Learning Assessment Plan

**Table 2: PhD ASSURANCE OF LEARNING ASSESSMENT PLAN - GOALS 1 through 3**

|  |  |  |  |
| --- | --- | --- | --- |
| **PhD LEARNING GOAL** | **Where and when measured?** | **How measured?** | **Criterion** |
| **1. Ph.D. students can communicate effectively in oral and written presentations.** | The qualifying exam at the beginning of 3rd year requires students to pass both a written exam and an oral exam. Students who fail either part of the exam will be automatically removed from the program | The qualifying exams by an examining faculty committee will evaluate both the written quality of the research statements and the presentation quality of the oral exam.Sampling: All PhD students | The examination committee sets the written exam, which could be composed of questions from classes the student has taken, or, alternatively, the student could be asked to analyze a dataset and suggest further research based on their analysis. The student will submit a written report. The student presents one of three possible options for the oral exam: (1) their own research paper(s), (2) an assessment of a set of assigned papers, (3) the student’s written component of the examination. The exam committee will attend the presentation and ask questions to be answered by the student. Based on the student’s presentation and the interaction with the student, the exam committee will provide one of three outcomes: (1) pass the student, (2) fail the student, (3) re-examination. |
| 2. Ph.D. graduates master the core knowledge and research tools in their major field of study.  | To graduate each student is required to publish one peer reviewed article | Sampling: All PhD students. | All students (100%) have to publish at least one article in a peer reviewed journal or conference. |
| 3. Ph.D. students demonstrate capacity to identify and develop a research project for their dissertation in a timely fashion.  | Students should defend their dissertation proposals at the end of the fourth year of studies. | Sampling: All PhD students. | By the end of the ninth semester (4.5 years) of the program, almost all students should try to successfully defend their dissertation proposal. |

# PhD Curriculum Alignment Map

Table 3: Ph.D. Curriculum Alignment Map

|  |  |  |  |
| --- | --- | --- | --- |
| Learning Goals/ Skill Sets | Corresponding Educational Experiences | Ethics Thread | Global Thread |
| PhD 1: Students can communicate effectively in written and oral presentations and structure research papers.  | All core courses involve individual and team presentations and require students to write research papers. | Research ethics is important part of the training. Issues such as, plagiarism, social responsibility, etc. will be discussed. Ethics in academic research will be reinforced through writing and critics.Some ethical issues will be discussed in performing financial research, such as fraud, social responsibility, climate impact, etc. | Significant part of the content is global |
| PhD 2: Ph.D. graduates master the core knowledge and research tools in their major field of study.  | All core courses address specific methods or research areas related to Data Science.  |  |
| PhD 3: Ph.D. students demonstrate capacity to identify and develop a research project for their dissertation in a timely fashion.  | The research with the advisor will enable the students to identify a research topic. |  |

Table 4: Ph.D. Preliminary Exam/Ph.D. Qualifying Exam/Ph.D. Proposal Defense/Ph.D. Dissertation/Ph.D. Defense

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Goals****/Quantitative Courses** | **PhD 1: Students can communicate effectively in written and oral presentations and structure research papers.**  | **PhD 2: Ph.D. graduates master the core knowledge and research tools in their major field of study.**  | **PhD 3: Ph.D. students demonstrate capacity to identify and develop a research project for their dissertation in a timely fashion and effectively disseminate knowledge through classroom teaching.**  | **Ethics Thread** | **Global Thread** |
| Ph.D. Preliminary Exam | No focus on oral communication skill. | Students write a paper in the form of a literature survey that must also contain some elements of a research. | Some focus on teaching. It will be necessary for students to demonstrate classroom skills either as a teaching assistant or as an instructor | Partially relevant | The entire content is global. |
| Ph.D. Qualifying Exam | The oral communication was particularly emphasized in this exam. The student presents one of three possible options: (1) their own research paper(s), (2) an assessment of a set of assigned papers, (3) the student’s written component of the examination. The exam committee will attend the presentation and ask questions to be answered by the student. | This exam is required for all students to pass at the end of their third year in the program. The exam consists of both written and oral parts. The examination committee consists of 3-4 faculty members based on the Ph.D. Student Handbook. The goal is to test whether the student can effectively apply the knowledge acquired to solve a challenging data science the student is proposing to address. | No focus on teaching. | Ethical conduct of academic research will be reinforced. | Significant part of the content is global. |
| Ph.D. Proposal Defense | Oral presentation and its effectiveness are emphasized in this exam. The student will be treated as a scholar who is able to defend the proposed research topic and methodology. The new knowledge generated from the proposed research needs to be validated.  | This exam is required when the student is ready to pursue dissertation research. The dissertation committee will be formed at this point to make sure the proposed research is on the right track and it has potential to generate new knowledge in the targeted field. | Teaching skills will be assessed as part of the program. In general, the student will be assigned as a teaching assistant to one or more courses related the student’s field. | Ethical conduct of academic research will be reinforced. | Significant part of the content is global. |
| Ph.D. Dissertation Defense | Oral presentation and its effectiveness are the important part of this exam. The student will be judged a scholar who can communicate the research objectives, methodology used, significant new contributions generated from the dissertation research. Failure to demonstrate such capability will prevent the student to be awarded the degree at a result. | This exam is the final exercise of measuring whether the student has mastered the knowledge and is capable of apply the existing knowledge to generated new knowledge in the chosen field. Any indication of inadequacy in the domain knowledge will be assessed by the committee members as part of the final assessment of the candidate’s quality. | Teaching skills will be assessed as part of the exam. Before a student can graduate from the program, sufficient teaching skills will be assessed for the final assessment of the candidate’s quality. | Ethical conduct of academic research will be reinforced. | Significant part of the content is global. |

# Ethics

The Ph.D. in Data Science Program also takes great effort to address the importance of Business Ethics. The following table shows the courses where ethics is explicitly addressed.

|  |  |
| --- | --- |
| **Goals/** | Students are aware of social responsibilities in a business environment and can reason about ethical issues. |
| FIN 703 Microeconomics Theory | Detailed examples are used to help students identify ethical issues, stakeholders, alternatives and identify an appropriate course of action.  |
| FIN 704 Econometrics | Students learn to use various measures of market concentration proxies and understand the usefulness of antitrust policy. Some issues on corporate responsibility are tested and highlighted  |
| CS 594 Enterprise and Cloud Security | Students learn security and privacy from the perspective of enterprise applications. |
| CS 596 Information security and the Law | Students learn ethics in information technology and the law. |
| CS 676 Advanced Topics in System Security | Students learn privacy and security issues computer systems. |

# Global Context

Another thread that runs through the Ph.D. in Data Science Program are global considerations. Following is a chart that maps our courses to global coverage using the legend below.

**Legend**

 – Entirely Global Content

 – Significant parts are global

 – Some global content

|  |  |  |
| --- | --- | --- |
| **Course** | **Legend** | **Notes** |
| FIN 703 Microeconomics Theory | Shape  Description automatically generated with medium confidence | This theory is taught and applied all over the globe and used global examples |
| FIN 704 Econometrics Theory and Application | Shape  Description automatically generated with medium confidence | This theory is taught and applied all over the globe and used global data to evaluate models |
| FE 655 Systemic Risk and Financial Regulation |  | Students learn the study of global financial systems as a system of complex adaptive systems |

# PhD Learning Goals, Objectives and Rubrics

Note: PhD Goal 1, *Our students will communicate effectively in writing and oral presentations* is common across all Stevens School of Business degree programs, however the assessment process and criteria differ from program to program.

For the written and oral skills assessment, student written report and presentation during the qualifying exam will be assessed by the qualifying exam committee.

**Table 4: PhD Learning Goal 1, Objectives and Rubrics**

|  |  |
| --- | --- |
| **PhD - 1** | **Learning Goal, Objectives and Traits** |
| **GOAL** | Our students will communicate effectively in writing and oral presentations. |
| **Objective 1:** | *Students will be able to pass written component of the qualifying exam* *by the end of the fifth semester.*  |
| **Traits** |   |
| Trait 1: | Satisfactory written report as evaluated by the examining committee submitted as part of the qualifying examinations |
| **Objective 2:** | *Students will be able to pass oral component of the qualifying exam by the end of the fifth semester.* |
| **Traits** |   |
| Trait 1: | Satisfactory oral presentation as evaluated by the examining committee as part of the qualifying examinations |

**Explanation for indirect measurements:**

Indirect measurements will be taken at periodic intervals. Depending on the measurement chosen a diagnostic tool will be selected for analysis. There are two indirect measures we can use to measure this learning goal:

a). Outside conference and workshop presentation acceptance;

b). School organized seminar/workshop presentations.

Both activities are neither required nor managed by the program, but they are outcomes of this learning goal that can be observed. We will collect the number of outside presentations done by our current students through periodic surveys as an indirect measure of this learning goal.

**PhD Goal 2:** *Ph.D. graduates master the core knowledge and research tools in their major field of study.*

The goal is to assure the expertise in the research field. The objective is that the students are able to write competitive research papers.

Appendix B contains a copy of the “Stevens School of Business Doctoral Activity Report,” which is administered annually and is used to collect data relevant to the assessment of Ph.D. goals 2 and 3. Appendix C contains the template used to gather information for the assessment of this goal.

|  |  |
| --- | --- |
| **PhD - 2** | **Learning Goal, Objectives and Traits** |
| **GOAL** | Our Ph.D. graduates master the core knowledge and research tools in their major field of study. |
| **Objective 1:** | *Students are able to write competitive research papers.* |
| **Traits** |   |
| Trait 1: | Number of publications at graduation |

**PhD Goal 3:** *Ph.D. students demonstrate capacity to identify and develop a research project for their dissertation in a timely fashion.*

The goal is to help the students to finish their dissertations within 5 years. There is not a specific timeline when the students should finish their proposal and a delay of a proposal correlates highly with a delay of the dissertation defense and extends the doctoral studies.

Appendix B contains a copy of the “Stevens School of Business Doctoral Activity Report,” which is administered annually and is used to collect data relevant to the assessment of Ph.D. goals 2 and 3. Appendix B contains a copy of the “Stevens School of Business Doctoral Activity Report,” which is administered annually and is used to collect data relevant to the assessment of Ph.D. goals 2 and 3. Appendix C contains the template used to gather information for the assessment of this goal.

|  |  |
| --- | --- |
| **PhD - 3** | **Learning Goal, Objectives and Traits** |
| **GOAL** | Our Ph.D. students demonstrate capacity to identify and develop a research project for their dissertation in a timely fashion. |
| **Objective 1:** | *Students will defend their dissertation proposal within 4.5 years but at latest in their fifth year of studies.*  |
| **Traits** |   |
| Trait 1: | Elapsed time to proposal defense |

**Explanation for Indirect Measurements:**

We will administer indirect measurements at periodic intervals. Depending on the nature of the measurement selected a diagnostic tool will be selected for analysis. We have two indirect measures to gauge the students’ progress in their mastering key knowledge in a timely manner.

The first indirect measure of this learning goal is to count the number of working papers or seminar presentations after passing qualifying exam. If a student can finish working papers to be submitted to peer-reviewed conferences or journals, it is a good indication that the student has mastered sufficient knowledge in the field and is able to make contributions to the field.

The second indirect measure is to conduct periodic surveys on student brown-bag seminar series presentation topics. As a requirement, all the PhD students who passed the qualifying exam are encouraged to present their research at the brown-bag seminar series every semester. A brief survey on research topics and findings will help us to assess the depth of their knowledge and progress they make in a timely manner.

**Explanation for Indirect Measurements:**

Indirect measurements will be taken at periodic intervals. Depending on the measurement chosen a diagnostic tool will be selected for analysis.

One method we plan to use is interviews. The interview will be structured, and the subjects will be the students in the sessions taught by our PhD students. These structured interviews will help us gather critical information about the key competencies like communication, body language, aptitude and attitude. The responses will be subjected to a content analysis. Other options include surveys and focus group discussions.

# Results of AACSB Learning Goal Assessments

Each learning goal has a number of learning objectives and performance on each objective is measured using a rubric that in turn contains a number of desired “traits”. Students are scored individually on each trait.

The grading sheets for each student are used to develop a Summary Results Sheet for each learning goal objective. A selection of these Summaries is included below.

The first table in the Summary Results Sheet for a learning objective and trait gives the counts of students falling in each of the three categories:

- Does not meet expectations
- Meets expectations
- Exceeds expectations

A typical table for recording results is shown on the next page.

The right-hand column in the table is used to record the average score of the students on each trait. This table provides an indication of the relative performance of students on each trait.

The second table on each sheet provides the counts of students who fall in each of the above three categories for the overall learning objective.

The person undertaking the assessment provides explanatory comments and recommendations on the bottom of the Results Summary Sheet. The recommendations suggest content or pedagogy changes for the next time the course is given.

# APPENDIX A

**Stevens School of Business**

**TEMPLATE OF AACSB DS Ph.D. LEARNING GOAL 1 ASSESSMENT**

**PROGRAM: PhD Program**

**Ph.D.1 GOAL: Our students will communicate effectively in writing and oral presentations.**

**LEARNING OBJECTIVE #1: Students will be able to pass written component of the qualifying exam by the end of the fifth semester.**

**LEARNING OBJECTIVE # 2: Students will be able to pass oral component of the qualifying exam by the end of the fifth semester.**

**ASSESSMENT DATE: ASSESSOR:**

**NO. OF STUDENTS TESTED: COURSE:**

|  |  |  |
| --- | --- | --- |
|  | **Number of Students** |  |
| **Learning Goal** **Traits** | **Not Meet** **Expectations** | **Meet** **Expectations** | **Exceed** **Expectations** | **Average Grade** **on Trait** |
| 1: Satisfactory written report as evaluated by the examining committee submitted as part of the qualifying examinations |  |  |  |  |
| 2: Satisfactory oral presentation as evaluated by the examining committee as part of the qualifying examinations |  |  |  |  |

|  |  |  |  |
| --- | --- | --- | --- |
| **Total Students by Category**(Based on Average score across all traits) | **Not meet expectations** | **Meet Expectations** | **Exceed Expectations** |
|  |  |  |  |

**COMMENTS:**

**REMEDIAL ACTIONS:**

# APPENDIX B

**Ph.D. student activity report: This report is submitted every semester to the Ph.D. program director and serves as a basis for assessing goals 2 and 3.**

**PhD Progress Report**

**Name:**

**Stevens ID:**

**PhD advisor:**

**Semester:**

**Milestones**: (The semesters in which you completed each of the program milestones that you have already cleared. The full list follows:

(a) Breadth requirement—coursework;

(c) Qualifying exam—oral;

(c) Qualifying exam—written;

(d) Doctoral signature credit seminar (PRV 961);

(e) Formation of thesis advisory committee & Thesis proposal;

(f) Thesis defense.)

Cleared:

Planned:

**Presentations**: (Any talks that you have delivered in the past 6 months including reading group presentations).

**Submissions**: (Any paper or abstract that you submitted in the past 9 months; please indicate if the paper is currently under peer review).

**Publications**: (Any paper or abstract that you published in the past 18 months).

**Additional information:** (You may also include additional information that may aid the committee in evaluating your progress).

If you have entered the PhD program after obtaining a Master’s Degree, please indicate conferral date, institution, and discipline.

Advisor Name (Print):

Advisor signature:

Date:

# APPENDIX C

**Stevens School of Business**

**TEMPLATE OF AACSB LEARNING DS Ph.D 2 GOAL ASSESSMENT**

**PROGRAM: PhD Program**

**Ph.D. 2 GOAL: Our Ph.D. graduates master the core knowledge and research tools in their major field of study.**

**LEARNING OBJECTIVE #2: Students are able to write competitive research papers.**

**NO. OF STUDENTS ASSESSED:**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **PhD Students** |  |  | **Count of:** |  |  |  |
| **Name** | **F / P\*** | **Years in Program** | **PRJ** | **Procs** | **Bk Chap** | **Books** | **Other** |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |

**\*F-T/ P-T: Fulltime (F), Part time (P) students**

**PRJ: Peer Reviewed Journal**

**Procs: Proceedings**

**Bk Chap: Book Chapters**

**COMMENTS:**

**REMEDIAL ACTIONS:**

# APPENDIX D

**Stevens School of Business**

**TEMPLATE OF AACSB** **DS Ph.D LEARNING GOAL 3 ASSESSMENT**

**PROGRAM: PhD Program**

**Ph.D. 3 GOAL: Our Ph.D. students demonstrate capacity to identify and develop a research project for their dissertation in a timely fashion.**

**LEARNING OBJECTIVE #3:** **Students will defend their dissertation proposal within 4.5 years but at latest in their fifth year of studies.**

**NO. OF STUDENTS ASSESSED:**

|  |  |  |  |
| --- | --- | --- | --- |
| **Last name** | **First name** | **Year** | **ProposalDefense** |
|  |  |  |  |
|  |  |  |  |
| **Total** |  |  |

**COMMENTS:**

**REMEDIAL ACTIONS:**