THE GEORGE WASHINGTON UNIVERSITY
School of Engineering and Applied Science

Online Programs Office

Researching and Writing the Praxis Paper: Guidance for Candidates and Advisors

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1 Introduction

Generally speaking, a praxis is "the practical application of a theory."[1] In academia, a praxis for the Doctor of Engineering stands between a thesis for a master's degree and a dissertation for a research doctorate such as the Doctor of Philosophy (Ph.D.).

A master's thesis usually addresses a subject of limited scope that has been researched by the student by consulting published source material or has been explored by limited experimentation by known techniques; there is normally no expectation of publishing the results in a professional venue. A dissertation for a research doctorate explores uncharted territory in a carefully circumscribed area of knowledge. It may involve invention of new research techniques or technology, and is by definition a contribution of new knowledge to the subject field; such work is normally reported in a professional journal, where it is available to everyone.

In contrast, the applied research for the GW School of Engineering and Applied Science Doctor of Engineering (D.Eng.) degree is written up as a praxis, in which engineering theory and practice are synthesized to create value for practical use. The praxis is a report on a practical problem in the management of engineering. It could be a case study or the description of the application of advanced engineering tools to a complex technical, environmental, or economic problem.

The SEAS D.Eng. in engineering management degree requires that a candidate write both a praxis proposal and a praxis paper. This document provides guidance for D.Eng.(EM) candidates and advisors on preparation of the praxis.[2]

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[1] Merriam-Webster, definition 2. https://www.merriam-webster.com/dictionary/praxis, accessed 28 Feb 2018.

[2] The following writing resources provide useful technical writing assistance: Praxis question (see http://writingcenter.gmu.edu/articles/7605); Thesis statement (see http://writingcenter.unc.edu/handouts/thesis-statements/); Research writing (see https://owl.english.purdue.edu/owl/resource/658/01/).

2 Doctor of Philosophy Research vs. Doctor of Engineering Research

Ph.D. research leads to foundational, basic findings that are publishable in peer-reviewed journals or books. The Ph.D. holder tends to practice engineering in the academy or in research investigation in a specific area.

The D.Eng. demands that the student's research be applied to solve an actual problem; thus, research for the D.Eng. is applied, rather than foundational like research for the Doctor of Philosophy (Ph.D.). The aim of D.Eng. research is to develop original solutions to real-world industry problems using the latest engineering concepts and techniques—to apply knowledge directly to problems encountered in daily life. While focusing on engineering practice, D.Eng. research in the field of engineering management also develops the practitioner's leadership potential.

In short, the essential difference between research toward the Ph.D. and toward the D.Eng. is the "basic" nature of the former and the "applied" nature of the latter.

Basic research (Ph.D.) can be defined as "systematic study directed toward greater knowledge or understanding of the fundamental aspects of phenomena and of observable facts *without specific applications* towards processes or products in mind"[3] (emphasis added). Directed toward increasing fundamental knowledge and understanding in the field of study, basic research is visionary and high-risk–high-reward. As such, it can lead to applied research or to development of advanced technology.

Applied research (D.Eng.) is a "systematic study to understand the means to meet a recognized and specific need. It is a *systematic expansion and application of knowledge* to develop useful materials, devices, and systems or methods."[4] (emphasis added). Applied research transforms findings of basic research to solutions to specific, complex, real-world problems or technological challenges, establishing their feasibility and practicality.

D.Eng. research efforts lead to increased in-house knowledge for the organizations that are involved, by leading to such outcomes as business processes improvement, time-to-market acceleration, and cost saving. In the long term, they can even result in sector-wide or society-wide business and policy change. Through collaborative effort, the knowledge generated is diffused from one firm to the industry as a whole, helping to develop a pool of highly skilled professionals and leaders.

3 Outline of the D.Eng.(EM) Program

The D.Eng.(EM) program goal is to graduate professionals who are applied researchers, technology managers and advocates, and leaders in their fields. Graduates will know

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[3] John F. Sargent Jr., "Department of Defense Research, Development, Test, and Evaluation (RDT&E): Appropriations Structure," Congressional Research Service, 7-5700, www.crs.gov, R44711, December 13, 2016.
[4] Sargent, 2016.

how to address problems that arise in the technological and engineering sectors that have a nontechnical impact on society. Courses on such topics as data analysis, knowledge management, entrepreneurship, technology marketing, and managing e-commerce technology are designed to broaden the students' knowledge base and prepare them for industry leadership.

D.Eng. graduates have developed skills in critical thinking, in identifying problems pertaining to inefficiencies in an organization, in devising optimal solutions, and in conducting research of real use to industry. This partnership between academia and industry generates and transfers new knowledge for immediate application, guiding industry and policy. The real-world problems attacked in D.Eng. praxes involve multidisciplinary factors from engineering, business, and social sciences. This broad interdisciplinary foundation is a significant aspect of the GW D.Eng. program and a major asset for its alumni.

3.1 Program Learning Objectives

The objectives of the D.Eng.(EM) program are to ensure that graduates can:

a. Explain and apply the processes of engineering management research to solve a real-world problem using current engineering management concepts and tools.
b. Produce a praxis or case study for use by practicing engineers to address a common concern or challenge.
c. Articulate their expertise and knowledge to apply it directly in a business or technical environment.

3.2 Two Research Documents and Two Oral Exams

A praxis proposal and a praxis paper must be successfully defended—separately and orally—before committees of the faculty. Upon completing the D.Eng.(EM) program classroom phase with a GPA of no less than 3.2, and successfully defending the praxis proposal, students undertake directed study to research, write and defend the praxis. Successful defense of the praxis is the final requirement for award of the degree.

a. *Praxis Proposal:* Defines the student's research, which is an analysis of a real-world problem on a topic related to engineering management, chosen by the student, and approved by the adviser. It is orally defended before a faculty committee.
b. *Praxis:* Research is guided by two advisers. It is orally defended before a committee of at least two faculty members and one outside adviser selected by the candidate. The outside advisor can be the "owner" of the problem solved by the praxis, and in any case must be an expert who can speak to the significance of the problem and evaluate the work.

3.3 Assessment

Before a defense, Turnitin originality checking services are applied to the final versions of praxis proposals and praxes. Defenses of the D.Eng. qualifying examination (praxis

proposal), and the final praxis follow the pattern long used at GW-SEAS for Ph.D./D.Sc. dissertations.

4 The Engineering Management Field of Study

The fundamental objective of the field of engineering management is to apply engineering principles and techniques to managerial and business problems that arise in the technology/commercial sector. Deep knowledge of both engineering and management are required for the application of engineering management techniques to succeed. A multidisciplinary area, engineering management involves aspects of engineering, systems thinking, mathematical modeling, and human factors, and encompasses such disciplines as management of technology, operations research, systems engineering, management science, industrial engineering, financial management, quality control, and project management.

4.1 Research Topics that are Acceptable for the Praxis

The American Society of Mechanical Engineers identifies eight domains of engineering management knowledge[5], any of which is suitable for a praxis, defined briefly as follows:

a. **Market Research, Assessment and Forecasting**
   Processes and activities involving market research: market analysis, benchmarking practices, business forecasting, risk analysis, trend analysis.
b. **Strategic Planning and Change Management**
   Steps involved in bringing a new product or technology to market; includes technology planning, knowledge management, lifecycle engineering, strategic management, financial risk management.
c. **Product, Service and Process Development**
   Identifying the engineering disciplines necessary for development of a product and its manufacturability and design methodology; can include feasibility analysis, lean production techniques, total quality management, Six Sigma.
d. **Engineering Projects and Process Management**
   Financial and project management aspects of a production; includes project management, scheduling, budgeting, supply chain and demand constraints, customer satisfaction, cycle time analysis.
e. **Financial Resource Management**
   Procurement and contract procedures, funding sources, economic analysis, budget and resource planning, inventory, and supply chain management.
f. **Marketing, Sales and Communications Management**
   Marketing practices; involves product portfolio analysis, global trade, international operations, pricing strategies.

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[5] ASME Book Committee, *Guide to the Engineering Management Body of Knowledge,* doi: 10.1115/1.802991, 2010 http://ebooks.asmedigitalcollection.asme.org/book.aspx?bookid=306 accessed 1 Mar 2018.

g. **Leadership and Organizational Management**
   Management styles and organizational structures most conducive to managing professionals; such topics as leadership, human resource management, organization structure.
h. **Professional Responsibility, Ethics and Legal Issues**
   Understanding and applying regulatory requirements, codes of ethics, standards. Intellectual property considerations.

A chart of engineering management domains of knowledge and their subdomains appears in Fig. 1 in Section 8 Appendix.

4.2 Research Methods that are Acceptable for the Praxis

Engineering management involves a diverse range of topics, problems, and questions, and D.Eng. research may use a variety of research methodologies, some of which are listed in Fig. 2 in Section 8 Appendix.

5 The Praxis Proposal (A Review)

By the end of the classroom course phase of the D.Eng. program, the student has been introduced to the design of research studies in applied engineering management settings from a practical perspective, has explored the fundamentals of applied research, and has learned to formulate appropriate research questions and hypotheses, and to design a research study from empirical data. Successful defense of the praxis proposal means that the student knows how to:

1) Define, summarize, and outline a problem description clearly
2) Select appropriate goals for an extended study
3) Identify the data needed for an extended study and where it is to be found
4) Explain in detail the solution method to be used
5) Organize, present, and defend a strong proposal before a group of decision makers

6 The Praxis

Research for the D.Eng.(EM) praxis is independent applied research in engineering management guided by at least two faculty advisors. Upon completing the praxis, students will have achieved the program learning goals (see Section 3.1 above).

The D.Eng.(EM) program is largely distinguished by the nature of its research phase. Since the praxis is, by definition, a report on the practical resolution of an actual, real-world problem in engineering, it may be either a description of the problem and how existing tools or techniques can fruitfully be applied to its resolution, or a case study of the application of advanced management tools or technologies in the resolution of an actual problem. To date, nearly all the praxes prepared for the D. Eng.(EM) program at GW have been of the former kind.

The praxis describes the phases of the research and reports the research findings in chapters that normally include Introduction; Literature review; Methodology; and Results, Discussions, Conclusions. These are briefly described below.

6.1 Introduction Chapter

The introduction provides a brief background about the problem that justifies the study. It discusses the significance of the problem, and it must include:

a. problem statement (purpose and significance of the study),
b. thesis statement (claim of the researcher and potential solution to the problem),
c. research questions (suggesting the relationship among variables that should be empirically testable),
d. the research objective (statement of the research direction and specific actions), and
e. hypotheses (declarative statements about expected or predicted outcomes).

6.2 Literature Review Chapter

Whereas a Ph.D. dissertation is expected to include a comprehensive review of related literature and a summary of all the research that has ever been published on that subject, the D.Eng. praxis literature search need only review those writings that support the limited practical application of the technology or case study. All available resources, such as books, journal papers, and web sites, can be used. The literature review critically analyzes the existing technical body of knowledge related to the problem under study. This critique should demonstrate that the author has a grasp of the major ideas and findings pertaining to his or her topic. The literature review includes an overview of the subject; categorization of the work under review based on such factors as opposing theories and methodologies; an explanation of the similarities and differences of the publications cited; and a critical analysis and evaluation of the works reviewed, including discussion of their strengths and weaknesses.

While, as stated above, a D. Eng. literature review focuses on application of theory and is not necessarily comprehensive, nevertheless, D.Eng. candidates must establish that they have deep understanding of the topic and awareness of the newest methods and approaches for solving the problem. Peer-reviewed articles published in high-impact journals are highly desirable references for this purpose. The most prestigious journals in engineering management at this writing are:

- *Engineering Management International*
- *Engineering Management Journal*
- *Engineering Management Research*
- *IEEE Transactions on Engineering Management*
- *Journal of Engineering and Technology Management*
- *Journal of Management in Engineering*

6.3 Methodology Chapter

This chapter contains a detailed overview of how the research was conducted and walks readers through the procedures and steps. The research methodology (or method) is the process of starting from raw data and ending up accepting or rejecting the research hypotheses. See Fig. 2.

6.4 Results, Discussion, and Conclusions Chapter

The results chapter should present the output, in the form of figures and tables, from applying the research methodology to raw input data. No discussion or interpretation should be included in the results chapter. The discussion describes the research results as related to the research questions and hypotheses and refers to the literature review for comparison. The conclusions summarize the overall point(s) that the researcher wants the reader to remember.

6.5 Examples of Contributions of Recently Defended Praxes

- One praxis created "a smart home energy management system using a limited memory algorithm for bound constrained problems, along with time-of-use pricing to optimize appliance scheduling in a 24-hour period. The allocation of energy resources for each appliance is coordinated by a smart controllable load device embedded in the household's smart meter. Simulation results confirmed that the proposed algorithm effectively improved the operational efficiency of the distribution system, reduced power congestion at key times, and decreased electricity costs for prosumers."
- Another modeled "The human brain … using the cognitive cycle, a continuous loop of detection, interpretation, and action which guides decision-making and performance. In human-driven queues, these elements can affect queuing performance. The research develops a generic system dynamics queuing model. Via simulation, this research demonstrates the application of the generic model to passport inspection stations at John F. Kennedy International Airport, [which] systematically develops a matrix of improvement strategies."
- A third "establishes a technical uncertainty framework and quantification methodology to reduce system failures and increase reliability within a metropolitan railway system using disruption data from the Washington Metropolitan Transit Authority."

6.6 Selected Praxis Titles

a. A Technology Maturity Assessment of Sustainment Dominated Systems under the Influence of Obsolescence
b. Planning for the Influence of Emerging Disruptive Technologies on IT Systems
c. A Generalized Approach to Measure and Predict Innovation Maturity Progression Aligned to Business Objectives
d. Identifying and Overcoming the Barriers to Cloud Adoption within the Government Space

e. Managing Risk as a Function of the Nuclear Work Model
f. Pre-Design Methodology for Establishing Scope–Budget and Scope–Duration Alignment for Capital Projects
g. Cross-Domain Knowledge Management Strategy for Mission Areas within the Force Projection Sector
h. Application of Multi-Criteria Decision-Making Methods to the DLA Energy Military Construction Portfolio Selection Process
i. Improving Team Performance by Identifying Significant Attributes Required in a Knowledge Management Solution for Fast-Paced Research Teams
j. Ranking of Cloud Service Providers Using a Dynamic TOPSIS Model for Provisioning of Enterprise IT Infrastructure in the Cloud
k. Application of Engineering Principles with a Comparison of Machine Learning Classification Methods to Predict Treatment of Outcomes in Head and Neck Cancer Patients
l. Quantitative Framework for Biopharmaceutical New Product Introduction
m. A Risk Matrix to Equip IT Practitioners in Government Operation Centers against Cyberattacks
n. A Practical Framework for Digital Service Innovation in the Public Sector: Improving North American Industry Classification System Code Usage to Enable the Convergence of Public, Private, and Multinational Participants
o. Establishing Interactive Teams to Help Locate Children Missing from State Care Using Quantitative Analysis Techniques
p. Reduction of Railway System Failures through Technical Uncertainty Analysis
q. Model-Based Alternative to Document-Based System Development for Enterprise Resource Planning

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8 Appendix: Illustrations

See next page.

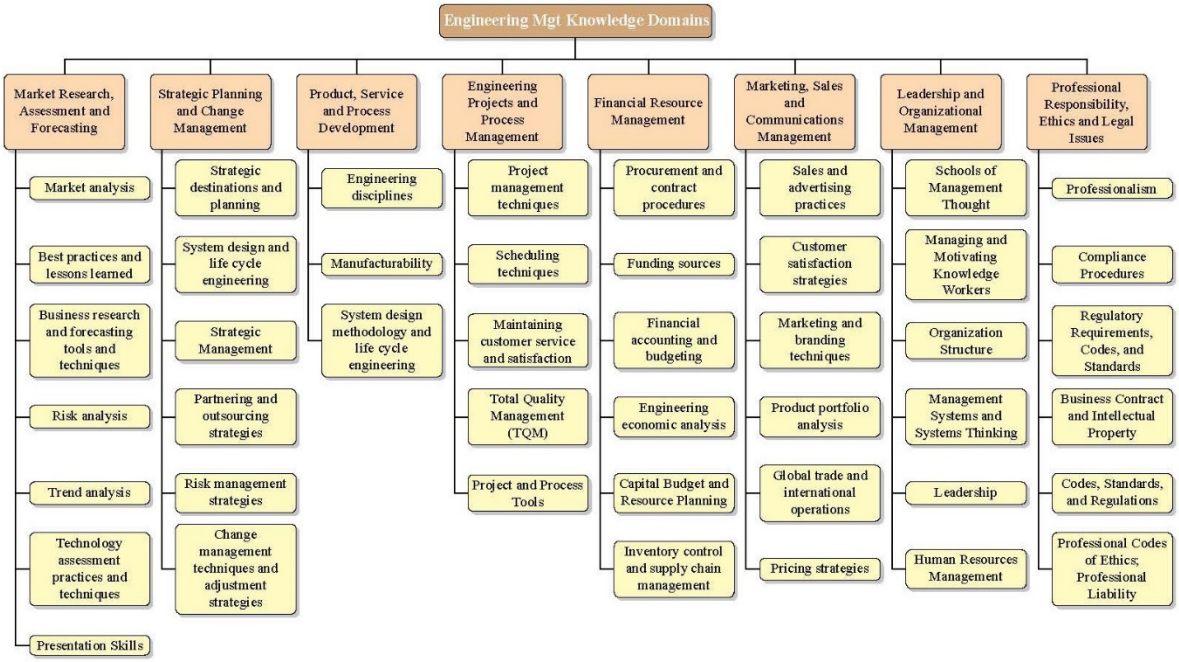

FIG. 1. ENGINEERING MANAGEMENT DOMAINS OF KNOWLEDGE.

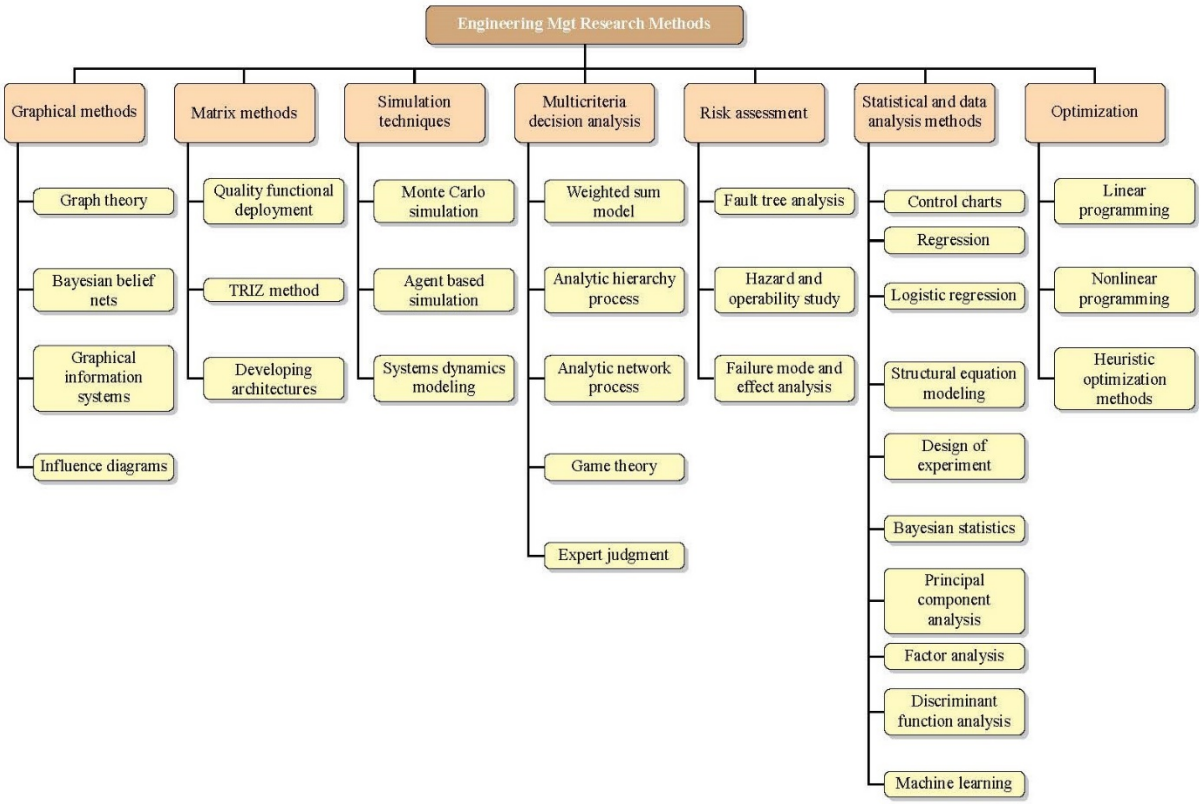

FIG. 2. RESEARCH METHODS IN ENGINEERING MANAGEMENT