LEHIGH UNIVERSITY | COMPUTER SCIENCE & ENGINEERING

PhD Student Handbook

Computer Science & Engineering

Lehigh University

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Earning a PhD involves developing a variety of complex and interdependent skill sets. Completing a PhD in the Computer Science and Engineering (CSE) Department at Lehigh will enable students to accomplish the following skill goals.

1. Demonstrate the capacity to conduct **independent research**. This capacity includes:
    a. *critical thinking* skills to identify and articulate a research question,
    b. the *technical* and *methodological proficiency* to perform the research,
    c. the ability to *report clearly the results* of their research and to *argue convincingly the significance* of their research, and
    d. the ability to *balance* the demands of research with other professional and personal commitments.
2. Obtain **fundamental skills** in core areas necessary to conduct computer science research. These skills include:
    a. familiarity with *research programming* techniques,
    b. a firm grasp of *algorithmic reasoning*, and
    c. developing a *research mindset* and familiarity with *general research practice* across a variety of computer science subdomains.
3. Become highly **effective communicators** in terms of both *written and oral* technical communication.
4. Develop **advanced knowledge** in a **variety** of computer science topics and areas. This knowledge will help *enable collaboration* with others who focus in those areas.
5. Become **community members** who actively participate in and contribute to their communities. This includes both the local CSE Lehigh community and the broader community of researchers and scholars within a student's subdomain.

PhD students cannot accomplish these skill goals on their own, nor should they be expected to. A student can expect their advisor to play a pivotal role in inculcating subject area skills (Goal 1.b, Goal 2.a, Goal 2.b, and Goal 4) and cultivating the habits of mind that typify an effective researcher (Goal 1.a and Goal 2.c). A student can also look to their advisor to model the professional comportment of a computer science researcher, including balancing among many diverse commitments (Goal 1.d), communicating clearly both the content and the import of their research (Goal 3 and Goal 1.c), and serving as responsible and contributing members of their various communities (Goal 5). Students can also expect their advisor to actively reinforce diversity, equity, and inclusion initiatives to help foster a welcoming environment for students of all backgrounds. Similarly, advisors play an important role in student well-being and can be expected to help students navigate graduate life, in part by guiding them to the various resources available.

A student and their advisor share a joint responsibility to determine the exact guidance and support necessary for the student to complete a successful PhD. Both advisors and students should be familiar with the requirements laid out in this handbook.

The timeline below outlines when students can be expected to develop each of these skills, along with the program milestones (described in the remainder of this handbook) that help inculcate and/or assess these skills. This table offers a normative timeline by which each skill

goal should be achieved. The detailed description of each milestone provides cut-off dates by which each student must demonstrate that they have achieved each skill goal.

Year(s)	Skill Goal(s)	Program Milestone(s)
1	Obtain fundamental skills necessary to conduct computer science research, including: - familiarity with research programming techniques (2.a), - a firm grasp of algorithmic reasoning (2.b), - a research mindset and familiarity with general research practice (2.c), and - a developing proficiency in both written communication and oral presentation (3)	Complete the three core courses Meet GPA requirement Attend at least 6 research seminars
1-3	Develop advanced knowledge in a variety of computer science topics (4), sufficient to collaborate with someone who focuses in that area	Complete the three breadth courses Meet GPA requirement
2-3	Demonstrate critical thinking skills (1.a) and a readiness to conduct (1.b) and to report (1.c) on independent research	Complete the qualifier
3	Be able to identify an interesting, important, and well-scoped research question (1.a); articulate a plan by which that question can be addressed (2.c, 3)	Complete admission to candidacy and the general exam
3-5	Complete a body of research that, as a whole, makes a novel and significant contribution within a chosen subfield of computer science (1.a through 2.c); clearly convey the substance of the research and its findings (3), as well as convincingly argue for the significance and novelty of that contribution (1.c)	Complete written dissertation and defense
n/a	Develop the ability to convey technical content to an audience with less expertise (3) Balance the demands of research with other professional and personal commitments (1.d)	Serve as a TA
n/a	Become a contributing member of the Lehigh CSE community (5)	Attend at least 6 research seminars Present at least once at the Graduate Research Seminar Series

1. Courses

Core Courses

Each PhD student must complete the following three (3) core courses:
- Advanced Programming Techniques (CSE 411)
- Research Methods (CSE 406)
- Advanced Algorithms (CSE 440)

CSE 411 will familiarize students with the technical aspects of conducting computer science research (Goal 2.a). CSE 406 will familiarize students with less technical aspects, such as designing research projects and situating the results thereof within a broader body of prior work (Goal 1.c and Goal 2.c). CSE 440 will provide students with a solid theoretical foundation (Goal 2.b).

PhD students must complete all three core courses during their first year. Exceptions must be approved in advance by the PhD Program Director.

Breadth Courses

Students must complete at least one (1) graduate course at the 400-level in at least three (3) of the following breadth areas.
- Artificial Intelligence and Data Science
- Robotics and Computer Vision
- Systems, Hardware, and Networking
- Interdisciplinary Applications

The faculty member who teaches each course will determine the breadth area towards which the course counts, if any. A student should consult with their advisor for recommendations on which breadth courses would be most useful for them. Completing these breadth courses helps familiarize students with advanced topics in a range of different subdomains across computer science (Goal 2.c). This breadth will help students to collaborate with others who specialize in a different area than their own (Goal 4).

Independent study courses (i.e., CSE 495) do *not* count towards the breadth requirement. Special topics courses (i.e., CSE 498) *may* count toward the breadth requirement. For such a course to count, the grade must be assigned based on multiple graded components, i.e., more than reading papers, discussing them, and completing a single final project. Any student wishing to include such a course toward the breadth requirement must receive approval before the course begins from the course's instructor, the student's advisor, and the PhD program director. An instructor may also determine that a given course does not apply to any breadth area.

Students may also wish to enroll in courses that are related to their research but are offered outside the CSE department. Such courses may count toward the breadth requirement if the

student receives approval from the student's advisor and from the PhD program director before the course begins.

The Department *encourages* students to complete all course requirements the same semester that they complete their Qualifier. Students *must* complete all course requirements before completing the General Exam.

Credit Requirements

In line with College policies in the RCEAS Graduate Student Handbook, PhD students admitted without a prior master's degree must complete at least 72 credits toward the PhD. Students who have earned a master's degree before admission to the PhD program must complete at least 48 credits toward the PhD (42 credits if the master's degree is from Lehigh). Credits beyond those earned to meet the above course requirements may come from any combination of further electives, supervised research credits (e.g., CSE 495), and/or dissertation credits.

GPA Requirement

A PhD student must maintain a GPA of 3.5 across all regular graduate courses, where regular graduate courses include both the three core courses and the three breadth courses.

Independent study courses (i.e., CSE 495) do *not* count toward the GPA requirement. Special topics courses (i.e., CSE 498) may count toward the bread the GPA requirement *only* if they are approved (before the course begins) to meet the breadth course requirement, as described above.

In line with RCEAS policy (from Section 4.2.1 of the RCEAS Graduate Student Handbook), courses where a student receives a grade of less than a C- do not count toward the course requirements. However, if such grades are received in a core course or a breadth course, those grades will factor into calculations for determining whether the student has met the GPA requirement. Furthermore, no regularly admitted student who receives more than four final course grades below a B- in courses numbered 200 or higher is allowed to continue registration as a graduate student.

2. Qualifier

The qualifier includes two portions: a qualifier project and a qualifier exam. The Department recommends that students complete the qualifier by the end of their second academic year. Students who do not complete the qualifier by the end of their third academic year may be required to leave the program. The qualifier is administered by a committee of three faculty members with an appointment in CSE. It helps ensure that students have the core skills necessary to conduct research in their selected subfield (Goal 1.b, Goal 2.a, and Goal 2.b)

Qualifier Project

The qualifier project must involve some sort of **substantial research activity**. That said, the exact nature and form of this activity may vary: an original research project, a survey paper, a replication study, a substantial piece of software, and other formats are all options. The qualifier project includes not only the conduct of the research itself but also producing a written document that summarizes the results of that research for the committee. The PhD student, advisor, and qualifier committee members should work together to determine the project format that aligns best with the student's research interests and goals. This project demonstrates the skill to perform independent research (Goal 1.b) and to communicate the results effectively in writing (Goal 3).

Qualifier Exam

The qualifier exam involves a public oral presentation of the qualifier project overseen by the qualifier committee.

In this oral presentation, the student presents the accomplishments of their qualifier project. The Department suggests that this presentation portion last roughly 30 minutes, though this length serves primarily as a guideline.

The student then answers questions, both from the committee and from audience members in attendance. The committee may optionally choose to dismiss the audience and ask the student further questions. The Department suggests that this question portion last roughly 30 minutes, though again this length serves primarily as a guideline. The student will then be excused while the committee deliberates to reach a conclusion on whether the student has passed the qualifier exam. Completing this exam helps students practice and refine their oral communication skills (Goal 3).

Students who do not pass the qualifier on their first attempt will be given one additional chance. The committee may request changes to the written project, a repetition of the oral exam, or both. Students who do not pass the qualifier on their second attempt will be required to leave the program.

3. Admission to Candidacy

The student must prepare a written dissertation proposal and submit it to their dissertation committee. The dissertation committee must include at least three faculty members with an appointment in CSE and at least one external member.

The written dissertation proposal must describe the research area in which the dissertation research is to be conducted, along with a plan for completing that research. The plan may include discussion of additional courses the student needs to complete, if any. The proposal will describe related work that has already been completed, both by the student and by others; the

work being proposed; plans for system implementation, experimental studies, data collection, analysis, etc. as appropriate; and the expected contributions of the proposed work. Providing this degree of detail will likely require at least 10-20 full pages of written content, plus a significant volume of references. If the advisor or committee members deem it necessary, the student may be required to revise the proposal document. The dissertation committee indicates their approval of the proposal by signing the admission to candidacy form. Preparing this proposal requires that students develop the ability to identify a novel research problem (Goal 1.a) as well as the ability to communicate effectively the importance of that research problem (Goal 1.c).

The Department recommends that students complete their admission to candidacy by the end of their third academic year. Students who do not complete their admission to candidacy by the end of their fourth academic year may be required to leave the program.

4. General Exam

The same semester in which the admission to candidacy is completed, the PhD candidate must also complete the general exam. This exam involves a public oral presentation of their dissertation proposal. The dissertation committee administers the exam. Committee members may ask questions that gauge the candidate's knowledge and background to ensure they have a sufficient grasp of the field to complete the proposed plan of research (Goal 1.b and Goal 2.c).

The Department recommends that PhD candidates be prepared to present for around 45 minutes. Procedures for asking questions of the candidate follow those from the qualifier exam: questions from the committee in front of the audience, questions from audience members, and closed-door questions from the committee. After all questions have been exhausted, the student will then be excused while the committee deliberates to reach a conclusion on whether the student has passed the general exam. The general exam ensures that the candidate has the necessary fundamental skills for computer science research (Goal 2), the ability to articulate and defend the importance of a proposed research plan (Goal 1.c), and the specific skills and knowledge necessary to conduct the proposed research plan (Goal 1.b).

Candidates who do not pass the general exam on their first attempt will be given one additional chance. The committee may request changes to the written dissertation proposal, a repetition of the oral presentation of the proposal, or both. Candidates who do not pass the general exam on their second attempt will be required to leave the program.

5. Dissertation Progress and Defense

A dissertation consists of a novel and significant contribution to knowledge. This is accomplished via concerted effort on a focused topic over an extended duration of time, usually multiple years. From the RCEAS Graduate Student Handbook:

> *The dissertation must address a topic related to the candidate's specialty in the major subject, show the results of original research, provide evidence of high scholarship, and make a significant contribution to knowledge in the field.*

The dissertation must be of sufficient quality to merit publication in a reputable conference or journal (Goal 3). The written dissertation document usually consists of multiple chapters, each of which clearly demonstrates one facet of the dissertation's contribution. The first chapter typically articulates and provides motivation for the research question(s) pursued (Goal 1.a). One chapter is often devoted to summarizing related work in a way that helps clarify the novelty and significance of the research presented in the dissertation. The final chapter generally summarizes the dissertation's contributions and describes the future directions those contributions illuminate (Goal 1.c). The PhD candidate should work closely with the advisor for guidance on how this general formulation should be used to present that candidate's specific research. The document must be prepared following the formatting guidance in the RCEAS Graduate Student Handbook.

The dissertation defense must be scheduled to occur at least seven months after the general exam, but will typically be a year or two later. If the student requires more than one year from the time of the general exam to complete the dissertation, meetings that update the committee on progress and discuss current challenges should be scheduled at least once every 12 months. These meetings will help update the committee members on the candidate's progress, as well as offer the candidate additional opportunities to improve technical communication skills (Goal 3). A copy of the written dissertation document must be provided to the committee at least two weeks before the defense date, with the exact timing decided collectively by the advisor, the PhD candidate, and the committee members.

The general procedure for the dissertation defense resembles that for the qualifier exam and for the general exam. The dissertation defense begins with a public presentation of the PhD candidate's research. A typical presentation will last roughly 45 minutes, though the advisor or committee members may request a longer or shorter presentation. The student then answers questions, both from the committee and from audience members in attendance. The committee will then dismiss the audience and ask the student further questions. The Department suggests that this question portion last roughly 45-60 minutes, though again this length serves primarily as a guideline. After all questions have been exhausted, the student will then be excused while the committee deliberates to reach a conclusion on whether the student has passed the dissertation defense.

6. Additional Requirements and Resources

In addition to the milestones above, PhD students must complete the following requirements.

Teaching Assistant

Each PhD student must complete at least one semester of teaching assistant (TA) service for a course in the CSE department. Doing so requires cultivating an ability to convey complex technical content to an audience with less familiarity or expertise (Goal 3). In most cases, this requirement will be completed in a single semester. On occasion, the department leadership may make partial TA-ships available, which usually involve similar types of work as a full TA position but with a lower expected time commitment. Combining more than one of such partial TA-ships can still meet this requirement, so long as the equivalent of one full semester of TA service is completed. While completing the TA requirement, students are expected to continue contributing to their research (Goal 1.d).

Research Seminars

During their first two years, PhD students must attend at least six (6) research seminars per semester. Doing so helps expose students to a breadth of topics in computer science, especially to topics outside the focus area of their own research (Goal 2.c and Goal 4).

Furthermore, students must present at a research seminar at least once during their time in the program. Doing so helps students refine their oral communication skills (Goal 3). It can also serve as a valuable opportunity to deliver practice versions of presentations, such as talks presenting conference papers. The *Graduate Research Seminar Series (GRSS)*, organized by PhD students, provides an optimal venue to satisfy this requirement. The public presentations that students are required to give for other milestones (e.g., the qualifier exam or the general exam) do *not* count toward the seminar presentation requirement.

Mentoring and Career Guidance

The Graduate Life and Education office provides a variety of programs for Graduate Writing Support. Examples include individual consultations, writing groups, writing workshops, and other formats.

Lehigh is also an institutional member of the National Center for Faculty Development and Diversity (NCFDD), a nationally-recognized, independent organization that provides online career development and mentoring resources for faculty, postdocs, and graduate students at any stage in your career.

PhD students are strongly encouraged to make use of these and other resources as supplements for the mentoring and guidance they receive from their faculty advisor and committee members.

7. Diversity, Equity, and Inclusion

Members of the CSE community come from highly diverse backgrounds. That diversity should be viewed not as a challenge to collegiality but as a resource for engendering a thriving and supportive community. From Lehigh's Principles of our Equitable Community:

- *We **affirm the inherent dignity** in all of us, and we maintain an inclusive and equitable community.*
- *We **recognize and celebrate** the richness contributed to our lives by our diverse community.*
- *We **promote mutual understanding** among the members of our community.*
- *We **confront and reject discrimination in all its forms**, including that based on age, color, disability, gender identity, genetic information, marital status, national or ethnic origin, political beliefs, race, religion, sex, sexual orientation, socio-economics, veteran status, or any differences that have been excuses for misunderstanding, dissension, or hatred.*

All members of the CSE community -- graduate students, faculty, staff, undergraduates -- have a right to feel welcome, respected, and understood. Nobody deserves otherwise. Similarly, we each have an obligation to promote open communication and to foster a welcoming, respectful, and understanding community for each other.

8. Well-being

A dissertation represents a significant, concerted, multi-year effort. However, it should not and cannot consume the entirety of a PhD student's or candidate's waking hours. The only healthy way to earn a PhD is to balance one's various professional pursuits -- research, teaching, and service -- and one's personal commitments (Goal 1.d). Neither should be completely sacrificed for the other. Each PhD student and candidate should look to their advisor, to other PhD students, to the department faculty, to the Lehigh University graduate school, and to other resources for guidance and exemplars of achieving a healthy balance. These resources include:

- Counseling and Psychological Services,
- the Graduate Life Office,
- the Office of International Students and Scholars,
- Lehigh's Taylor Gym and Campus Recreation Programs,
- the campus Health and Wellness Center,
- the Dean of Students,

and many others. Students should also strive to serve as examples of such a balance for their peers (Goal 5).