

Joint PhD Program in Computer Science and Learning Sciences

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PROGRAM RATIONALE

The Joint PhD Program in Computer Science and Learning Sciences builds on enduring and growing connections between research on learning and research in computation. Rapid technological advances continue to create new and exciting ways to both understand and support learning in all settings and in all stages of life. This program is intended for students with an interest in both fields who would otherwise be forced to choose one area or the other. Students from a variety of backgrounds will be provided with rigorous training in the learning sciences and computer science with the aim of producing independent scholars.

AREAS OF INTEREST

The possible areas of study are broad and draw from the diverse expertise of affiliated faculty. **However, all research must have clear relevance to both Computer Science and Learning Sciences.** Example areas of interest include educational data mining; computational modeling as a means to understand complex scientific phenomena; adaptive technology for learning; equity issues in computing; intelligent tutoring systems; and interaction design to support learning. The following areas often span both computer science and learning:

Interaction Design	Computational modeling and simulations
Artificial Intelligence	Programming language design
Machine Learning	Crowd Sourcing
Social Computing	Cognitive Modeling
Learning Analytics	Game Design
Educational Data Mining	Computer Science Education
Visualization	Learning at Scale
Tangible and Ubiquitous Computing	Robotics

COURSES

Students are expected to take courses during the first two years of their graduate career. Every student is required to take courses that fulfill specific requirements for breadth and depth in computer science and learning sciences. Students are also expected to take coursework and continue reading beyond these specific requirements. In particular, students should take coursework that is relevant to their research.

Learning Sciences Foundational Courses (4 courses)

- LS 401 ---OR--- EECS 371: Knowledge representations
- LS 402: Social Dimensions of Teaching and Learning

- LS 403: Foundations of the Learning Sciences
- LS 426: Design of Technological Tools for Thinking and Learning

Learning Sciences Approved Methods Courses (choose 3 courses)

- LS 410: Quantitative Methods I
- LS 451: Quantitative Methods II (regression analysis)
- LS 451: Discourse Analysis
- LS 415: Field Methods
- LS 416: Advanced Qualitative Methods
- LS 451: Computational Methods
- EECS 472 / LS 451: Designing and Constructing Models with Multi-Agent Languages

Computer Science Foundational Courses (at least 5 courses)

Students will declare a Computer Science concentration (e.g., Graphics and Interactive Media or Cognitive Systems). Students should take at least 5 courses in CS that are approved for graduate credit (all 300 and 400-level courses, unless specifically listed as ineligible for graduate credit). Students should consult the qualifying procedures for their program to ensure they have the necessary background for their concentration. The requirements for GIM and CogSys are listed below for reference:

Graphics and Interactive Media (GIM)	Cognitive Systems (CogSys)
<p>All GIM students are required to demonstrate proficiency in computer science and other core fields of GIM:</p> <ul style="list-style-type: none"> • Programming (comparable to CS 111+211+311) • Theory <ul style="list-style-type: none"> ◦ Fundamental algorithms ◦ Computing and complexity theory • Systems (2 of the following) <ul style="list-style-type: none"> ◦ Operating systems ◦ Databases ◦ Computer architecture ◦ Networking ◦ Programming languages • Graphics or media • Cognitive and social systems (any course in AI, cognitive science, social science) 	<p>By the Qualifying Exam, you should be conversant with the material in the following courses:</p> <p>EECS 325: Artificial Intelligence Programming EECS 337: Semantic Information Processing EECS 338: Practicum in Intelligent Information Systems EECS 344: Design of Computer Problem Solvers EECS 348: Introduction to Artificial Intelligence EECS 349: Machine Learning EECS 371: Knowledge Representation</p>

Breadth Courses (3 courses)

Three additional courses are required within years 2 and 3. Any non-required, graduate-level course in any school or department can be used to fulfill the breadth requirement.

RESEARCH

The primary goal of the program is to prepare students to be independent researchers in Computer Science and Learning Sciences. There are a variety of ways in which students learn to conduct research, including formal coursework in research methods. However, the most important way in which students learn to conduct research is through mentored participation in research.

Students are encouraged to begin to participate in research activities as early as possible in their graduate career. In the fall and winter quarters of their first year, students may simply attend meetings of different research group. Then, as they decide on a permanent advisor, they may take responsibility for research activities under close supervision, gradually taking on more responsibility and more autonomy, until they are prepared to conduct independent research. Since students enter with very different levels of preparation for conducting research, there is no single path. Students should develop an individual plan for engaging in research in consultation with their advisor(s).

Students are required to begin participating in research in the winter quarter of their first year. To fulfill this requirement, students must minimally attend meetings of one or more research groups or meet with a faculty member (typically the temporary or permanent advisor) on a regular basis to discuss research. It is expected that the amount of research activities and the level of responsibility will increase steadily over time.

COMMUNITY & RESIDENCY

The CS+LS Program at Northwestern is a learning community made up of graduate students, research scientists, post-doctoral fellows, undergraduates, and professional staff. PhD students play an important role in this community. To maintain the health of that community, the faculty have the following expectations of all PhD students:

- Students will be present as much as possible during working hours throughout the school year and the summer.
- Students will attend and actively participate in public events sponsored by Computer Science and Learning Sciences Programs, including brown bags, colloquia, job talks, and dissertation defenses.
- Students who have personal or family reasons for exceptions to these expectations should consult with their advisors.
- There is a strong expectation of participation in the community with the goal of fostering an environment conducive to effective and innovative research programs.

ACADEMIC MILESTONES

Begin research	Winter quarter 1 st year
Identify permanent advisor	Summer before 2 nd year
Completion of required coursework	End of 2nd year
Written LS qualifying literature review	End of 2nd year
Written CS qualifying exam	End of 2nd year
Written research paper (LS & CS)	Summer before 3rd year
Oral presentation of the research (LS & CS)	Beginning of 3rd year
Dissertation prospectus	By the end of 4th year
Pre-defense	
Defense	

ADMISSION TO CANDIDACY

Admission to candidacy is an important milestone on the road to a PhD. This is based on an evaluation of the students' work in the first two years, including coursework, residency requirement, qualifying exams, written and oral research presentations at the beginning of the third year, and participation in research activities. At the completion of the qualifying process, students whose work meets the standards of the program are admitted into candidacy. Two important considerations in this evaluation are: (1) Has the student demonstrated the breadth and depth of understanding necessary to be a successful researcher? (2) Has the student demonstrated the ability to conduct research of sufficient quality to complete a dissertation within a reasonable period of time with a reasonable level of faculty supervision? There is no pre-determined number of students who are admitted into candidacy. All students who are judged to be performing at an appropriate level will continue in the program. If the faculty do not feel that they have enough evidence yet to make a decision, a student might be asked to conduct an additional task by a specified deadline, at which point their case will be reviewed again. Occasionally, there are students whose performance does not indicate that they will be able to successfully complete a dissertation of the quality expected by the Learning Sciences faculty, and they are not invited to continue in the program.

(See also the [TGS website for the deadline for admission to candidacy](#)).

WRITTEN QUALIFYING EXAMS

While the written qualifying exam is an important element of the process of qualifying for candidacy, it is only one component of the review that faculty conduct. As part of the progress review conducted at the end of the second year, faculty also take into consideration a student's performance in courses and in their research, as evidenced both by their the year research presentation and the report of his or her advisor.

Learning Sciences

In Learning Sciences, the written qualifier takes the form off a guided literature review completed over the course of the second year with guidance from a panel of three faculty members. Information about the guided literature review can be found in the LS PhD Program Handbook.

Cognitive Systems

The Cognitive Systems Qualifying Exam is a one-day written exam, traditionally the Monday or Tuesday after Finals week of Spring Quarter. The exam is open-book, open-notes, and graded anonymously. Graduate students must take the exam at the end of their second year. The committee for a student's Qualifying Exam is determined by the student's adviser and CogSys Group's faculty.

YEAR RESEARCH PRESENTATION AND PAPER

As part of the qualifying process, students are required to conduct a research project that they write up and present publicly. As part of this research, a student must formulate a question or hypothesis and pursue it using an appropriate research methodology. The paper and presentation should ground the research in the existing literature, describe and justify the research design, present the findings, and describe limitations and next steps. In the presentation and the paper, students will be evaluated on the quality of the research and on the clarity, coherence, and organization of their communication.

The presentation is a 20-minute presentation to an academic audience modeled on a conference presentation. The model for the paper is a journal or Computer Science conference submission. As many faculty as are able will attend the presentations and participate in their evaluation. The paper is due and the presentation takes place at the beginning of the third year. The paper due date and presentation schedule will be announced at the beginning of the summer quarter. Two faculty members, including the student's primary advisor, will evaluate each paper.

DISSERTATION PROSPECTUS AND DEFENSE

The dissertation prospectus is a document that describes and justifies a plan for a research project to be completed by the student. The Prospectus is due by the end of the fourth year of study. This research project will be the basis for the PhD dissertation. The prospectus must chart a line of research that will make a substantial contribution to an important area at the intersection of Learning Sciences and Computer Science. It must explain how the research builds on prior work in the field and describe the plan of research in sufficient detail to allow a faculty committee to determine if the work is designed appropriately to meet its goals, and if its results will represent a sufficient contribution to merit a doctorate from Northwestern. The prospectus is reviewed by a committee of at least three faculty members and chaired by the student's advisor. The committee must include representatives from both CS and LS with the intention to bring expertise from both disciplines.

The remaining requirements for the composition of a Prospectus committee is [specified on The Graduate School website](#). When the dissertation committee feels the student is ready, a Prospectus defense is scheduled. The scheduling of this defense should be done in consultation with the advisor and the committee.

Outcome

At the conclusion of a prospectus defense, a student may pass or may be required to revise the document and/or defend it again.

PhD DISSERTATION AND DEFENSE

The PhD dissertation is the culmination of a graduate career. A dissertation represents a substantial piece of work that makes a contribution to the fields of Learning Sciences and Computer Science. The dissertation is submitted to the student's dissertation committee for review. Once the committee has determined that the dissertation is ready to be defended, the student can schedule a dissertation defense. A hardcopy of the dissertation must be given to the CS + LS Program Assistant at least 2 weeks before the defense, and it must be made available electronically, so that all interested faculty may read it in advance. The defense itself consists of a public presentation followed by private discussions.

Public Presentation

The primary audience for the defense presentation is the faculty. Other members of the community (students, postdocs, and other researchers) are invited to attend the defense presentation as observers. Only faculty members and members of the students' dissertation committee are invited to ask questions or comment at the defense presentation. The defense presentation consists of:

- A 45-minute presentation that presents and defends the findings of the dissertation. Students should be careful to allocate sufficient time to present their findings. Questions during this time will be limited to clarification questions.
- A 15-20 minute question-and-answer session between faculty and committee members and the student.

A faculty member who is not a member of the student's committee will serve as the chair of the defense presentation. The chair will keep time and serve as moderator for questions. At the conclusion of the public presentation, the observers leave the room.

Private Discussion

If any faculty member requests it, there may be an additional question-and-answer session with the student after the outside observers leave. This session is limited to 15-20 minutes. Following this private q-and-a, there is a private discussion among the faculty and the student's dissertation committee without the student in the room. This discussion provides an opportunity for the faculty to provide their feedback on the defense and/or the dissertation to the dissertation committee. There is no pre-determined time limit for this discussion.

Outcome

At the conclusion of the discussion, the student leaves the room for a period during which the committee makes a decision about the outcome of the defense. A student may pass the defense with no conditions, or may be asked to revise the dissertation, repeat the defense presentation, repeat the discussion, or some combination of these or other conditions that the committee feels are appropriate.

Submission of the Dissertation

Once the dissertation has been approved by the committee, the student prepares the dissertation for submission. Students should obtain [guidelines for submission](#) from The Graduate School and be aware of all deadlines for submission. The student must fill out the form entitled "[TGS Final Exam](#)" and receive signatures from all dissertation committee members. This form is available on CAESAR; it should be submitted to the Program Assistant. The PhD Completion information can be found on [The Graduate School's website](#).

TEACHING

To support their professional development, all PhD students are required to serve as a teaching assistant (TA) for at least three courses during their graduate career (at least 1 CS course and 1 LS course). As part of this apprenticeship, students should expect to be involved in all aspects of the planning, management, and assessment in collaboration with the professor. In their second teaching assistantship, students can expect to be responsible for teaching at least one class session or week of the course.

ADVISING

The Advisor

A PhD advisor plays a very important role in a graduate student's life and career. The PhD advisor supervises the student's research, provides guidance on academic and career issues, and serves as the

chair of the student's dissertation committee. Because the advisor plays such a critical role, it is important to find the best possible match for both research interests and personality.

The First-Year Advisor

Entering students are assigned a first-year faculty advisor. We will attempt to match students with first year advisors based on mutual research interest, and we expect that most students will continue with the same advisor beyond the first year. However, it is not uncommon for students to switch advisors during their first or second year. There are many valid reasons for changing advisors, so students should be aware that they have the option to do so. However, changing an advisor is likely to slow a student's progress toward a degree and has practical implications. If a student has made commitments to complete work with or for an advisor, the student should make every reasonable attempt to fulfill that commitment as part of the plan for switching advisors.

By the summer before the second year, a student should select a permanent advisor. (In some cases, a student may be co-advised by two faculty members or a student may continue to have more than one advisor into the second year.) The annual performance review form for the first year requires a student to identify an advisor and obtain the advisor's signature. Students must have an advisor to continue into their second year.

A faculty member becomes a student's permanent advisor by mutual agreement. A faculty member is not obligated to advise any particular student nor to continue advising a student if the advisor is not satisfied with the quality of the student's work. Before selecting an advisor, a student should have a clear idea from the faculty member what he or she expects of the student, how the advisor expects the student to be funded, and how they will work together (e.g., how often they will meet and in what settings). In the case of students whose advisor will be supporting them with a research assistantship, the student and advisor should have a clear understanding of what the student will be expected to do for the research assistantship and the relationship between that work and their dissertation research.

ANNUAL PERFORMANCE REVIEW

Every spring quarter, each student is required to submit an annual report describing his or her progress during the past year and goals for the coming year. The program steering committee then reviews each student in conjunction with that student's advisor. The committee considers the student's self-report and other evidence of students' progress, including course work, research activities, publications, presentations, and other professional activities. Following this review, each student receives a letter with feedback on progress and suggestions for the coming year. Students whom the faculty feel are not making satisfactory progress will be notified of this as part of this review process.

ACADEMIC INTEGRITY

The PhD program adheres to and endorses The Graduate School at Northwestern University's policies on academic integrity, found on the website <http://www.tgs.northwestern.edu/academicservices/integrity/>.

TGS policies state:

"Academic integrity is fundamental to every facet of the scholarly process and is expected of every student in The Graduate School (TGS) in all academic undertakings. Integrity involves firm adherence to

academic honesty and to ethical conduct consistent with values based on standards that respect the intellectual efforts of both oneself and others. Ensuring integrity in academic work is a joint enterprise involving both faculty and students. Among the most important goals of graduate education are maintaining an environment of academic integrity and instilling in students a lifelong commitment to the academic honesty that is fundamental to good scholarship. These goals are best achieved as a result of effective dialogue between students and faculty mentors regarding academic integrity and by the examples of members of the academic community whose intellectual accomplishments demonstrate sensitivity to the nuances of ethical conduct in scholarly work.

Standards of academic integrity are violated when a student engages in actions including:

- cheating in the classroom or on examinations, including master's final examinations and Ph.D. qualifying examinations;
- the intentional and deliberate misuse of data in order to draw conclusions that may not be warranted by the evidence;
- fabrication of data;
- omission or concealment of conflicting data for the purpose of misleading other scholars;
- use of another's words, ideas, or creative productions without citation in either the text or in footnotes;
- paraphrasing or summarizing another's material in such a way as to misrepresent the author's intentions;
- and use of privileged material or unpublished work without permission.”

In cases for which violations of academic integrity is expected or evidence is found, the program will enact procedures to pursue those cases under the guidance of the Dean, Coordinator, and faculty, as well as through The Graduate School as appropriate. TGS’s Dishonesty Procedures can be found on the website: <http://www.tgs.northwestern.edu/academicservices/integrity/dishonesty/>.

In addition to the policies of the program and The Graduate School, students should be aware of and adhere to the policies outlined by Northwestern University:

<http://policies.northwestern.edu/policies-by-audience.html#student>

HANDBOOK INSERT: Learning objectives and Assessment Criteria

Program: Joint PhD Program in Computer Science and Learning Sciences

Graduate Program Goals/Mission Statement:

The Joint PhD Program in Computer Science and Learning Sciences builds on enduring and growing connections between research on learning and research in computation. Rapid technological advances continue to create new and exciting ways to both understand and support learning in all settings and in all stages of life. This program is intended for students with an interest in both fields who would otherwise be forced to choose one area or the other. Students from a variety of backgrounds will be provided with rigorous training in the learning sciences and computer science with the aim of producing independent scholars.

Learning objective(s) <i>Students should be able to...</i>	Milestone/ Requirement/Capacity	Assessment Strategies and Criteria* <i>How do we know this objective has been achieved? What criteria do we have to measure success?</i>
Contribute original research to the scholarly community.	Dissertation Prospectus/ Research Publications	
Students will have familiarity with the three stands of the learning sciences : cognition, social & cultural context, and design as well as a working understanding of a range of learning sciences research methods .	Students will demonstrate this familiarity in their written learning sciences qualifying exams at the end of their second year in the program.	The exam requires students to draw on foundational literature to demonstrate depth-of-knowledge in one of the strands. Each question is read by three faculty graders who score responses on a 10-point scale guided by a rubric.
Students will have familiarity with a breadth of computer science topic areas . Topic areas include, but are not limited to,	Students must take at least 5 courses in Computer Science to fulfill their	Students must pass the appropriate computer science qualifying exam (typically Cognitive Systems or Graphics and Interactive Media)

systems, theory of computation, programming languages, algorithms, cognitive systems, human-computer interaction.	concentration requirements: EECS 211, 311, 325, 337, 338, 344, 348, 349, 371	
Students will demonstrate expertise in one area of computer science within the division of <i>graphics and interactive media</i> or <i>cognitive systems</i> .	Students will demonstrate this expertise by completion of the appropriate computer science qualifying exam.	