

Education **IN MATHEMATICS, SCIENCE & TECHNOLOGY**

The M.A. and Ph.D. programs in Education in Mathematics, Science & Technology (EMST) in the Graduate School of Education at the University of California, Berkeley prepare students to understand and improve learning and instruction in mathematics, science, and technology across the lifespan (with emphasis on middle-school through university). These programs seek fresh insights into major educational problems using the perspectives of cognitive science, socio-cultural theory, and the resources of modern technology. In the programs, students:

1. develop scientific understandings of learning and instruction in mathematics, science, and technology;
2. build frameworks and theories (of knowledge organization, of problem solving, of teaching) as well as contributing to the empirical scientific knowledge base for education;
3. conduct “design experiments” in which innovative instructional strategies, materials and technologies are crafted in theoretically principled ways, and studied as they are used in classroom settings.
4. work in partnership with teachers and with natural scientists.

The program is unusual in emphasizing both conducting research that makes fundamental contributions to the field’s understanding of thinking, teaching, and learning, while also contributing to the solution of practical instructional problems. Foci of faculty work have included the development of instructional units at middle-school, secondary, and collegiate levels; studies of highly effective instruction; and studies of transformative uses of new technology.

The EMST program uses an "apprenticeship" approach to graduate studies. In their first semester, students affiliate with one or more research groups, and are increasingly involved in planning and carrying out research projects. Many EMST courses have empirical projects, which are often the basis for students’ first- and second-year projects and papers for their qualifying examinations. Such coursework and projects establish the base for, and often evolve into, dissertation projects.

Students acquire a firm grounding in the theories and methodology underlying this interdisciplinary specialty through classes, seminars, colloquia, and research in three areas:

- individual and collective cognition (e.g., conceptual change, genetic epistemology, embodied cognition, and metacognition),
- learning and knowledge in the disciplines (e.g., the nature of mathematical problem solving, programming and problem solving), and
- design of instruction (e.g., cognitive consequences of technology, principles of effective physics learning environments productive apprenticeship in disciplines).
- Colloquia bring topnotch scientists and educators from around the country to speak at Berkeley on a regular basis.

Students with strong backgrounds in mathematics, science, engineering, computer science, psychology, cognitive science, or technology may apply to obtain an M.A. or Ph.D. The Ph.D. prepares students for careers in university or college research and teaching, professional design of instructional materials, and research for policy and other private or governmental organizations. The M.A. prepares students for Ph.D. studies and for careers in instructional design, educational policy, or educational reform.

Focus of Study

Sample research foci within EMST include studies of mathematical thinking and problem solving, cognition in the sciences, embodied cognition, the analysis and design of effective "local cultures" for learning both in and out of school, equity, and the development of distributed and individual computational environments to enhance learning.

The faculty has an especially deep expertise in explorations of individual and collective cognition and the study of learning in particular scientific disciplines. The program draws on complementary expertise from across the School of Education. Students interested in applying to the program should examine faculty web pages and read the sample papers linked to them, in order to get a sense of the work that is done in EMST.

EMST DEGREE REQUIREMENTS

Course Requirements

Ph.D.

All students admitted to the Ph.D. program must complete a required set of courses; Some set by the Graduate School of Education and some by the degree program. In many cases, it is possible to satisfy requirements in both categories with one course. Students should consult with their faculty advisors when choosing courses for their degree program.

M.A./Ph.D.

The Graduate School of Education also requires that all students admitted to the Ph.D. program without an M.A. should complete the M.A., Please refer to the *Graduate School of Education Handbook for Advanced Degree Students* for more information.

The second year project report (due the first day of the student's fifth semester) will serve as the Master's project. Since a second year paper is required of all M.A./Ph.D. students (and is then used as one of the three papers for the pre-qualifying exam), this will allow students in good standing to pick up the Master's degree in their fifth semester, on the way to more advanced degree work.

M.A

The EMST terminal M. A. works along the same apprenticeship lines of the EMST doctoral degrees. Students affiliate themselves with faculty members' research groups when they enter the program. Master's students must meet the School's requirements for the degree: 21 units plus thesis (Plan I). They take a constrained selection of the courses required for the EMST doctoral program, supplemented by a Master's thesis that is, usually, a modification of the program's required first-year project.

EMST terminal master's students must take one course in each of the following categories:

- SCMATHE 210, First Year Seminar (two semesters; fall and spring)
- EMST-approved Qualitative and Quantitative methodology courses
- School of Education core course selected from approved list
- Individual and Social Perspectives (former General Cognition)
- Discipline-specific
- Curriculum and Technology Design

Ph.D COURSE REQUIREMENTS

GRADUATE SCHOOL OF EDUCATION REQUIREMENTS

Please carefully read the “Handbook for Advanced Degree Students in the Graduate School of Education,”

The EMST program requires doctoral students to complete courses in each of the following seven areas. These courses provide exposure to the major concerns and issues of this field of study. Students who wish to substitute other courses to meet the requirements may petition the EMST Curriculum Committee. There is additional course work required by the Graduate School of Education.

NB: Students must take required courses for a letter grade. A student's transcript is required to have a balance of courses with letter grades and pass/fail grades (or satisfactory/unsatisfactory) such that two-thirds of the course units have earned a letter grade.

First Year Seminar | two semesters during first year of enrollment:

SCMATHE 210 Practicum in Science and Mathematics Education, Research and Development

Individual & Social Cognition (formerly General Cognition) | **two courses required:** Courses involving a cognitive science approach to thinking, learning or instruction.

EDUC 226	Constructive Epistemology (diSessa)
EDUC 227	Metacognition (Linn, White)
EDUC 229A	Problem Solving and Understanding (x-listed as Psychology 220D (Ranney)
EDUC 229B	Cognitive Science Approaches to Learning (diSessa)
EDUC 229D	Discourse and Learning in Math and Science Classrooms (Engle; added F'08)
EDUC 229F	Conceptual Change (diSessa)
EDUC 232	Problem Solving and Understanding in Elem. School Classroom (Metz)
EDUC 290C	Representations (diSessa)
EDUC 290C	Principals for Embodied Design (Abrahamson; added Sp '06)
EDUC 290C	Neo-Vygotskian Perspectives on Cognitive Development (Saxe; added May '07)
EDUC 290C	Cognitive Ergonomics in STEM Education Research (Abrahamson; added August '07)

Discipline | one course required: Project-based courses on learning and instruction in a particular subject area (mathematics, computer science, or one of the physical sciences). In addition to extensive readings, the student must conduct, report on, and write up an empirical study (an experiment, clinical interviews, models of out-loud protocols, field work, etc.) germane to the course.

EDUC 222A	Programming & Problem Solving (Linn)
EDUC 224A	Mathematical Thinking and Problem Solving (Schoenfeld)
EDUC 224B	How People Learn Computer Science (Staff)
EDUC 290C	Scientific Thinking and Learning (Diehl, Allen, White, Chang)
EDUC 290C	Learning Chance: Computer-Supported Inquiry into Probability (Abrahamson; added May '07)

Curriculum and Technology Design (formerly Curriculum and Instruction) | **one course required:**

Project-based courses on the principled development of instructional materials. A major part of such courses is the production and/or evaluation a substantial piece of instruction.

SCMATHE 220C Instructional Design in Science/Mathematics Education (Linn)

EDUC 221A	Ambitious Instruction in Mathematics: Theory into Practice (Engle; added January '06)
EDUC 221B	Curriculum Development & Instruction in Science
EDUC 222B	Design of Computer-Based Instruction
EDUC 290C	Scientific Cognition: Development, Learning & Instruction (Metz; added Dec '06)
EDUC 295B	Technology, Curriculum and Instruction (Staff)

EDUC 290C Design-Based Research in Mixed-Media Learning Environments (Abrahamson; approval pending)

Colloquia | four semesters taken in first two years of enrollment (second year requirement added Dec '06)
SCMATHE 292 Research Seminar and Colloquium (Chang)

Methodology | three courses: one chosen from Qualitative Methods, one chosen from Quantitative Methods, and one chosen from either category in consultation with your faculty advisor(s):

Qualitative Methodology

EDUC 228A Qualitative Methodology (Metz & Saxe; Ranney)
EDUC 228B Modeling of Knowledge and Cognitive Processes
EDUC 212 Cognition and Learning in Social Context
EDUC 288B Theory and Methods of Field Work
EDUC 290C Modeling-Based Methodology for Design, Learning and Research (Abrahamson; approval pending)
EDUC 293V Video-Analysis Seminar (Engle; added August 2007)

Maybe also apply for waiver based on previous or proposed coursework.

Quantitative Methodology

EDUC 293A/L Sec. 1 Methods of Analysis for Educational Research and Decision-making
EDUC 293 A/L Sec. 2 Data Analysis in Educational Research and Program Evaluation.

Maybe also apply for waiver based on previous or proposed coursework.

STEPS TOWARDS THE PHD

First Year and Annual Evaluations

At the beginning of a student's second year in the Ph. D. program the faculty of EMST evaluate the student's "first year" progress towards the Ph.D. This evaluation is based on papers, projects, coursework and grades produced during the previous academic year as well as reports from the first year advisors. At this time, the faculty will make a recommendation to the School of Education as to whether they feel the student should be allowed to proceed with the Ph.D. Subsequently, all EMST students are given an annual evaluation (held each fall during the first three weeks of the semester) to determine whether they are making the expected progress through the program and what steps they may need to take to improve their progress. All EMST faculty at an annual meeting carries out the evaluation of students. In preparation for this meeting, all students are asked to submit a current curriculum vitae and an evaluation form that supplements the vitae. Although course progress is important, research and professional growth are the main bases of annual evaluations.

After the evaluation meeting, each student is sent a letter that summarizes the faculty's evaluation. This letter becomes part of the student's permanent file. A copy is also sent to the Graduate Division. In some instances the letter may specify certain things that a student should do to maintain good standing in the program.

First and Second Year Projects

In line with the division's commitment to the apprenticeship model, Ph.D. students in EMST are involved in research projects through coursework or research assistantships from their very first semester. As an extension of this work, students are expected to submit, at the beginning of their third and fifth semesters respectively, major first and second year papers that are the result of a significant empirical study or a development project.

These studies and writing of the results are done under the supervision of the two co-advisors selected from the EMST faculty who will also act as the two readers for the evaluation of the project. Typically, for the first year project the 1st reader will be the provisionally assigned first year advisor. The student will select the second reader during the year. By the second year the student should designate a long-term advisor, who would then act as the first reader for the second year project. A second member of the faculty would be asked to be the second reader.

Typically, first and second year projects should expand upon course projects or work done on faculty research projects. They are expected to be significantly larger in scope and more polished than course papers. If the Nth year project presents the report of one or more empirical studies, then the report should contain a significant amount of data analysis. If it is primarily a development project, it should contain theoretical and empirical components as well; that is, there should be a solid rationale explaining why the materials were developed; there should be reports of "trial runs" with a reasonable number of subjects, and a discussion of the ways that the trial runs (a) substantiated or called into question the theoretical assumptions underlying the project, and (b) suggested revision of the materials.

There are at least two very different approaches to the development of these projects:

1. Student as second author: Using this approach, the student begins by having an implementation role in the research as well as writing responsibilities. That is, the advisor or course instructor largely conceptualizes the work and defines the student's role in it while the student carries out the work and writes up the results. This is the model most likely to be used for the first year project.
2. Student as first author: In this approach, the student takes a major role in conceptualizing the project that is then carried out. This model is more likely to be used by the second year student. At this point in the graduate program the student is more knowledgeable and the standards are accordingly higher.

By the third year the student is ready to conceptualize a dissertation project and has refined the tools to carry out the work.

Either model is, of course, acceptable for either project. In choosing the approach, students should seek guidance on the projects from their advisor and feedback from the project co-advisor.

Supervising and Evaluation

Two readers who discuss their evaluations with the entire EMST faculty perform the evaluation of the first and second year projects. When a Ph.D. student is admitted to EMST, a "first-year advisor" is

assigned. It is understood that this assignment is temporary (although quite often the first year advisor will turn into the student's dissertation advisor) and not binding; should a student, later in the year, discover that he/she want to work with another faculty member, this can be arranged without ramifications of any sort. The idea is to ensure that for the first year project there is one faculty member with primary supervisory responsibility for each student. During the year the student will ask a second member of the faculty to act as the "second reader."

Project Quality

The quality of the project should evolve to meet the standards of professional societies, such as AERA or the journals *Cognitive Science*, or *Cognition and Instruction*. In particular, the papers should be organized and written as though they were to be submitted to a professional journal or presented at meetings of professional societies: such papers are typically substantive and relatively terse. We would expect the papers to be 20-30 pages. Exemplary project models are on file in the EMST program office (4533 Tolman Hall). Another good source of information is the SESAME Lecturer, Dr. David Kaufmann (4609 Tolman Hall).

Pre-Qualifying Examination

The purpose of the pre-qualifying examination is to provide feedback to the student regarding the student's readiness for the qualifying examination; this will certify that the student is competent at the professional level in the discipline and ready to embark on dissertation work. (Please note that there is a separate process for reviewing dissertation proposals. See the School's Graduate Student Handbook for details). Such competence includes: familiarity with aspects of both quantitative and qualitative methodologies; the ability to review large bodies of literature and write integrative summaries of them; the ability to discuss the implications for instructional theory and practice of various works in the literature (and one's own projects); and some experience in experimental and instrument design.

The student is expected to develop these areas of competence over the course of completing her or his course and project work; the pre-qualifying procedures are designed to provide an opportunity for feedback to students at this stage in the academic development and not to serve as a major hurdle. As always, students should consult with their advisers regarding preparation and the appropriateness of their choice of papers.

The required option within EMST, among those offered by the Graduate School of Education, is the "three papers option," in which the student submits three papers to the faculty as evidence of her or his academic preparation. It is fully expected that at least one and possibly both of the student's annual project reports will serve as "position papers" for the pre-qualifying examination; other course papers or research projects should round out the choice of papers (the dissertation proposal is not an acceptable "third paper"). Since the project reports will demonstrate significant mastery of methodological and empirical detail, it is likely that the additional paper(s) will either be theoretical or review papers which may well have been prepared for courses the student has taken, but may also be first versions of review papers for the student's qualifying exam.

Qualifying Examination (Orals)

In accordance with University requirements, four examiners, of whom at least one must be a professor at UCB from outside the department, are chosen by the candidate in consultation with the student's principal advisor, for approval by the graduate advisor and the dean. In the EMST division the examination is approximately three hours in length, structured so that the first hour is devoted to exploring the student's general command of the larger problems of Education, beyond the areas of

concentration to which the other two hours will be devoted. Prior to the exam the student submits to the advisor a list of readings books and articles, knowledge of which the examiners can presuppose in the exam. After review and possible emendation by the student's advisor, the reading list will be sent to the other members of the exam committee for review. This should be completed at least one month before the date of the examination. The exam will address the position papers and may include the dissertation prospectus, if appropriate.

The purpose of the examination is to allow the faculty to evaluate the student's qualifications to independently undertake the dissertation project. Passing the exam reflects the faculty's confidence in the student's knowledge and preparation to carry on dissertation research. The examination is normally taken during the seventh semester of the program, after course work and other program requirements have been fulfilled.

Qualifying Examination and Dissertation Prospectus Review is required of all Ph.D students. Details for completion of the Qualifying Examination can be found in the School of Education's handbook for Advanced Degree Students.

Dissertation Research

The dissertation is the result of a major piece of research that typically requires one or two years to complete. The dissertation should be an outgrowth of research conducted throughout the student's graduate career, although this is by no means enforced.