A program to prepare interdisciplinary research and development specialists in mathematics education and structural learning at the doctoral level is described. Program objectives, course offerings, faculty, information about trainees (educational background, examination results, research, publications, present position), and publications resulting from the program are all listed. Requirements for the doctoral degree in mathematics education research are specified and sample programs are included. (DT)
FINAL REPORT
Grant No. OEG-0-71-3477 (927)

GRADUATE TRAINING IN MATHEMATICS
EDUCATION RESEARCH AND STRUCTURAL LEARNING

Joseph M. Scandura
Graduate School of Education
University of Pennsylvania
Philadelphia, Pennsylvania

August 1972

U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE

Office of Education
Bureau of Research
Final Report
Grant No. OEG-0-71-3477 (520)

GRADUATE TRAINING IN MATHEMATICS
EDUCATION RESEARCH AND STRUCTURAL LEARNING

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The research reported herein was performed pursuant to a grant with the Office of Education, U.S. Department of Health, Education, and Welfare. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their professional judgment in the conduct of the project. Points of view or opinions stated do not, therefore, necessarily represent official Office of Education position or policy.

U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE

Office of Education
Bureau of Research

[Signature]
Chief, Research Training Branch
Program Objectives

The primary aims of the program were to prepare interdisciplinary research and development specialists in mathematics education and structural learning at the doctoral level (Ph.D. and Ed.D.).

The long-term objective to which this program addressed itself was to increase understanding of the learning, teaching, measurement, and creation of mathematics and other structural knowledge, at all levels, and to develop rationales and methodologies, based on such understanding, for the technological development of instructional materials and measuring instruments.

The program, itself, was concerned with the graduate training of bright, innovative, and tenacious students who had received bachelor's or master's degrees at recognized colleges or universities with majors in mathematics, logic, formal linguistics, statistics, experimental psychology, or mathematics education. More specifically, the program was designed to provide the trainee with:

(a) sufficient understanding of mathematics and its nature as a structured discipline so that he is able to prepare suitable mathematical materials for use in research and to discuss mathematical questions with mathematicians in an intelligent manner;

(b) sufficient familiarity with the area of research concern (i.e., mathematics education) as it exists in practice to provide a common bond between other colleagues in mathematics education whose primary concerns are of a more clinical nature;

(c) sufficient grounding in research methodologies, technologies, and the philosophy of science to independently undertake most research projects and to be able to converse intelligently with specialists exercising non-mathematical problems in research design and analysis, and

(d) sufficient understanding of the underlying behavioral sciences of psychology and educational psychology so that, in his quest for increased understanding and improved methodologies, he may bring to bear relevant knowledge and appropriate research techniques and converse intelligently with scientists in the parent behavioral disciplines.

We feel that these objectives have been achieved and that education in our country has and will benefit as a result.
The trainee was also expected to select one or more subareas within the four areas indicated above for special emphasis, the choice depending on the type of research he wished to undertake after graduation. For more details concerning the nature of the programs see the appended item "Requirements for the Ph.D. and Ed.D. in Mathematics Education Research."

**Courses offered in the Program**

<table>
<thead>
<tr>
<th>Course No.</th>
<th>Course Title</th>
<th>Semester Hours</th>
<th>Class Hours</th>
<th>Required/Elected by Students</th>
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<tr>
<td>Educ. 728</td>
<td>Proseminar in Structural Learning</td>
<td>3</td>
<td>3</td>
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</tr>
<tr>
<td>Educ. 729</td>
<td>Research in Mathematics Education</td>
<td>3</td>
<td>3</td>
<td>required</td>
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<tr>
<td>Educ. 828</td>
<td>Seminar in Structural Learning</td>
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<td>3</td>
<td>required</td>
</tr>
<tr>
<td>Educ. 829</td>
<td>Seminar on Innovation in Mathematics Curriculum and Instruction</td>
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<td>3</td>
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<td>Educ. 830</td>
<td>Seminar on Psychology of Mathematics Learning</td>
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<td>Educ. 839</td>
<td>Practicum in Mathematics Education</td>
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<td>Educ. 660</td>
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<td>Educ. 367</td>
<td>Experimental Design and Analysis of Variance and Covariance</td>
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<td>Seminar in Experimental Design</td>
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<td>Ling. 642</td>
<td>Mathematical Logic</td>
<td>6</td>
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<tr>
<td>Math. 510</td>
<td>Topics in Analysis</td>
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<td>3</td>
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<td>Math. 520</td>
<td>Topics in Geometry</td>
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<td>Math. 530</td>
<td>Topics in Algebra</td>
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<tr>
<td>Math. 365</td>
<td>Foundations of Analysis</td>
<td>3</td>
<td>3</td>
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<tr>
<td>Math. 370</td>
<td>Algebra I</td>
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<td>Math. 371</td>
<td>Algebra II</td>
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<td>Math. 380</td>
<td>Honors Analysis I</td>
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<td>Math. 381</td>
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<td>Math. 410</td>
<td>Complex Variables</td>
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<td>Math. 420</td>
<td>Theory of Differential Equations</td>
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<td>3</td>
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<tr>
<td>Math. 430</td>
<td>Probability</td>
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<td>Math. 440</td>
<td>Numerical Analysis</td>
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<td>Math. 460</td>
<td>Differential Geometry</td>
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<td>Math. 600</td>
<td>Geometric Analysis</td>
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<td>Elective</td>
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<td>Math. 601</td>
<td>Real Analysis</td>
<td>3</td>
<td>3</td>
<td>Elective</td>
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<tr>
<td>Math. 602</td>
<td>Algebra</td>
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<td>3</td>
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<tr>
<td>Math. 607</td>
<td>General Topology</td>
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<th>Course No.</th>
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<td>Complex Analysis</td>
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<td>Math. 641</td>
<td>Intro. to Algebraic Topology</td>
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<td>Math. 691</td>
<td>Theory of Logical Models</td>
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<td>Educ. 761</td>
<td>Psychology of Human Learning</td>
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<td>Educ. 762</td>
<td>Psychology of Human Development</td>
<td>3</td>
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<td>Educ. 766</td>
<td>Test Construction I</td>
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<td>Educ. 769</td>
<td>Test Construction II</td>
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<td>Educ. 871</td>
<td>Seminar in Experimental Design I</td>
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<td>Educ. 872</td>
<td>Seminar in Experimental Design II</td>
<td>3</td>
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<tr>
<td>Psych. 600</td>
<td>Proseminar in General Psychology</td>
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<td>Psych. 710</td>
<td>Developmental Psychology</td>
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<td>Psych. 725</td>
<td>Verbal Learning and Behavior</td>
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<td>Psych. 750</td>
<td>Mathematical Learning Theories</td>
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<td>Phil. 436</td>
<td>Intro. to Philosophy of and Logical Foundations of Mathematics</td>
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<td>Phil. 524</td>
<td>Problems in Logic and Modern Methods</td>
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<td>Phil. 536</td>
<td>Set Theory</td>
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<tr>
<td>Ling. 603</td>
<td>Mathematical Systems in Linguistic Structure</td>
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<td>Ling. 630</td>
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<td>Ling. 643</td>
<td>Theory of Recursion</td>
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<td>Seminar in Logic</td>
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<td>Ling. 645</td>
<td>Linguistics and Mathematical Logic</td>
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<tr>
<td>Ling. 654</td>
<td>Linguistic Transformations</td>
<td>3</td>
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<td>E.E. 623</td>
<td>Intro. to Digital Computers: Programming and Logic</td>
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<td>E.E. 640</td>
<td>Theory of Automata</td>
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<td>E.E. 674</td>
<td>Mechanical Languages</td>
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<td>E.E. 675</td>
<td>Programming Languages</td>
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<td>Stat. 601</td>
<td>Intermediate Statistics</td>
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<td>Stat. 602</td>
<td>Proseminar in Mathematical Statistics I</td>
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<td></td>
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<tr>
<td>Stat. 602</td>
<td>Proseminar in Mathematical Statistics II</td>
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<tr>
<td>Stat. 623</td>
<td>Design of Experiments and Experimental Optimization</td>
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<td>Stat. 624</td>
<td>Regression and Variance Analysis</td>
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<tr>
<td>Stat. 625</td>
<td>Multivariate Analysis I</td>
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<tr>
<td>Stat. 625</td>
<td>Multivariate Analysis II</td>
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</table>

3.
Faculty

The faculty responsible for the program and courses related to the program were:

Joseph H. Scandura, Ph.D., Program Director and Associate Professor of Education
Neal Gross, Ph.D., Dean of the Graduate School of Education
Morris S. Vitello, Ph.D., Emeritus Professor of Psychology
(Former Dean of the Graduate School of Education)
Justin Fox, Ph.D., Professor of Psychology
Andrew R. Baggsley, Ph.D., Professor of Education
Eugene Calabi, Ph.D., Thomas A. Scott Professor of Mathematics
John H. Carr, Ph.D., Professor of Electrical Engineering
William B. Castetter, Ph.D., Professor of Education (Former Acting Dean of the Graduate School of Education)
Frederick B. Davis, Ed.D., Professor of Education
James M. G. Fell, Ph.D., Professor of Mathematics
Peter J. Freyd, Ph.D., Professor of Mathematics
Henry Glattman, Ph.D., Professor of Psychology
Henry Hiz, Ph.D., Professor of Linguistics
Francis H. Tuckin, Ph.D., Professor of Psychology
Albert Nijenhuis, Ph.D., Professor of Mathematics
Sung Bae Rim, Ph.D., Professor of Mathematics
David Shale, Ph.D., Professor of Mathematics
Steven Shatz, Ph.D., Professor of Mathematics
Richard L. Solomon, Ph.D., Professor of Psychology
Erling E. Boe, Ph.D., Associate Professor of Education
Roger L. Sisson, MS, Associate Professor of Operations Research and Statistics
David R. Williams, Ph.D., Associate Professor of Psychology
Joanna P. Williams, Ph.D., Associate Professor of Education
John Corcoran, Ph.D., Associate Professor of Linguistics
Zoltan Domotor, Ph.D., Assistant Professor of Philosophy
Charles E. Poyar, Ph.D., Assistant Professor of Education
Dorothy L. Jones, Ph.D., Assistant Professor of Education
Robert C. Jones, Ph.D., Assistant Professor of Operations Research and Statistics
Sandra U. Scarr, Ph.D., Assistant Professor of Education
John H. Durnin, Ph.D., Lecturer on Education (part time)
George F. Lowrance, Ph.D., Lecturer on Education (part time)
George Zampetti, M.S., Supervisor of Student Teaching (part time)
Trainees

There were a total of 26 students enrolled in the program over the past six years. Of these, 17 received some support from the U.S. Office of Education. Of these students enrolled in the program, five students received Ph.D.'s; one received a Ph.D. from Louisiana State University), five students received Master degrees and five students expect to receive Ph.D.'s during the 1972-73 academic year.

U.S. Office of Education Supported Trainees

Mr. Louis Ackler, age 20

<table>
<thead>
<tr>
<th>Education</th>
<th>Overall GPA</th>
<th>Math GPA</th>
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<tbody>
<tr>
<td>U.S. Air Force Academy, 1961-64</td>
<td>2.93</td>
<td>3.34</td>
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<tr>
<td>B.A. University of Denver, 1965</td>
<td>3.47</td>
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<td>University of Penna. (in program) 1968-69</td>
<td>3.38</td>
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<td>3.25</td>
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Graduate Record Examination: December, 1967

Scores: 610 Verbal Percentile Rank 73
        790 Quantitative Percentile Rank 97
        730 Advanced Math Percentile Rank 63

Language Examinations passed: French: 8/69

Ph.D. Preliminary Examination: Not taken

Research: The effects of irrelevant attributes and operations on rule learning (with D. Voorhies)

Publications: None.

Present position: Mathematics teacher, Council Rock School District

Degree: M.A., 1970

Miss Margaret Ahern, age 36

<table>
<thead>
<tr>
<th>Education</th>
<th>Overall GPA</th>
<th>Math GPA</th>
</tr>
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<tr>
<td>B.A. College of St. Rose, 1967</td>
<td>3.55</td>
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<tr>
<td>University of Penna. (in program) 1967-1968</td>
<td>3.25</td>
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</table>

Graduate Record Examination:

Scores: 580 Verbal
        610 Quantitative
        530 Advanced Math
Mrs. Joan Barkerdale, age 23

Education

<table>
<thead>
<tr>
<th>Degree</th>
<th>Institution</th>
<th>Overall GPA</th>
<th>Math GPA</th>
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<tbody>
<tr>
<td>B.A.</td>
<td>University of Massachusetts, 1966</td>
<td>3.47</td>
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<tr>
<td>M.S.</td>
<td>University of Penna. (in program)</td>
<td>3.42</td>
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Graduate Record Examination: April, 1967

Scores:
- 540 Verbal Percentile Rank 69
- 600 Quantitative Percentile Rank 97
- 750 Advanced Math. Percentile Rank 96

Language Examinations passed: Spanish 12/67
Ph.D. Preliminary Examination: Not taken
Present Position: Unknown
Degree: M.A., 1969

Dr. Joanna Burris, age 42

Education

<table>
<thead>
<tr>
<th>Degree</th>
<th>Institution</th>
<th>Overall GPA</th>
<th>Math GPA</th>
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<tr>
<td>B.A.</td>
<td>Trenton State College, 1943</td>
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<tr>
<td>M.S.</td>
<td>University of Penna., 1966</td>
<td>3.75</td>
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<td>M.S.</td>
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<td>3.2</td>
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<td>1966-1967</td>
<td>3.4</td>
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<tr>
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<td>1967-1968</td>
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Graduate Record Examination: Admitted before required
Language examinations passed: French, 4/67 and German, 6/67
Ph.D. Preliminary Examination: Passed, 4/69
Research: Dissertation
Publications:

Present position: Assistant Professor of Mathematics and Coordinator of Developmental Research in Mathematics Education, Burlington County College
Degree: Ph.D., 1972
Dr. John Durnin, age 34

**Education:**

<table>
<thead>
<tr>
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<th>Math GPA</th>
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<td>M.S. University of Utah, 1966</td>
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<td>1968-1969</td>
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**Graduate Record Examination:** June, 1967

Scores: 540 Verbal Percentile Rank 77  
650 Quantitative Percentile Rank 94  
640 Advanced Math Percentile Rank 86

**Language examinations passed:** French, 10/67 and Spanish, 4/68

**Ph.D. Preliminary Examination:** Passed, 11/69

**Research:** Basic research in mathematics education (See publications). Assisted with development of mathematics text for elementary teachers.


**Present position:** Research Associate, University of Pennsylvania

**Degree:** Ph.D., 1971

Dr. Walter Ehrenpreis, age 39

**Education:**

<table>
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<tr>
<td>M.A. University of Conn., 1959</td>
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<td>Post Masters, University of Pennsylvania</td>
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<td>University of Penna. (in program) 1967-1968</td>
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<td>1968-1969</td>
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**Graduate Record Examination:** Admitted before required

**Language examinations passed:** German 6/67, French 10/67

**Ph.D. preliminary examination:** Passed, 4/69

**Research:** Assisted with development of mathematics text for elementary teachers. Dissertation

**Publications:** *An Algorithmic Approach to Mathematics Concrete Behavior Foundations* (with Scandura, J. M., Durnin, J. H., and Luger, G.)
Present Position: Associate Professor of Mathematics and Mathematics Education, Trenton State College

Miss Francine Endicott, age 24

Education:

B.A., Fontbone College, 1968
Univ. of Penna. (in program) 1968-69
          1969-70
          Overall GPA 3.8 3.8
          Math GPA   3.8 3.8
Graduate Record Examination: October, 1967
Scores: 710 Verbal Percentile Rank 92
        710 Quantitative Percentile Rank 88
        620 Advanced Math Percentile Rank 45

Language Examinations passed: French, 1/70; German, 9/70
Ph.D. Preliminary Examination: Passed 9/71
Research: Rule generality in the selection of mathematical rules
Publications: None

Degree expected: Ph.D., 1972

Miss Judith Gera, age 27

Education:

B.S. California State College, 1966
University of Penna. (in program) 1966-69
          Overall GPA 3.2 3.5
          Math GPA   3.3 3.3
Graduate Record Examination: Not taken

Language Examinations passed: None taken
Research:
Publications: None

Present Position: Student
Degree: M.S., 1967

Dr. Gerald Goldin, age 28

Education:

B.A., Harvard University, 1964
M.A. Princeton, 1966
Ph.D., Princeton, 1969
Graduate Record Examination: January, 1964

Scores: 710 Verbal
        790 Quantitative
        920 Advanced Physics

Language Examinations Passed: None required
Ph.D. Preliminary Examination: Not taken
Research: Mathematical Models for Theory of Knowledge and Structural Learning
Present Position: Assistant Professor of Education, University of Pennsylvania

Sister Jeannine Gramick, age 29

Education:

<table>
<thead>
<tr>
<th>Degree</th>
<th>Overall GPA</th>
<th>Math GPA</th>
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</thead>
<tbody>
<tr>
<td>B.A. College of Notre Dame, Md. 1965</td>
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<td>3.6</td>
</tr>
<tr>
<td>M.A. University of Notre Dame, 1969</td>
<td>3.61</td>
<td>3.61</td>
</tr>
<tr>
<td>University of Penna., 1969-1970</td>
<td>3.6</td>
<td>3.0</td>
</tr>
</tbody>
</table>


Scores: 630 Verbal  Percentile Rank 76
        660 Quantitative Percentile Rank 92
        750 Advanced Math Percentile Rank 71

Language Examinations Passed: French, 10/70; German, 6/70
Ph.D. Preliminary Examination: Passed, 9/71
Research: Assisted in the development of new materials for teacher training. Dissertation
Publications: None
Present position: Student
Degree expected: Ph.D., 1972

Mrs. Linda Hunsicker, age 24

Education:

<table>
<thead>
<tr>
<th>Degree</th>
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<th>Math GPA</th>
</tr>
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<tbody>
<tr>
<td>B.A. University of Penna., 1969</td>
<td>3.17</td>
<td>3.36</td>
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</table>
Graduate Record Examination: October, 1969

Scores: 650 Verbal
       590 Quantitative
       640 Advanced English

Language Examinations passed: None taken
Ph.D. Preliminary Examination: Not taken
Research:
Publications: None
Present position: Unknown

Mr. Myron Kaplan

<table>
<thead>
<tr>
<th>Education</th>
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<th>Math GPA</th>
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<tr>
<td>B.A. Temple University, 1966</td>
<td>3.77</td>
<td>3.94</td>
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<tr>
<td>M.A. University of Penna., 1968</td>
<td>3.42</td>
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<td>Univ. of Penna. (in program) 1968-1969</td>
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<td>1969-1970</td>
<td>3.5</td>
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</table>

Graduate Record Examination: January, 1966

Scores: 560 Verbal Percentile Rank 76
       750 Quantitative Percentile Rank 99
       730 Advanced Math Percentile Rank 96

Language Examinations Passed: French 9/66; German 5/68
Ph.D. Preliminary Examination: Not taken
Research: Developing new techniques and formulas for test item analysis
Present Position: Assistant Professor of Mathematics, Bucks County Community College
Degree Expected: Ph.D., on leave
Dr. George Lowerre, age 39

Education:

<table>
<thead>
<tr>
<th>Degree</th>
<th>Institution</th>
<th>Overall GPA</th>
<th>Math GPA</th>
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<tbody>
<tr>
<td>A.B.</td>
<td>Hamilton College, 1954</td>
<td>3.7</td>
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<td>M.A.</td>
<td>Cornell University, 1957</td>
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<td>Post Masters, Univ. of Washington</td>
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<td>3.75</td>
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<td></td>
<td>1968-1969</td>
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</table>

Graduate Record Examination: Advanced Math, March 1967

Score: 950 Advanced Math Percentile Rank 99

Language Examinations Passed: French 4/68; German 4/68

Ph.D. Preliminary Examination: Passed, 11/69

Research: Assisting with writing of a mathematics text for elementary teachers.

Publications: Solutions of Problems to Fibonacci Quarterly

Present Position: Assistant Professor of Mathematics and Education, Our Lady of Angels College

Degree: Ph.D., 1972

Mr. Robert McGee, age 36

Education:

<table>
<thead>
<tr>
<th>Degree</th>
<th>Institution</th>
<th>Overall GPA</th>
<th>Math GPA</th>
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<tbody>
<tr>
<td>B.A.</td>
<td>Holy Cross College, 1958</td>
<td>3.2</td>
<td>2.8</td>
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<td>M.S.</td>
<td>Notre Dame, 1960</td>
<td>2.8</td>
<td>2.8</td>
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<td>M.Ed.</td>
<td>S.U.N.Y. at Buffalo, 1968</td>
<td>3.3</td>
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<tr>
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<td>1963-1969</td>
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Graduate Record Examination: January, 1958

Scores: 650 Verbal Percentile Rank 90
        700 Quantitative Percentile Rank 99

Language Examinations Passed: German, 6/68 and French, 8/68

Ph.D. Preliminary Examination: Passed, 4/69


Present Position: Chairman and Assistant Professor of Mathematics and Mathematics Education, Cabrini College

Degree expected: Ph.D., on leave.

Mr. Christopher Toy, age 27

Education: Overall GPA Math GPA
B.A. San Francisco State College, 1965 3.7 3.6
M.A. San Francisco State College, 1967 3.8
University of Penn. (in program) 1967-1968 3.6 3.5
1968-1969 3.75 3.5
1969-1970 3.33

Graduate Record Examination: May, 1965
Scores: 640 Verbal Percentile Rank 88
920 Quantitative Percentile Rank 96
880 Advanced Math Percentile Rank 99

Language Examinations passed: Not taken
Ed.D. Preliminary Examination: Not taken
Research: Teacher education in mathematics.
Publications: None

Present Position: Assistant Professor of Mathematics, New Hampshire College of Accounting and Commerce.

Degree: MA., 1970

Mr. Donald Voorhis, age 26

Education: Overall GPA Math GPA
B.S. Loyola University, 1967 3.9 4.0
University of Penna (in program) 1967-1968 3.75 3.33
1968-1969 3.75 3.0
1969-1970 4.0 4.0
Graduate Record Examination: November, 1966

Scores:
- Verbal: 610 Percentile Rank 84
- Quantitative: 730 Percentile Rank 99
- Advanced Math: -380 Percentile Rank 99

Language Examinations Passed: French, 6/68 and German, 8/68
Ph.D. Preliminary Examination: Passed, 9/70
Research: The effect of relevant attributes and operations on rule learning (with Louis Ackler). Investigation of logical rule usage with high school students.

Present Position: Student
Degree expected: Ph.D., 1972

Mr. Wallace Wulfeck, age 25

Education:

<table>
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<tr>
<th>Degree</th>
<th>Institution</th>
<th>Overall GPA</th>
<th>Math GPA</th>
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<tr>
<td>B.A.</td>
<td>University of California, Santa Barbara</td>
<td>2.82</td>
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<td>M.A.</td>
<td>U.C.S.B.</td>
<td>3.10</td>
<td>4.0</td>
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<td>University of Penna. (in program) 1971-72</td>
<td>3.75</td>
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</table>

Graduate Record Examination: October 1970

Scores:
- Verbal: 750 Percentile Rank 99
- Quantitative: 780 Percentile Rank 98
- Advanced Education: 660 Percentile Rank 99

Language Examinations Passed: To be taken
Ph.D. Preliminary Examination: To be taken
Research: Examination of student attitude and teacher attitude toward mathematics and its association with student's achievement in mathematics.

Previous positions: Math Teacher, Goleta Valley H.S., Goleta, California, 9/69-6/71
Degree expected: Ph.D., 1973
Trainees not supported by U.S. Office of Education

Dr. Lawerence A. Couvillon, age 33

Education:

<table>
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<th>Degree</th>
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<th>Year</th>
<th>Overall GPA</th>
<th>Math GPA</th>
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<tr>
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<td>Louisiana State University</td>
<td>1968</td>
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<td>M.A.</td>
<td>Louisiana State University</td>
<td>1964</td>
<td>3.9</td>
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<td>M.S.</td>
<td>Louisiana State University</td>
<td>1967</td>
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<td>Ph.D.</td>
<td>Louisiana State University</td>
<td>1970</td>
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Graduate Record Examination:

Scores: 500 Verbal
670 Quantitative
680 Advanced Math

Present Position: Assistant Professor of Mathematics Education, Florida State University

Mr. Nathan Fain, age 42

Education:

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<th>Degree</th>
<th>Institution</th>
<th>Year</th>
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<th>Math GPA</th>
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<tr>
<td>B.S.</td>
<td>Knoxville College</td>
<td>1967</td>
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Graduate Record Examination

Scores: Unknown

Language Examinations Passed: None taken
Ph.D. Preliminary Examination: Not taken
Research:
Publications: None
Present Position: Unknown

Miss Julia Gattie, age 33

Education:

<table>
<thead>
<tr>
<th>Degree</th>
<th>Institution</th>
<th>Year</th>
<th>Overall GPA</th>
<th>Math GPA</th>
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<tr>
<td>A.B.</td>
<td>Gettysburg College</td>
<td>1960</td>
<td>3.61</td>
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<td>M.S.</td>
<td>Purdue University</td>
<td>1963</td>
<td>3.07</td>
<td>3.07</td>
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<td>University of Penna. (in program)</td>
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</table>
Graduate Record Examination: February, 1969

Scores: 540 Verbal
        780 Quantitative
        740 Advanced Math

Percentile Rank 51
Percentile Rank 99
Percentile Rank 69

Language Examinations passed: Not taken
Ed.D. Preliminary Examination: Not taken
Research: Publications: None
Present position: Unknown
Degree: M.A., 1971

Mrs. Julia Hirsh, age 39

Education

B.A. Middlebury College, 1958
M.A. University of Pennsylvania, 1969
University of Penna. (in program)

Overall GPA 3.82
Math GPA 3.83

Graduate Record Examination: Not taken
Language Examinations passed: French, 9/66 and German, 10/68
Ph.D. Preliminary Examination: In Mathematics, passed 1969
Research: Maryland Math Project, University of Maryland; assisted with rewriting and evaluating mathematics text for elementary teachers.
Publications: None
Present Position: Student
Degree expected: Ph.D., 1973

Mr. Joseph Kudera, age 32

Education

B.A. Jersey City State College
M.A.T. Harvard University
University of Penna. (in program)

Overall GPA 3.6
Math GPA 3.6

Graduate Record Examination

Scores: 520 Verbal
        580 Quantitative
        890 Advanced Math
Language Examinations Passed: None taken
Ph.D. Preliminary Examination: Not taken
Research: None
Publications: None
Present Position: Director Computer Services, University of Pennsylvania

Mr. George Luger, age 31

Education:

<table>
<thead>
<tr>
<th>Institution</th>
<th>Overall GPA</th>
<th>Math GPA</th>
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<tr>
<td>B.A. Gonzaga University, 1963</td>
<td>3.1</td>
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<td>M.A. Gonzaga University, 1965</td>
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<td>M.A. University of Notre Dame, 1969</td>
<td>3.2</td>
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Graduate Record Examination: January, 1967
Scores: 640 Verbal Percentile Rank 90
        740 Quantitative Percentile Rank 99
        640 Advanced Math Percentile Rank 86

Language Examinations Passed: French, 10/70
Ph.D. Preliminary Examinations: Passed
Research: Dissertation
and Ehrenpreis, V.)
Present Position: Supervisor of Student Teaching, University of Pennsylvania.
Degree expected: Ph.D., 1972

Mrs. Linda Moulton, age 28 (part-time student)

Education:

<table>
<thead>
<tr>
<th>Institution</th>
<th>Overall GPA</th>
<th>Math GPA</th>
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<tbody>
<tr>
<td>A.B. Bryn Mawr College, 1965</td>
<td>3.2</td>
<td>2.7</td>
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<tr>
<td>M.A.T. Harvard University, 1966</td>
<td>3.5</td>
<td>3.5</td>
</tr>
<tr>
<td>University of Pennsylvania, 1967-1968</td>
<td>3.5</td>
<td>3.0</td>
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<td>1968-1969</td>
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<td></td>
<td>1969-1970</td>
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Graduate Record Examination: November, 1964
Scores: 590 Verbal Percentile Rank 82
        650 Quantitative Percentile Rank 94
        600 Advanced Math Percentile Rank 75
Language Examinations passed: Not taken
Ed.D. Preliminary Examination: Not taken
Research
Publications: None
Present position: Assistant Professor of Mathematics, Beaver College
Degree expected: Ed.D., on leave

Mr. Gerald Satlow, age 30

Education:

<table>
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<tr>
<th>Degree</th>
<th>Institution</th>
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<th>Math GPA</th>
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<td>B.A. Antioch College, 1965</td>
<td>2.9</td>
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<td>M.A.T. Wesleyan University, 1967</td>
<td>3.3</td>
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Graduate Record Examination: January, 1965

Scores:
- 710 Verbal Percentile Rank 98
- 760 Quantitative Percentile Rank 99
- 650 Advanced Math Percentile Rank 88

Language Examinations passed: Not taken
Present position: Assistant Professor of Mathematics and Mathematics Education, Cabrini College

Miss Agnes Rash, age 29 (part-time student)

Education:

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<tr>
<th>Degree</th>
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<tr>
<td>B.A. Holy Family College, 1963</td>
<td>2.85</td>
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<td>M.S. Notre Dame University, 1966</td>
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17
Graduate Record Examination: July, 1968

Scores: 620 Verbal
        780 Quantitative
        840 Advanced Math

Percentile Rank 62
Percentile Rank 99
Percentile Rank 87

Language Examinations passed:
Ph.D. Preliminary Examination:
Research: Dissertation
Publications: None
Present position: Instructor in Mathematics, St. Joseph's College
Degree expected: Ph.D., 1972

Practicum Training

In the program there were two major areas of research specialization: basic research in structural learning and developmental research in mathematics education. Practicum training in basic research involved theoretical, experimental and analytical investigations into the nature of mathematical and structural learning. Developmental research in mathematics education involved the investigation of mathematical abilities of kindergarten children, the analysis of elementary school curricular materials, the development of teacher education materials and the development of two sets of self instructional materials for teaching basic arithmetic skills, one for children and the other for adults.

An important result of practicum, besides experience, was that the trainees co-authored several publications, presented papers at professional meetings and made recognized contributions to publications of the project director.

Publications coauthored by trainees:


Publications in which trainees obtained practicum experience


Papers presented at professional meetings by trainees (speaker is underlined)


Scandura, J. M. Structural Learning Progress Report with
Durnin, J. H. Assessing Behavior Potential
Endicott, F. Studies in Rule Selection
Voorhies, D. Information Processing Capability of Human Subjects
Second Annual Meeting on Structural Learning, Philadelphia, April, 1971


Requirements for the Ph.D. and Ed. D.
in
MATHEMATICS EDUCATION RESEARCH
GRADUATE SCHOOL OF EDUCATION
UNIVERSITY OF PENNSYLVANIA

GENERAL NATURE OF THE PROGRAM

Ph.D. A minimum of twenty course units and proficiency in two research
tools (e.g., modern foreign languages, computer technology) are required
for the Ph. D. as outlined in the Graduate School Bulletin.

Ed.D. In general, the Ed.D. in mathematics education is similar to the
Ph.D. with: (1) somewhat greater breadth required in education, (2) a
minimum of 22 course units, (3) no language requirement, and (4) greater
flexibility allowed in the dissertation. Ordinarily, an Ed.D. candidate
undertakes a dissertation involving development and/or implementation
in mathematics education.

Residency. The program requires a heavy commitment and the student
should plan to pursue the program on a full-time basis. Typically, the
student may expect to complete the requirements for the degree within four
full years of study. Although no formal recognition is given to master's
degrees, the total time required may be reduced where the previous work
has direct relevance to the student's program of study. For example,
students entering the program with a strong master's degree in mathematics,
logic, formal linguistics, statistics, or experimental psychology may
normally expect to complete the requirements for the degree in about
three years.

Prerequisites. Students generally are expected to attain or have attained
as a minimum level of competency the equivalent of a University of Pennsyl-
vania bachelor's degree in mathematics. In those instances where students take undergraduate courses in mathematics to bring themselves up to this level, the courses taken normally do not count as credit toward the degree.

This requirement may be reduced or eliminated for special students with a strong behavioral background or a strong background in some other area which bears directly on the activities of the program.

Core. All students normally take the full sequence of courses and seminars in mathematics education: Research in Mathematics Education, 729*; Seminar on Innovation in Mathematics Curriculum and Instruction, 829; Seminar on the Psychology of Mathematics Learning, 830; Practicum in Mathematics Education, 33); and Research Seminar in Mathematics Education, 929.

The Research seminar (929) is open to Post-Doctoral students as well as to students in the program.

Generally speaking, students should also expect to complete Proseminar in Educational Psychology, 660, or Proseminar in General Psychology (Psychology 600); Experimental Design, 867 or 871; and a course in Linguistics or Logic as part of the CORE.

Areas of Specialization. There are two major areas of specialization: basic research and development. Current emphases in the former area involve theoretical, experimental, and analytical investigations into the nature of mathematics and structural learning. In the developmental area, the primary emphasis is on teacher education, although considerable attention is also given to school curriculum objectives, measurement and teaching methods.

Within each area of specialization, students will ordinarily elect to emphasize either mathematics or behavioral science.

Mathematical Emphasis: The minimum requirement is for the student to attain the equivalent of a University of Pennsylvania Master's degree in Mathematics, or other mathematical area represented by some Graduate Group in the GSAS. The numbers on this page refer to courses in the Graduate School of Education unless otherwise specified.
ber of required courses will be contingent upon the student’s background, but in any case, students will generally take at least one graduate course in relevant departments in order to develop personal relationships with faculty members.

Behavioral Emphasis: The student will normally take most of his course work (beyond the prerequisites) in the behavioral sciences. In certain cases, a philosophical emphasis may be allowed.

Research Experience. A distinguishing feature of the program is the requirement of active participation in basic research and/or development in mathematics education.

Evaluation. A student is expected to maintain a superior level of performance in his studies. If his grade point average falls below 3.5, at the end of the first year, he must receive special permission to continue in the doctoral program. During the Spring semester of his second year, if a student’s work is marginal, he will normally be recommended for a terminal master’s degree in mathematics education. In this evaluation, competence in research and/or development and implementation will be weighted most heavily.
Check List of Degree Requirements with Suggested Deadlines

1. Evaluation of transfer credits (if applicable)  
   Spring - 1st year

2. Preliminary Examination  
   Fall or Spring - 1st year

*3. Attain 3.5 C.P.A. in course work by end of first year.  
   End Spring term - 1st year

4. Language requirements (preferably completed by end of first year of study)  
   Summer - 1st year

5. Satisfactory performance in 1st year research practicum (or other approved activity)  
   September - 2nd year

*6. Minor Examinations  
   Fall or Spring - 2nd year

*7. Student informed if second year research is unsatisfactory  
   Spring - 2nd year

8. Satisfactory completion of second year project  
   September - 3rd year

*9. Final Major Examination  
   End of 3rd year

10. Satisfactory completion of third year project  
    September - 4th year

11. Submit Dissertation proposal  
    September - 4th year

*12. Defense of proposal  
    October - 4th year

*13. Satisfactory completion of dissertation  
    Spring - 4th year

14. Final oral examination  
    Spring - 4th year (or following Fall)

* Indicates a major step toward the degree.
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>Math. 365</td>
<td>Foundations of Analysis</td>
</tr>
<tr>
<td>Math. 370 - 371</td>
<td>Algebra</td>
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<tr>
<td>Math. 380 - 381</td>
<td>Honors Analysis</td>
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<tr>
<td>Math. 390 - 391</td>
<td>Honors Algebra</td>
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<tr>
<td>Math. 410</td>
<td>Complex Variables</td>
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<td>Math. 420</td>
<td>Theory of Differential Equations</td>
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<tr>
<td>Math. 430</td>
<td>Probability</td>
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<tr>
<td>Math. 440</td>
<td>Numerical Analysis</td>
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<td>Math. 460</td>
<td>Differential Geometry</td>
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<tr>
<td>Math. 510</td>
<td>Topics in Analysis</td>
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<td>Math. 520</td>
<td>Topics in Geometry - Topology</td>
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<td>Math. 530</td>
<td>Topics in Algebra</td>
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<td>Math. 600</td>
<td>Geometric Analysis</td>
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<td>Math. 601</td>
<td>Real Analysis</td>
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<tr>
<td>Math. 602</td>
<td>Algebra (2 Semesters)</td>
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<tr>
<td>Math. 607</td>
<td>General Topology</td>
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<td>Math. 609</td>
<td>Complex Analysis</td>
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<tr>
<td>Math. 641</td>
<td>Introduction to Algebraic Topology (Prerequisites, Topology and Algebra)</td>
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<td>Math. 691</td>
<td>Theory of Logical Models (2 Semesters)</td>
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<tr>
<td>Educ. 660</td>
<td>Proseminar in Educational Psychology</td>
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<td>Educ. 761</td>
<td>The Psychology of Human Learning</td>
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<td>Educ. 762</td>
<td>Psychology of Human Development</td>
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<td>Educ. 768, 769</td>
<td>Test Construction I, II (2 Semesters)</td>
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<td>Educ. 863</td>
<td>Seminar in Educational Psychology</td>
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<tr>
<td>Educ. 867</td>
<td>Experimental Design and Analysis of Variance and Covariance</td>
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Educ. 871, 872
Psych. 600, 601
Psych. 710
Psych. 721
Psych. 725
Psych. 750
Phil. 436
Phil. 524
Phil. 536
Ling. 602
Ling. 603
Ling. 630
Ling. 642
Ling. 643
Ling. 644
Ling. 645
Ling. 659

Seminar in Experimental Design I, II
Proseminar in General Psychology
Developmental Psychology (prerequisite: Proseminar in Psych.)
Learning Theories (prerequisite: Proseminar in Psych.)
Verbal Learning and Behavior (prerequisite: Proseminar in Psych.)
Mathematical Learning Theories (prerequisite: Proseminar in Psych.)
Introduction to Philosophy of and Logical Foundations of Mathematics
Problems in Logic and Modern Methods (2 semesters)
Set Theory
Formal Linguistics
Mathematical Systems in Linguistic Structure
Proseminar in Formal Linguistics
Mathematical Logic (2 semesters)
Theory of Recursion (Prerequisite: Mathematical Logic)
Seminar in Logic (prerequisite: Mathematical Logic)
Linguistics and Mathematical Logic
Linguistic Transformations
E.E. 523 Intro. to Digital Comp.: Programming and Logic
E.E. 640 Theory of Automata (prerequisite: Consent of instructor)
E.E. 674 Mechanical Languages (prerequisite: Algebra, Logic, and Programming & Logic or Consent of instructor)
E.E. 675 Programming Languages (prerequisite: Programming and Logic)
Stat. 602-I & II Proseminar in Mathematical Statistics and Statistical decision theory (2 Semesters)
Stat. 623 Design of Experiments and Experimental Optimization (prerequisite: Proseminar in Math. Stat. or equivalent)
Stat. 624 Regression and Variance Analysis (prerequisite: Course in Statistics and consent of instructor)
Stat. 625 I, II Multivariate Analysis (2 Semesters)
SAMPLE PROGRAMS

Example 1. The program of a student with a bachelors degree in mathematics, which is not at the same level of degree requirement as the University of Pennsylvania's and with no or little background in psychology and who wishes to emphasize mathematics, might look as follows:

<table>
<thead>
<tr>
<th>First Year</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fall Semester</strong></td>
</tr>
<tr>
<td>Educ. 729</td>
</tr>
<tr>
<td>Educ. 867</td>
</tr>
<tr>
<td>Math. 380</td>
</tr>
<tr>
<td>Math. 390</td>
</tr>
</tbody>
</table>

| **Spring Semester** |
| Educ. 660 | Prosem. in Educ. Psychology | 1 c.u. |
| Educ. 839 | Practicum in Mathematics Ed. | 1 c.u. |
| Math. 381 | Honors Analysis | 1 c.u. |
| Math. 391 | Honors Algebra | 1 c.u. |

**Summer Sessions**

- Preparation for Language Exams
- Research Assistance (Continuation of Practicum) or other approved activity
## Second Year

### Fall Semester
- Edu. 999: Independent Study (Research Proj.) or elective course 1 c.u.
- Math. 600: Geometric Analysis 1 c.u.
- Math. 607: General Topology 1 c.u.

### Spring Semester
- Edu. 830: Sem. on Psych. of Math Learning 1 c.u.
- Edu. 999: Independent Study (Research Proj.) or elective course 1 c.u.
- Math. 601: Real Analysis 1 c.u.
- Math. 609: Complex Analysis 1 c.u.

### Summer Sessions
- Completion of 2nd year project or an approved activity.

## Third Year

### Fall Semester
- Edu. 999: Independent Study 1 c.u.
- Ling. 642: Mathematical Logic elective 1 c.u.

### Spring Semester
- Edu. 999: Independent Study 1 c.u.
- Ling. 642: Mathematical Logic elective 1 c.u.
Summer Sessions

Completion of 3rd year project
Prepare dissertation topic

Fourth Year
A student will register for
Ed. 929 while working on the
dissertation.

Example 2. The program of a student with a strong
undergraduate degree in mathematics who wishes to
emphasize behavioral research might look as follows:

First Year

<table>
<thead>
<tr>
<th>Fall Semester</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Educ. 871</td>
<td>Sem. in Experimental Design</td>
<td>1 c.u.</td>
<td></td>
</tr>
<tr>
<td>Educ. 761</td>
<td>Psych. of Human Learning</td>
<td>1 c.u.</td>
<td></td>
</tr>
<tr>
<td>Psych. 600</td>
<td>Prosem. in Gen. Psych.</td>
<td>1 c.u.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spring Semester</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Educ. 839</td>
<td>Practicum in Mathematics Ed.</td>
<td>1 c.u.</td>
<td></td>
</tr>
<tr>
<td>Educ. 872</td>
<td>Sem. in Experimental Design</td>
<td>1 c.u.</td>
<td></td>
</tr>
<tr>
<td>Educ. 999</td>
<td>Independent Study (Research Proj.)</td>
<td>1 c.u.</td>
<td></td>
</tr>
<tr>
<td>Psych. 750</td>
<td>Math. Learning Theories</td>
<td>1 c.u.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Summer Sessions</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparation for Language Exams</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Research Assistance (continuation of Practicum)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>or other approved activity</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Second Year

#### Fall Semester
- **Educ. 327**: Sem. on Innov. in Math. Curriculum & Instruction 1 c.u.
- **Educ. 339**: Independent Study 1 c.u.
- **Ling. 342**: Mathematical Logic 1 c.u.
- **Psych. 721**: Learning Theories 1 c.u.

#### Spring Semester
- **Educ. 335**: Sem. on Psychology of Math. Learning 1 c.u.
- **Educ. 339**: Independent Study 1 c.u.
- **Ling. 342**: Mathematical Logic 1 c.u.
- **Psych. 725**: Verbal Learning and Behavior 1 c.u.

#### Summer Sessions
- Completion of 2nd year project or approved activity

### Third Year

#### Fall Semester
- **Educ. 339**: Independent Study 1 c.u.
- **Ling. 343**: Recursion Theory 1 c.u.
- **elective**: 1 c.u.

#### Spring Semester
- **Educ. 339**: Independent Study 1 c.u.
- **Ling. 344**: Seminar in Logic 1 c.u.
- **elective**: 1 c.u.
Summer Sessions

Completion of 3rd year project
Preparing dissertation topic

Fourth Year

A student will register for Ed. 929 while working on his dissertation.

Example 3. The program of a student with a masters degree in mathematics or beyond (equivalent to Univ. of Penn. M.A.), with little psychology background and who wishes to emphasize mathematics, might look as follows:

**Second Year**

**Fall Semester**

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Educ. 729</td>
<td>Res. in Math. Educ.</td>
<td>1 c.u.</td>
</tr>
<tr>
<td>Educ. 999</td>
<td>Independent Study</td>
<td>1 c.u.</td>
</tr>
<tr>
<td>Educ. 867</td>
<td>Exper. Design &amp; Anal. of Var. &amp; Covar.</td>
<td>1 c.u.</td>
</tr>
<tr>
<td>Educ. 829</td>
<td>Seminar on Innov. in Math.</td>
<td>1 c.u.</td>
</tr>
</tbody>
</table>

**Spring Semester**

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Educ. 839</td>
<td>Practicum in Math. Educ.</td>
<td>1 c.u.</td>
</tr>
<tr>
<td>Educ. 999</td>
<td>Independent Study</td>
<td>1 c.u.</td>
</tr>
<tr>
<td>Educ 830</td>
<td>Sem. on Psych. of Math.</td>
<td>1 c.u.</td>
</tr>
<tr>
<td>Educ 660</td>
<td>Proseminar in Educ. Psych.</td>
<td>1 c.u.</td>
</tr>
</tbody>
</table>
### Summer Sessions
- Preparation for Language Exams
- Research Project (cont. as Practicum)

### Third year

#### Fall Semester

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Educ. 999</td>
<td>Independent Study</td>
<td>1 c.u.</td>
</tr>
<tr>
<td>Math. 691</td>
<td>Theory of Logical Models</td>
<td>1 c.u.</td>
</tr>
<tr>
<td>Ling. 643</td>
<td>Recursion Theory</td>
<td>1 c.u.</td>
</tr>
</tbody>
</table>

#### Spring Semester

<table>
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<tr>
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<th>Title</th>
<th>Credits</th>
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<tr>
<td>Educ. 999</td>
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<td>Math. 691</td>
<td>Theory of Logical Models</td>
<td>1 c.u.</td>
</tr>
<tr>
<td></td>
<td>elective</td>
<td>1 c.u.</td>
</tr>
</tbody>
</table>

#### Summer Sessions
- Completion of 3rd year project
- Preparation of dissertation topic

### Fourth Year
- A student will register for
- Ed. 929 while working on the
dissertation.