THE PREPARATION OF COLLEGE MATHEMATICS INSTRUCTORS

DISSERTATION

Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy in the Graduate School of The Ohio State University

By

LYMAN COLT PECK, B.S., S.M.
The Ohio State University
1953

Approved by:

[Signature]
Adviser
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CHAPTER I

INTRODUCTION

The Problem

It is the intent of this study to present objective data on current practices utilized in preparing college mathematics instructors and to present judgments and opinions from within the profession of higher education on the desirability of these practices. Present practices and desired practices are compared and contrasted and thus utilized, along with the background of literature on the problem, to yield recommendations for the preparation of college mathematics instructors. Attention in this study is directed primarily toward the role of the graduate school in the preparation of these instructors.
Evidence of the Problem

Since the rise of the university in Medieval Europe and the subsequent spread to colonial America, there has been a steady shift in the character of higher education. From an institution with a low store of knowledge where professors and students were only "passers of the torch," the college has become a "medium through which young men and women are to develop and follow their own vocational and cultural interests to the end that they may live fuller lives and prepare for making a living."\(^1\)

The last twenty years have seen marked changes. Enrollments have increased tremendously due both to a growing awareness of the value of higher education to the individual and to society, and to the simple arithmetic of an increased birth rate. The prediction of 4,600,000 college students by the year 1960 caused the President's Commission on Higher Education to call for an increase in the number of college teachers from 150,000 in 1949 to 350,000 by 1960.\(^2\) Any evi-

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\(^1\) Harold Moore Byram, Some Problems in the Provision of Professional Education for College Teachers, p. 3.

dence of dissatisfaction with present programs of college teacher preparation has strong implications for re-examining graduate programs before expansion on the scale outlined by the President's Commission is undertaken. There are many indications that such a re-examination is wanted, but that established traditions in graduate schools often stand in the way. The following quotation brings out this point:

Undergraduate curriculums are subject to manipulation; but the training of those who are to teach undergraduates—that is, the graduate students of today who become the professors of tomorrow—remains unaltered. The scientific specialist claims the right to create scientific specialists. For him the undergraduate problem is minor. Consequently, in the effort to keep up the pace, humanities and social scientists, however great their concern for the undergraduate curriculum, imitate the scientist and retain the right to control the specialized education of their own graduate students.

One of the first organized attacks on the problems of college teaching was made at the University of Chicago in 1930. Reporting on this study, Gray listed the following deficiencies which were seen in college teaching at that time:

1. Lack of singleness of aims of the old college—small, in-bred though it was, it was not departmentalized nor was the teacher so independent of the others as he is becoming.

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"Howard Mumford Jones, Education and World Tragedy, pp. 50-51."
2. We are expounders of subjects, and not instruments to activate those before us.

3. We exhibit indifference and contempt for fields of knowledge different from our own.

4. We substitute virtual compulsion for individual initiative in the matter of research.

5. Enthusiasm for teaching is lacking. Teaching is regarded as a means for getting to do research.*

In 1930 a report of an investigation into characteristics of college teachers showed weaknesses very similar to those found by Gray, given above. Reports by college presidents and deans of 363 institutions of higher education to the University of Chicago Committee on Preparation of Teachers have been summarized by Kelley as follows:

1. Weaknesses in College Instructors.
   a. Personal traits were a handicap.
   b. Lack of breadth of training.
   c. Interested in research rather than in teaching.
   d. Lacked training for teaching.

2. Strengths in College Instructors.
   a. Well prepared in his specialty.
   b. Competent as a research worker.
   c. Generally high native intelligence.
   d. Generally sincerely devoted to scholarly interests.


5 Fred J. Kelley, Toward Better College Teaching, pp. 4-6.
If these deficiencies were present to an important degree in the majority of college teachers, the resulting dissatisfaction would mount into roars of criticism. The evidence in the literature indicates that the problem is not of such magnitude, yet of proportions large enough to warrant some concern.

Writing of the general education movement in secondary and higher education, Earl J. McGrath, the United States Commissioner on Education, praised the graduate schools for having afforded many benefits to our society by producing excellent scholars and professional people. On the other hand, he felt that the purposes of general education were not being carried out by college teachers to the same degree of excellence, as shown by the following statement:

That these same institutions have not given proper training for future college teachers seems equally clear. Until fundamental changes are made in graduate education it will be very difficult if not impossible to develop an adequate program of general education.

This failure of the graduate schools was stated in more detail by the President's Commission as follows:

... the failure of individuals to learn how to teach is largely the failure of the present graduate school system. Inflexible requirements for the degree, the formality and dispersion of the

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established curriculum, the absence of programs designed to develop skill in presenting subject matter, and the lack of appropriate guidance have been largely responsible for the fact that advanced degrees frequently do not indicate an ability to teach. 7

While there may be those who disagree with it, the above quotation does present a point of view which is held by many. This position is in opposition to that reported held by the Association of American Universities, which is:

That association's Committee on graduate work in 1948 made an intensive study of member opinion concerning the graduate school's responsibility for training college teachers. The results may well be surprising to those unfamiliar with the ground swells of thinking within the last five years. Twenty-three of the thirty-four member institutions definitely favored giving "specific informal training and practice in teaching" to prospective college teachers. 8

The evidence thus far presented has been general, pointing toward the need for improvement of college teaching as a whole, but not specifically aimed at college mathematics instruction. The following comment by Nielson points out an important weakness in college mathematics teaching, and submits a plan for removing it:


A constant complaint by our students and by young men in industry is that professors lack the necessary experience from which to draw practical situations for their illustrations. The complaints are entirely too numerous to be unfounded, and we cannot continue to ignore them.\(^9\)

Nielsen then proposes that in order to improve this situation mathematics professors spend summers and sabbaticals in work in industry. It is possible for such an arrangement to produce results which would be of advantage both to industry and to the teaching profession as well.

Narrow specialization in pre-doctoral work, even in areas within the field of mathematics, was the characteristic of graduate training upon which a group of outstanding mathematicians concentrated their attention in 1934. This group, The Commission on the Training and Utilization of Advanced Students of Mathematics, was formed under the direction of the trustees of the Mathematical Association of America. Finding that most doctoral students in mathematics spent most of their three years of graduate study in preparation for their theses, and that almost half of them produced no research of consequence after receiving the Ph.D. degree, this commission made recommendations, some of which were rather in advance of the thinking in graduate depart-

ments of that day. These recommendations are summarized on page 11 of the present study.

In evaluating programs for the preparation of Ph.D.'s in mathematics one is aided greatly by information on the kinds of employment in which these people become established. A large proportion of the recipients of the Ph.D. in mathematics become professors. The employment status as of September, 1940 of 695 living recipients of the Ph.D. degree in mathematics from 1930-31 to 1939-40 shows that 647 were employed as follows:

- 26.9 per cent in graduate schools.
- 55.8 per cent in colleges.
- 2.9 per cent in both graduate schools and colleges.
- 3.6 per cent in junior colleges.
- 4.3 per cent in other educational institutions.
- 6.5 per cent in non-academic employment.

These data show that 93.5 per cent of the Ph.D. recipients studied by Hollis who were in the field of mathematics were employed in educational institutions. This is in contrast to the fact that, of the total number (20,783) of employed Ph.D.'s in that study, 71 per cent were employed in educational institutions. Thus the percentage of Ph.D.'s employed


11 E. V. Hollis, Toward Improving Ph.D. Programs, p. 74.
in education was considerably higher in mathematics than in other academic areas.

However, place of employment does not give the complete picture of the type of employment. Hollis went further to show that the types of duty of the 647 employed recipients of the Ph.D. degree in mathematics were as follows:

- 85.1 per cent in teaching.
- 5.6 per cent in research.
- 1.9 per cent in administration.
- 3.9 per cent in teaching and research.
- 1.9 per cent in teaching and administration.
- 0.3 per cent in research and administration.
- 1.7 per cent in other duties.

Hollis' investigation of the teaching duties of the total group (20,783) of Ph.D.'s in his study revealed that 50.5 per cent of them were occupied in teaching. Again the percentage of Ph.D.'s in mathematics who were teachers was much larger than in other subjects. These data show rather conclusively that, in the period just prior to World War II, the great majority of the recipients of the Ph.D. degree in mathematics taught in institutions of higher learning.

With the advent of the war, however, the demands of industry, science, and the armed forces caused Ph.D.'s to go directly from graduate schools into research positions, and

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12E.V. Hollis, *op. cit.*, p. 86.
even to abandon teaching positions in favor of non-academic employment. Since many of these forces are still acting to draw mathematicians from academic employment into research, there is likelihood that Hollis' data may not be accurate in describing the employment status of Ph.D.'s in mathematics at the present time. Information regarding such employment is needed in making any decisions affecting doctoral programs in mathematics. These needed data have been provided by the present study, revealing information in terms of the per cent of recent Ph.D.'s who are teaching, and also in terms of the per cent of present Ph.D. candidates who are planning to teach at the college level. These data will be found on pages 50 and 51.

Most college mathematics teachers obtained the mathematical background from which they teach from the course of study pursued during their graduate work. Some heads of graduate mathematics departments frankly admit that they do not consider the preparation of college mathematics instructors one of their functions; others feel that this is one of their obligations and wish that they could do something about it; still others plan programs with this as a definite part of their goals.
Evidence of Attempted Solutions of the Problem

From the evidence available in the literature it must be concluded that the problem of how to prepare effective instructors of college mathematics has not been submitted to many attacks. In 1934 the Mathematical Association of America undertook to outline a plan for revision of existing doctoral programs in mathematics, the sole purpose being to take cognizance of the fact that most Ph.D.'s in mathematics teach. Its recommendations can be briefly summarized as follows:

1. There should be two types of programs leading to a doctor's degree in mathematics, the one stressing preparation for research, the other stressing preparation for college teaching.

2. Elements common to both types are:
   a. Basic study in each major sub-division of mathematics.
   b. Beginning graduate work in at least one field outside of mathematics.
   c. Preparation for teaching, including observation and assisting in college classes; supervised practice teaching in a variety of college courses; guided reading in educational theory and practice.
   d. Final examination.

3. Elements peculiar to the program for research mathematicians should be:
   a. Intensive specialization in mathematics beyond 2 (a) above.
b. A research thesis of high calibre, developed by the candidate himself.

4. Elements peculiar to the program for teaching mathematicians should be:

a. Additional work in mathematics and related fields, with emphasis upon breadth.

b. One or more "minor" theses, showing ability to learn independently, to synthesize, and to communicate mathematical ideas clearly.

c. A major thesis, not necessarily of research calibre, but showing mastery of some aspect of advanced mathematics and a good expository ability.

5. A new title for those completing the new type of program; perhaps "Doctor of Mathematics" or "Doctor of Philosophy in Course" should be considered.13

This report is the only one found in the literature which is a reflection of the thinking of a large group of mathematicians and professors of mathematics on the problem under consideration.14

Almost certainly an outgrowth of the results of the


14 The members of this commission were: E.J. Moulton (chairman), Northwestern University; William Betz, Rochester Public Schools and University of Rochester; W.L. Hart, University of Minnesota; J.C. Hassler, University of Oklahoma; E.R. Hedrick, University of California at Los Angeles; E.V. Huntington, Harvard; M.H. Ingraham, University of Wisconsin; R.G.D. Richardson, Brown University; H.E. Slaught, University of Chicago; and E.B. Stouffer, University of Kansas.
work of this Commission is shown in the appearance of a notice in the National Mathematics Magazine in 1935 stating that Dr. E. R. Hedrick would give, that summer, at Columbia University, a course in the teaching of mathematics in junior colleges and the lower divisions of colleges and universities. Ways of arranging the subject matter of mathematics through the calculus were to be stressed, as well as a study of the relations of mathematics to other fields.15

In a study reported in 1936 by Richardson, he states that, out of 4,444 college teachers of mathematics, "the best information available indicates that probably somewhat less than 1,300 of the present teachers of mathematics have the Ph.D. degree."16 Richardson also observed that graduate schools were producing only half as many Ph.D.'s as there were new positions in school faculties. This observation and the exclamatory nature of the above quotation imply that he felt that the Ph.D. degree is a necessary prerequisite to college teaching in mathematics.


The above attitude toward the relation of the Ph.D. degree to college teaching is reflected in the following statement made in 1947 by a group of mathematicians representing the National Council of Teachers of Mathematics: "The typical teacher of college mathematics has a doctor's degree (Ph.D.) or is well along toward completing his work for that degree."\(^\text{17}\)

In 1939, as a result of a thorough study of the types of preparation for teaching mathematics in England, Wales, and the United States, Ivan S. Turner set forth some principles upon which methods of training mathematics teachers could be based. Although the level of instruction in Turner's study was the high school, the nature of his set of principles is such that they apply to college teaching. The following are the principles which he set forth:

1. Prospective mathematics teachers should receive a thorough course of training in mathematics.

2. This training should be given in a university or an institution of equivalent rank by teachers who are themselves mathematicians of outstanding competence and who appreciate and understand the difficulties inherent in mathematics, whether it be regarded as a subject of learning or of teaching.

\(^{17}\) Commission on Post-war Plans of the National Council of Teachers of Mathematics, Guidance Pamphlet in Mathematics for High School Students, p. 12.
3. Mathematics teachers should study the important branches of pure mathematics, mechanics, the history of mathematics, applications of mathematics, as, for example, the study of its logical foundations, and particularly the essential connection between the various branches of advanced mathematics and their counterparts at the more elementary stage.

4. Mathematics teachers should make a more or less extensive study of some other subject, preferably one closely related to mathematics.

5. The teacher, during his period of active service, should strive to progress in his acquaintance with and mastery of many aspects of mathematical knowledge.

6. A period of professional training is a necessary part of preservice training of mathematics teachers.

7. The content of this course of professional training should be organized principally for the purpose of training teachers for teaching mathematics.

8. Mathematics teachers should be equipped to teach at least a second (and preferably an allied) subject; and they should therefore undertake a course of professional training in this subject.

9. This period of professional training of mathematics teachers should include some courses in the theory and practice of education, and in psychology. 18

In a study made in 1946, B. W. Jones made an attempt, on a limited scale, to determine the extent to which teaching assistants in mathematics were supervised. Thirteen re-

plies from letters sent to fifteen colleges and universities yielded the following information:

1. Two institutions had no teaching assistants.

2. Two felt the need for supervision but had neither the time nor the staff to engage in the task.

3. Six schools have, or planned to have shortly, supervision in the form of class visitation. The following means were employed:
   a. Visits only upon complaint by students or on the request of the assistant.
   b. Formal visits, conferences, grade given on teaching effectiveness, and a report to the staff.

4. Three schools have members of the mathematics staff in charge of courses involving sections taught by assistants. The assistants are helped, individually and in groups, with their teaching problems.19

Jones was trying to determine whether or not the period of the teaching assistantship was being utilized to its fullest potentialities as a period during which the fledgling instructor can be guided and aided in preparing to teach by all of the resources of the mathematics staff and the college as well. With no supervision at all, this period could be no more helpful to the prospective instructor than his first experience at full-time teaching. The President's Commission expressed its concern that such exploratory teaching experi-

ences, however they might be called, should be "... far more comprehensive and more expertly aimed at developing teaching competence than the typical graduate assistantship." 20

The most complete program of instructor preparation which was found in the literature was reported in 1948 from the mathematics department at the University of Michigan. This program consisted of regular group lecture and discussion meetings, a consultation service, and classroom visitation followed by individual conferences. Designed to aid the teaching fellows in mathematics, the program had the following objectives:

1. to provide for the welfare of freshman and sophomore students by maintaining a high quality of instruction.

2. To serve thereby the best interests of the university as an educational institution.

3. To help the teaching fellows, frequently inexperienced and sometimes lacking in confidence, by making his present job easier, and by providing training in the work to which many of his later years will probably be devoted. 21


Perhaps the most recent evidence to show that the problem of preparing college mathematics instructors holds interest for mathematicians lies in the fact that, at the 1951 and 1952 annual meetings of the National Council of Teachers of Mathematics, part of the regularly scheduled time devoted to college mathematics has been given to presentation and discussion of the problems of preparing instructors. Although nothing of significance to the profession at large has been produced at these meetings, from the experience of this writer as he attended it is clear that the enthusiasm and interest exhibited by the participants resulted in benefits of an individual nature. There is every reason to believe that persons attending these meetings will continue to work on this problem, and to hope for benefits of a more general character.

It requires very little association with teachers of college mathematics for one to observe that their educational backgrounds are extremely varied. Instructors may be found with the bachelor's, the master's, the doctor's degree, and some with more than one degree of the same rank. It is found that permanent appointments tend to be given to those with the Ph.D. more readily than those without it. Even though college administrators often find that instructors must be retrained to some extent after joining their staffs,
a great many liberal arts colleges insist upon the Ph.D. in new appointments. One reason for this is given by Woodburne:

This insistence on the Ph.D. seems a curious thing in terms of the problem faced by these colleges. ... The answer is that accrediting agencies have established a certain percentage of Ph.D.'s on the staff as a pre-requisite to the college's being accredited.22

The existence of the tendency to require the Ph.D. for college teachers, either through explicitly stated rules or implicitly in salary and promotion schedules, led this writer to limit the present study to the doctoral preparation of college mathematics instructors. This decision dictated the omission of any study of the in-service training of college teachers. Much can be done toward the improvement of college mathematics teaching through this important avenue, and it is not to be inferred that this fact is not recognized by the author.

The Method of Solving the Problem

Since the literature on preparation for college teaching yielded very little in the subject field of mathematics,
it was necessary to obtain by other means some estimate of current practices in this area. At the same time it seemed that some measure of the desirability of present practices would be valuable information. Comparing and contrasting these practices can give insights into needs and suggestions for eliminating, modifying, or adding parts of graduate mathematics programs.

With these purposes in mind, data showing present practices and desirability ratings of present practices were obtained from the following four groups of people:

1. Chairmen of mathematics departments which offer doctoral programs.
2. Deans of liberal arts colleges.
3. Chairmen of undergraduate mathematics departments.
4. Instructors of college mathematics.

The members of each group were sent questionnaires requesting information on what is being done in the pre-service preparation of college mathematics teachers and on the desirability of these and other practices. These questionnaires are included in the Appendix.

The first group named above was chosen because its members have the major responsibility in the pre-service prepara-
ration of instructors of college mathematics, fifty-four institutions were found to have mathematics departments which granted the Ph.D. degree at some time between 1930 and 1951. Twenty-nine (54 per cent) of the chairmen of these departments replied to the questionnaires sent to them. In several cases the respondents commented that they believed their replies to be representative of the minds in the department. In at least two cases the questions were discussed in a departmental meeting. A postal card was sent to those who did not reply after one month. This increased the number of returns from 27 to 29 and was the only attempt made in any of the questionnaires in this study to secure more replies than the initial request produced.

A second questionnaire, very different from that sent to the graduate mathematics chairmen, was sent to the deans of liberal arts colleges and to the chairmen of undergraduate mathematics departments. In this questionnaire the attempt was made to draw out the reactions of persons in charge of


24 See Appendix B for this questionnaire.

25 See Appendix C for this questionnaire.
hiring new mathematics instructors and supervising their work. A list of 677 institutions which granted degrees in mathematics below the doctoral level in the year 1949-50 was obtained, and a questionnaire was sent to the dean of the college of liberal arts of every other one of these institutions. The chairmen of the mathematics departments in the remaining institutions were sent a questionnaire of the same kind. The list of institutions was arranged alphabetically by states and alphabetically within each state; this indicates the extent to which the formation of these groups, deans and mathematics chairmen, was the result of random sampling. Of 338 deans thus reached, 179 (53 per cent) replied; of 339 chairmen of undergraduate mathematics departments, 178 (53 per cent) replied. Although in a few cases persons other than the dean answered a questionnaire, such as the curriculum coordinator, the registrar, or the president, these persons will be referred to as deans throughout this study. The map on the following page shows the geographical distribution of the institutions to which questionnaires were sent and from which they were received.

In the initial stages of this study the writer had intended that the fourth group of persons to supply data should

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GEOGRAPHICAL DISTRIBUTION OF INSTITUTIONS IN STUDY

KEY:

**128** DEANS; **+** UNDERGRADUATE; **C** GRADUATE.
be college mathematics instructors who had been teaching not more than three years since receiving the Ph.D. degree. It was felt that such "beginners" would be more capable of recalling details of their graduate school preparation which were significant in the sense of having helped or failed to help them in their present teaching positions. A method of obtaining their names and addresses was needed, so the deans, undergraduate department heads, and graduate department heads were asked in their questionnaires to supply names and addresses of mathematics instructors satisfying the above conditions. Subsequently it was discovered that the wording of this request was not sufficiently clear, with the result that names of instructors with the Ph.D. but with more than three years of teaching experience as a Ph.D., names of instructors with only the master's degree, and names of instructors in a miscellaneous group were submitted as well. This, however, was easily turned to advantage, for inclusion of the experiences and judgments of all of these instructors has broadened the scope of the study without making it unwieldy.

In this way the names of 242 persons were obtained and a questionnaire, somewhat different from the two previously
mentioned, was sent to each. \(^{27}\) Ninety-one (38 per cent) re-
plied. Below are shown the groups into which these instruc-
tors have been divided. \(^{28}\) The abbreviated title for each
group will be used throughout the study as it appears below:

Classification of 91 College Mathematics instructors

43 Beginning instructors, Ph.D.
Instructors who have taught not more than
three years since receiving the Ph.D. degree.

17 Experienced instructors, Ph.D.
Instructors who have taught more than three
years since receiving the Ph.D. degree.

16 Beginning instructors, M.A.
Instructors who do not have the Ph.D. degree
and who have taught not more than three years
since receiving the master's degree.

15 Other instructors.
Instructors who do not have the Ph.D. degree
and who did not indicate the lower degree held.

In the "experienced Ph.D." group only three indicated
having had less than ten years of college teaching experience
since receiving the Ph.D. degree, and three had more than
twenty years of experience after the Ph.D. To that extent,
then, these persons are experienced instructors. The "begin-
ning Ph.D." group is well distributed with persons of one,

\(^{27}\) See Appendix G for this questionnaire.

\(^{28}\) Although all ranks from instructor to full professor are
present among these groups, it will be convenient to refer to
these persons as instructors throughout the study.
two, and three years of teaching experience after receiving the Ph.D. The majority of the "beginning M.A." group indicated that they had completed most of the requirements for the Ph.D. degree except the dissertation, and so this group represents a middle stage in the preparation of college mathematics instructors.

The questions asked in the three groups of questionnaires have been arranged into four general classifications which form the basis for the organization of the data in the following four chapters. Chapter II is devoted to some characteristics of college mathematics teaching, as obtained from the instructors themselves and from their deans and department heads. The next chapter deals with the academic preparation of prospective college mathematics instructors; the mathematics courses and related courses which they take and those which are considered necessary for the Ph.D. degree. In Chapter IV the troublesome question of professional preparation is discussed, and the reactions of all four groups of persons involved in this investigation to several phases of this topic are presented. Although it is realized that it is impossible to divorce how to teach from what to teach, professional preparation and academic preparation have been separated for convenience of presentation. The question of
a need for standards of certification for college teachers is discussed in Chapter IV also. The final group of data from the questionnaires is presented in Chapter V in an account of the role of the dissertation and research in the training of prospective college mathematics instructors. Here the assumption that the Ph.D. degree is necessary in the preparation of these instructors is reviewed and tested against the judgment of the persons in the study. The last chapter presents a summary of the results of this investigation, conclusions drawn from implications found in the data, and some recommendations for improving the preparation of college mathematics instructors.

The Method of Presenting the Data

This study brings under consideration several practices which are used in preparing college mathematics instructors. Replies to the questionnaires employed show the extent to which these practices are being used and the desirability with which they are regarded by graduate mathematics chairmen, college deans, undergraduate mathematics chairmen, and college mathematics instructors. The questions presented to the individuals of these four groups may be seen in detail
The data obtained from these questions are presented, in the main part, in tabular form, where percentages are given, each having been calculated to the nearest integral per cent. Thus, in each one of a group of n percentages with the same base, there may be an absolute error of ± \( \frac{1}{n} \) per cent. The respondents to the questionnaires were asked to express their opinion of the desirability of practices for preparation of college mathematics instructors or college mathematics instructors by rating the practices "very undesirable," "undesirable," "neutral," "desirable," or "very desirable." The desirability ratings for the practices were reported both in the form of the per cent of the group giving each rating and as an "average" rating for the entire group responding for the entire group respondents. The average used is a weighted arithmetic mean of the five ratings given. The weights, -2, -1, 0, +1, and +2, respectively, were given. The base upon which the mean for any given group was calculated was the total number within that group who gave a rating. The data obtained from these questionnaires are presented, in Appendices C, D, and E, respectively.
CHAPTER II

SOME CHARACTERISTICS OF COLLEGE MATHEMATICS TEACHING

Grammatically speaking, the verb "teach" governs both a direct and an indirect object. Where one instructor may say that he "teaches mathematics" and another may say that he "teaches college students," it does not seem presumptuous to say that they both mean that they "teach mathematics to college students." In the typical liberal arts college, a mathematics instructor will teach many branches of mathematics to many types of college students. He may teach remedial, or subfreshman mathematics; mathematics for general education; traditional freshman mathematics, the prerequisite to the calculus; the calculus sequence; courses not closely dependent upon the calculus; courses beyond the calculus; and he may teach graduate courses or supervise graduate research. The students with whom he comes in contact exhibit just as much variety. He may teach mathematics to students whose sole interest lies in satisfying a general education requirement and who regard mathematics as a neces-
evil to be encountered only in educational institutions. On the other hand, he may have students to whom mathematics is a constant source of stimulating wonder, enrichment, and satisfaction, and who will follow it as their major course of study. Such variety of interest clearly reflects the diverse purposes which have led these students to enrol in mathematics courses. They will eventually become workers and leaders in the trades, businesses and professions which form the backbone of our society. Thus, in degrees of influence varying with the ultimate goals of his students, a mathematics instructor is an instrument for shaping society. As such, and with the present emphasis upon general education in college curricula, his task is much broader than mere teaching mathematical facts and processes. He must be able to show how mathematics is affecting and is affected by personal and social situations in the present, in the past, and to some extent, in the foreseeable future.

As mathematics instructors go about their duties in the classroom they do some things better than others; some problems which they meet are more troublesome than others; those who are placed above them administratively see their strong points and weak points as teachers. These factors, judgments and opinions as they are, are of value in considering what
sort of preparation seems desirable for college mathematics instructors. The following presentation begins with the kinds of courses taught by beginning mathematics instructors.

The Teaching Duties of College Mathematics Instructors

Two facets of the teaching duties of college mathematics instructors may be considered: The type of course taught immediately after receiving the Ph.D.; and the type of course taught after a probationary period, when they would be considered experienced instructors. If there is a difference between these types of duties, then graduate instruction should anticipate and plan for both the short and the long range needs of prospective college instructors. If there is no appreciable difference, then the graduate program is somewhat simplified.

The table on the next page lists the types of courses in college mathematics which the instructors included in this study had taught since receiving their Ph.D. degrees. The types are arranged in descending order of the frequency with which they were reported by the group of beginning instructors with the Ph.D. It is immediately seen that this
### Table 1

**TEACHING DUTIES OF COLLEGE MATHEMATICS INSTRUCTORS**

(Each entry is a per cent, based on the total number of instructors in each column.)

<table>
<thead>
<tr>
<th>Type of Course</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>First year mathematics</td>
<td>88</td>
<td>94</td>
<td>69</td>
<td>53</td>
<td>80</td>
</tr>
<tr>
<td>The calculus sequence</td>
<td>88</td>
<td>94</td>
<td>75</td>
<td>40</td>
<td>80</td>
</tr>
<tr>
<td>Courses requiring calculus</td>
<td>86</td>
<td>88</td>
<td>50</td>
<td>40</td>
<td>72</td>
</tr>
<tr>
<td>Courses not requiring calculus</td>
<td>56</td>
<td>70</td>
<td>69</td>
<td>40</td>
<td>59</td>
</tr>
<tr>
<td>Graduate courses</td>
<td>54</td>
<td>65</td>
<td>13</td>
<td>7</td>
<td>40</td>
</tr>
<tr>
<td>General mathematics</td>
<td>28</td>
<td>35</td>
<td>56</td>
<td>13</td>
<td>31</td>
</tr>
<tr>
<td>Remedial mathematics</td>
<td>23</td>
<td>12</td>
<td>25</td>
<td>13</td>
<td>20</td>
</tr>
<tr>
<td>Directing graduate theses</td>
<td>17</td>
<td>35</td>
<td>6</td>
<td>0</td>
<td>16</td>
</tr>
<tr>
<td>Methods of teaching mathematics</td>
<td>7</td>
<td>18</td>
<td>13</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>Science or engineering</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>7</td>
<td>2</td>
</tr>
</tbody>
</table>

**Key:**

I : 43 beginning instructors with the Ph.D. degree.
II : 17 experienced instructors with the Ph.D. degree.
III : 16 beginning instructors with the Master's degree.
IV : 15 other instructors.
Total: 91 instructors.

Sequence is the same for the group of experienced instructors, save for the position of remedial mathematics, and is exactly the same for the total group of instructors. There is evi-
dently is no need in the pre-service preparation of college mathematics instructors to distinguish between immediate and subsequent teaching duties, for they are essentially the same. The teaching duties of those instructors with only the master's degree do not follow the same sequence of those of the first two groups. The low percentages teaching graduate courses and directing thesis work are to be expected in view of the limited experience in advanced mathematics which these persons have had.

The first five types of courses listed in Table 1 are what one familiar with the job of college mathematics teaching might expect to find. Certainly they represent courses for which the instructor needs thorough understanding of advanced mathematics. The next two types are far from being traditional college mathematics, and have come into college curricula within the last twenty or thirty years as a result of widespread changes in principles of secondary education. The skills involved in teaching such courses are not wholly mathematical. Teachers of remedial mathematics are often confronted with difficulties due to students having well-established psychological blocks to learning in mathematics. Teachers of general mathematics, or mathematics for general education, are confronted with the delicate task of selecting
from the large storehouse of mathematics those features which will help their students see the value of mathematics as a cultural subject, as a means of communication, as a prime mover in science, and a source of personal enjoyment. It is an open question whether or not graduate programs for prospective mathematics instructors should provide for these understandings to be developed.

Troublesome Problems Met in Teaching

On the assumption that clues to points of weakness in any program of preparation can be found by investigating the problems confronted by the graduates of that program, the instructors in this study were presented with a list of teaching problems and were asked to indicate those which had been particularly troublesome in the teaching that they had done since receiving the Ph.D. degree. Those who did not have the Ph.D. degree answered on the basis of the experience which they had had.

The problems in this list were suggested by lists of problems encountered by college teachers in their beginning year of teaching as reported in two studies of the preparation
### Table 2

PROBLEMS OF BEGINNING COLLEGE MATHEMATICS INSTRUCTORS

(Each entry is a per cent of the corresponding group.)

<table>
<thead>
<tr>
<th>Problem</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Difficulties due to background of training and experience with which the students come to college</td>
<td>63</td>
<td>82</td>
<td>63</td>
<td>67</td>
<td>67</td>
</tr>
<tr>
<td>2. Developing in the students the ability to do straight thinking</td>
<td>49</td>
<td>47</td>
<td>63</td>
<td>27</td>
<td>59</td>
</tr>
<tr>
<td>3. Adapting instruction to differences found in the personnel of the class</td>
<td>41</td>
<td>47</td>
<td>31</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>4. Developing student interest and stimulating student thinking</td>
<td>37</td>
<td>53</td>
<td>30</td>
<td>40</td>
<td>39</td>
</tr>
<tr>
<td>5. Heavy teaching duties</td>
<td>30</td>
<td>24</td>
<td>25</td>
<td>33</td>
<td>28</td>
</tr>
<tr>
<td>6. Relating the subject being taught to other areas of knowledge</td>
<td>28</td>
<td>24</td>
<td>31</td>
<td>27</td>
<td>27</td>
</tr>
<tr>
<td>7. Organizing and presenting materials within the ability range of students</td>
<td>24</td>
<td>24</td>
<td>25</td>
<td>27</td>
<td>25</td>
</tr>
<tr>
<td>8. Difficulties due to lack of administrative understanding of teaching problems</td>
<td>17</td>
<td>6</td>
<td>19</td>
<td>7</td>
<td>13</td>
</tr>
<tr>
<td>9. Getting students to relate material being taught to current problems and situations</td>
<td>15</td>
<td>18</td>
<td>25</td>
<td>13</td>
<td>17</td>
</tr>
<tr>
<td>10. Lack of physical facilities in the classroom</td>
<td>15</td>
<td>30</td>
<td>13</td>
<td>7</td>
<td>16</td>
</tr>
</tbody>
</table>
Table 2  
(continued)

<table>
<thead>
<tr>
<th>Problem</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>11. Interpreting the results of tests for measuring achievement</td>
<td>12</td>
<td>30</td>
<td>25</td>
<td>20</td>
<td>19</td>
</tr>
<tr>
<td>12. Counseling and giving individual advice to students</td>
<td>10</td>
<td>6</td>
<td>0</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>13. Developing proper student-teacher relationships</td>
<td>7</td>
<td>12</td>
<td>13</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>14. Utilizing students' interests in planning and conducting classwork</td>
<td>7</td>
<td>30</td>
<td>13</td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td>15. Lack of preparation in all areas of mathematics</td>
<td>5</td>
<td>0</td>
<td>13</td>
<td>20</td>
<td>8</td>
</tr>
<tr>
<td>16. Arranging the units of the course in the proper sequence</td>
<td>5</td>
<td>6</td>
<td>0</td>
<td>20</td>
<td>7</td>
</tr>
<tr>
<td>17. Lack of training for college level teaching</td>
<td>0</td>
<td>12</td>
<td>6</td>
<td>13</td>
<td>6</td>
</tr>
<tr>
<td>18. Understanding the needs and objectives of the students</td>
<td>0</td>
<td>0</td>
<td>13</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>

Key:

I : 43 beginning instructors with the Ph.D. degree.
II : 17 experienced instructors with the Ph.D. degree.
III : 16 beginning instructors with the master's degree.
IV : 15 other instructors.
Total: 91 instructors.
Neither study concentrated upon a single subject matter area, but utilized data from college teachers in different fields.

With surprisingly few exceptions, the descending orders of frequency shown by the percentages in Table 2, above, are in close agreement throughout the four groups of instructors. Since the range in years of teaching experience represented by these groups is rather large, these problems may therefore be called perennial problems faced by college mathematics instructors. The first four of these can be characterized as student-centered problems, in contrast to No. 5, which is an administrative problem, and to No. 6, which depends upon each instructor's knowledge and experience in subject matter. It is interesting to note the relatively large percentage of the experienced instructors which reported having experienced difficulty in utilizing students' interests (problem No. 14). This may be due to an increasing awareness of the need for thus vitalizing one's teaching, the longer he is in the profession. It may also be due to an increase in emphasis upon this aspect of teaching in the graduate preparation of the beginning instructors in this study. This latter point is

supported by the percentages in problem No. 17, where again
the group of experienced instructors has the largest percen-
tage. No. 6, "relating the subject being taught to other
areas of knowledge," was troublesome to 27 per cent of the
entire group. This is not an alarmingly large percentage,
but since the ability under question is of great importance
in teaching, every attempt should be made to decrease this
percentage. The data of Kidd's and Byram's studies, obtained
from even smaller samplings of college mathematics instruc-
tors than the present study, cannot be used to determine
whether or not fewer instructors today are beset by the
problems in Table 2.

Strengths and Weaknesses of
College Mathematics Instructors
as Reported by Deans and Department Heads

It has been said that most men will point out ten weak-
nesses for every single strength when asked to judge a per-
son. Perhaps this is not due to unprincipled fault-finding,
but to an innate and sincere desire to point out desired
improvements in what seems to be an imperfect situation.
Therefore the significance of the data shown below may not
reside in the fact that the ratio of persons reporting
strengths to those reporting weaknesses is nearly four to one, but that this ratio is no larger than it is.

To the request for a list of strengths and weaknesses in the preparation of beginning college mathematics instructors there were approximately eighty replies from the heads of undergraduate mathematics departments and the same number from the deans of liberal arts colleges. The comments as

Table 3

<table>
<thead>
<tr>
<th>STRENGTHS IN COLLEGE MATHEMATICS INSTRUCTORS</th>
<th>Reported by deans and undergraduate mathematics department heads</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Each entry is a per cent of the corresponding group.)</td>
<td></td>
</tr>
<tr>
<td><strong>Strengths</strong></td>
<td><strong>Deans (179)</strong></td>
</tr>
<tr>
<td>1. Strong mathematical background</td>
<td>4</td>
</tr>
<tr>
<td>2. Enthusiastic about mathematics and about teaching it</td>
<td>1</td>
</tr>
<tr>
<td>3. Strong background in allied fields</td>
<td>2</td>
</tr>
<tr>
<td>4. Willing and able to see and help with student difficulties</td>
<td>2</td>
</tr>
<tr>
<td>5. Had previous high school teaching experience</td>
<td>1</td>
</tr>
</tbody>
</table>
given on the returned questionnaires have been condensed into the five strengths and weaknesses which appear in Tables 3 and 4, respectively.

The data in these tables help to bring out explicitly areas of necessary emphasis in the preparation of college mathematics instructors. For example, some consider a "strong background in allied fields" a strength, where others recognize the inability to "show applications of mathematics to other fields" as a weakness. Evidently knowledge of mathematics alone is not sufficient to insure good teaching. Weaknesses No. 1, 2, and 6 in Table 4 add emphasis to this.

Table 4

WEAKNESSES IN COLLEGE MATHEMATICS INSTRUCTORS
Reported by deans and undergraduate mathematics department heads

(Each entry is a per cent of the corresponding group.)

<table>
<thead>
<tr>
<th>Weaknesses</th>
<th>Reported by:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Deans (179)</td>
</tr>
<tr>
<td>1. Too theoretical, or assumes too much on the part of the students</td>
<td>9</td>
</tr>
<tr>
<td>2. Too specialized in advanced pure mathematics; tends to emphasize specialty in teaching</td>
<td>7</td>
</tr>
</tbody>
</table>
Table 4
(continued)

<table>
<thead>
<tr>
<th>Weaknesses</th>
<th>Reported by:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Deans (179)</td>
</tr>
<tr>
<td></td>
<td>Heads (178)</td>
</tr>
<tr>
<td></td>
<td>Total (357)</td>
</tr>
<tr>
<td>3. Weak in student-instructor relationships; subordinates student to subject; does not help with student learning problems</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>8</td>
</tr>
<tr>
<td>4. Poor teacher: not enthusiastic or does not understand teaching problems</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>6</td>
</tr>
<tr>
<td>5. Cannot show applications of mathematics to other fields</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>6</td>
</tr>
<tr>
<td>6. Has a narrow view of mathematics in relation to the total college program</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>3</td>
</tr>
<tr>
<td>7. Teaches the &quot;how&quot; rather than the &quot;why&quot; of mathematics</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>8. Prefers research rather than teaching</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>9. Lack of classroom experience</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>10. Underrates the students</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>11. Unable to explain without the text</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>12. Shows off his ability and knowledge</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

Strength No. 4, weakness No. 3 and, to some extent, weakness No. 10 point to the importance of giving prospective college mathematics teachers a realization that their job is more
than lecturing and giving examinations. Enthusiasm for teaching is shown to be a highly desirable quality in the effectiveness of a college instructor since it is the central factor in strength No. 2 and in weaknesses No. 4 and 8.

Slightly more than one-half of the deans and undergraduate mathematics chairmen listed no strengths or weaknesses, thus suggesting the conclusion that they consider the teaching done by their beginning mathematics instructors to be adequate. However, this fact may reflect a lack of rapport between these administrators and the instructors under them, if not actual ignorance of just how these instructors do behave in the classroom. On the other hand, those strengths and weaknesses which were reported, having been written in rather than checked off from a suggested list, are likely to be highly authentic and a true reflection of the judgments of these administrators.

Some Characteristics of Effective College Mathematics Instructors

Some very general characteristics of effective college teachers were presented in 1938 in a report on the training
of college teachers. 2 From those which were considered most desirable in this study by Gray, a list of eleven was chosen and presented to the deans and undergraduate mathematics chairmen in the present study. It was expected that the reactions to these questions would be that the characteristics were desirable because of the manner in which they were chosen. Nevertheless, an insight into the relative degrees of desirability was obtained and this information has been summarized in the following table.

Table 5

RATINGS OF CHARACTERISTICS
OF COLLEGE MATHEMATICS INSTRUCTORS
Reported by deans and undergraduate mathematics department heads

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Deans (179)</th>
<th>Heads (178)</th>
<th>Total (357)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Good preparation in the entire field of mathematics</td>
<td>VD</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>2. Breadth in general education</td>
<td>VD</td>
<td>VD</td>
<td>VD</td>
</tr>
<tr>
<td>3. Competency in research</td>
<td>D</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>4. Good personality</td>
<td>VD</td>
<td>VD</td>
<td>VD</td>
</tr>
<tr>
<td>5. Broad understanding of human nature of men and women of college age</td>
<td>VD</td>
<td>VD</td>
<td>VD</td>
</tr>
</tbody>
</table>

2William S. Gray, ed., Preparation and In-service Training of College Teachers.
### Table 5 (continued)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Rated by:</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Deans</td>
<td>Heads</td>
<td>Total</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(179)</td>
<td>(178)</td>
<td>(357)</td>
<td></td>
</tr>
<tr>
<td>6. Enthusiasm for and devotion to teaching as a profession</td>
<td>VD</td>
<td>VD</td>
<td>VD</td>
<td></td>
</tr>
<tr>
<td>7. Understanding of the teaching-learning process</td>
<td>VD</td>
<td>VD</td>
<td>VD</td>
<td></td>
</tr>
<tr>
<td>8. Willingness continuously to survey, repair, and supplement his general and</td>
<td>VD</td>
<td>VD</td>
<td>VD</td>
<td></td>
</tr>
<tr>
<td>professional education</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Capacity for democratic living, as shown by participation in college</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>and community life</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Understanding of role of mathematics in higher education and of place of</td>
<td>VD</td>
<td>D</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>higher education in our society</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Understanding of contribution of mathematics to general education and to</td>
<td>VD</td>
<td>D</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>vocational and professional education</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Key:**

- **D** = Desirable
- **VD** = Very desirable

Each rating in Table 5 is a weighted average of the ratings given by the members of each group, as explained above on page 28. Both groups agreed in rating all of these
traits on the desirable side of the scale; in fact, the majority of the ratings are "very desirable." It should be noted that "competency in research" did not receive the "very desirable" rating, although it was rated "desirable" by both groups. Evidently research ability in college mathematics instructors is not the most desirable characteristic wanted by administrators. Other characteristics such as "breadth in general education," "enthusiasm," and "understanding the teaching-learning process" are more highly valued.

In the three cases where the ratings of the two groups differed (Nos. 1, 10, and 11), the group of deans gave the higher rating. Yet the predominant influence in those three cases was that of the group of mathematics chairmen, for it resulted in ratings of "desirable" for the total group. In No. 1, the mathematicians were being realistic in not rating preparation in the entire field of mathematics higher than "desirable." In Nos. 10 and 11, the deans seem to show a less narrow point of view with regard to the question of the role of mathematics in higher education in their rating of "very desirable."

Both the deans and the undergraduate mathematics chairmen on the average feel very strongly that their mathematics
instructors should have good personalities, enthusiasm for teaching, and a willingness to grow professionally. These traits are much more intangible and more difficult to develop through formal programs of training than the other three characteristics which received "very desirable" ratings:

No. 2. Breadth in general education

No. 5. Broad understanding of human nature of men and women of college age.

No. 7. Understanding of the teaching-learning process.

By their very natures the three characteristics immediately preceding must be developed either from a background of teaching experience, or from organized study of college teaching problems, or both. If these characteristics are desired or expected in beginning college mathematics instructors, they must be developed during their graduate school experience.
In this study programs of graduate mathematics students are divided into two parts: academic and professional preparation. This is not meant to imply that there is no common meeting ground for these two areas of experience. By academic preparation will be meant those courses or seminars in which the students learn the subject matter in mathematics, in areas closely related to mathematics, and in areas not closely related, exclusive of courses in educational theory or practice. It cannot be said that academic preparation covers merely what instructors will teach. They will go far beyond the level of undergraduate college mathematics, often branching into avenues of mathematical study so advanced that a direct application of this learning to their teaching may never be made, even though they should teach graduate courses in mathematics. This does not mean that effective teaching at the elementary college levels is not reinforced by advanced study in the general areas of algebra, analysis, and geometry, or even in more specialized areas such as har-
monic functions, topology, or Galois theory. The benefits of such study are often referred to as furnishing "mathematical maturity," "breadth of perspective," or "the gestalt of the subject," as shown by a good understanding of the interrelated nature of mathematics as a logical system of thought, how it is related to other fields of thought, and how mathematics is used. The assumption is often made that this elusive characteristic, however it be named, is a consequence of advanced mathematical study alone. There seem to be other variables which enter into the problem. The point of view with which the graduate student enters upon his graduate study of mathematics helps to determine the extent to which these desirable outcomes are achieved. The professor also is an influential factor, for in the hands of one these understandings may be fully achieved by most students, while in the hands of another the whole process may be mechanical and largely meaningless.

In one of the most recent conferences on the preparation of college teachers a work group, concentrating upon examination of the characteristics of institutional programs, commended the following features of some experimental programs in progress:

The introduction of broad interdepartmental and interdivisional programs at the graduate level, or, in the case of departmental concentration,
considerable training in related fields to the end that, (a) prospective college teachers may acquire a better grasp of the interrelationships among the several disciplines in a given field, (b) they may be better prepared to teach a reasonable breadth of courses and to participate in the development of new types of interdivisional programs, and (c) their own scholarly efforts and creative work may have greater significance.\(^1\)

Houston Peterson, in his book about great teachers, points out that each had an extremely profound grasp of the subject matter of his field. However, none was limited to his own specialty, for Peterson says:

> Yet, paradoxically, the fine teacher, who knows his subject thoroughly and has the power to excite interest in it, always carries his students beyond its boundaries.\(^2\)

In a report which dealt very specifically with the problem of preparing teachers of college mathematics, the following recommendations for academic preparation were made:

1. Foundation courses in each sub-field of advanced mathematics, followed by additional advanced work, with emphasis upon breadth of training.

2. Elementary graduate work in a field closely related to mathematics, with subsequent work in other fields, again emphasizing breadth.\(^3\)

\(^1\) Theodore C. Blegen and Russell M. Cooper, *The Preparation of College Teachers*, p. 165.


There is evidently more than speculative thinking about the question of breadth in graduate education, if the reports in the literature are true. Definite questions such as the following come to mind: "Have the recommendations of the Mathematical Association of America been followed?" "Do any of the experimental programs in progress extend into the graduate mathematics departments?" Data furnishing partial answers to these questions have been obtained from graduate mathematics departments and from recent graduates who have reported on the nature of their graduate study.

The two tables of data which follow show that the majority of the new Ph.D.'s in mathematics in the last five years have taken college teaching positions, and that the majority of the present candidates for the Ph.D. in mathematics plan to become college teachers.

Table 6

PER CENT OF PH.D.'S TAKING COLLEGE MATHEMATICS TEACHING POSITIONS DURING 1947-1952

Reported by the chairmen of 29 graduate mathematics departments.

<table>
<thead>
<tr>
<th>Per cent of Ph.D.'s</th>
<th>0</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
<th>60</th>
<th>70</th>
<th>80</th>
<th>90</th>
<th>100</th>
<th>No Reply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per cent of depart-</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>14</td>
<td>7</td>
<td>3</td>
<td>17</td>
<td>17</td>
<td>24</td>
<td>10</td>
</tr>
<tr>
<td>ments reporting</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^1\) These positions were taken soon after graduation.
Table 7

PER CENT OF PH.D. CANDIDATES PLANNING TO BECOME COLLEGE MATHEMATICS INSTRUCTORS  
Reported by the chairmen of 29 graduate mathematics departments

<table>
<thead>
<tr>
<th>Per cent of candidates</th>
<th>0</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
<th>60</th>
<th>70</th>
<th>80</th>
<th>90</th>
<th>100</th>
<th>No Reply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per cent of departments reporting</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>14</td>
<td>0</td>
<td>3</td>
<td>14</td>
<td>10</td>
<td>38</td>
<td>14</td>
</tr>
</tbody>
</table>

The over-all average of the data in Table 7 is 60 per cent. This means that 60 per cent of the Ph.D. candidates in 25 (86 per cent) of the graduate mathematics departments in this study are planning to become college mathematics instructors. Thus, whether or not it is recognized by the graduate mathematics faculties, one of their major purposes, in terms of numbers of students, is to prepare instructors of college mathematics. The first aspect of this preparation which will be presented here deals with the mathematics courses taken by graduate mathematics students.

Courses in Mathematics

One of the original features of graduate instruction as it was brought to this country from Germany was the principle
that instruction should be based upon the individual student's abilities and interests. Nearly all of the large graduate schools today are faithfully trying to uphold this principle in the face of graduate classes of unwieldy size. When graduate schools adhere closely to this principle it becomes nearly impossible for them to give definite answers to questions concerning requirements for graduate degrees in any subject.

This difficulty has arisen in this study and, although not completely solved, enough data have been obtained to allow formulation of a set of courses to serve as a nucleus for graduate study in mathematics. The heads of graduate mathematics departments were asked what courses are studied by most of their Ph.D. candidates and also what courses are considered necessary for the Ph.D. degree. The next four tables summarize their replies. The courses and topics in Tables 8 - 10 were chosen by the respondents from a list of forty-two topics in advanced mathematics and closely related topics. These may be seen in Appendix D, question No. 25.

In Table 8 forty-five per cent or more of the department chairmen replying indicated seventeen topics which are studied by most of their candidates in mathematics. These
Table 8

MATHEMATICS COURSES FOR THE PH.D. DEGREE, THOSE STUDIED AND THOSE CONSIDERED NECESSARY Reported by the chairmen of 29 graduate mathematics departments.

<table>
<thead>
<tr>
<th>Course or topic</th>
<th>Per cent of departments reporting</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Studied</td>
</tr>
<tr>
<td>Functions of a real variable</td>
<td>93</td>
</tr>
<tr>
<td>Modern higher algebra</td>
<td>93</td>
</tr>
<tr>
<td>Matrix theory</td>
<td>93</td>
</tr>
<tr>
<td>Functions of a complex variable</td>
<td>90</td>
</tr>
<tr>
<td>Differential equations</td>
<td>90</td>
</tr>
<tr>
<td>Group theory</td>
<td>86</td>
</tr>
<tr>
<td>Infinite series</td>
<td>79</td>
</tr>
<tr>
<td>Projective geometry</td>
<td>66</td>
</tr>
<tr>
<td>Differential geometry</td>
<td>66</td>
</tr>
<tr>
<td>Set theory</td>
<td>62</td>
</tr>
<tr>
<td>Field theory</td>
<td>62</td>
</tr>
<tr>
<td>Fourier series</td>
<td>62</td>
</tr>
<tr>
<td>Point set topology</td>
<td>55</td>
</tr>
<tr>
<td>Number theory</td>
<td>48</td>
</tr>
<tr>
<td>Calculus of variations</td>
<td>48</td>
</tr>
<tr>
<td>Vector analysis</td>
<td>48</td>
</tr>
<tr>
<td>Foundations of mathematics</td>
<td>45</td>
</tr>
<tr>
<td>Harmonic functions</td>
<td>38</td>
</tr>
<tr>
<td>Combinatorial topology</td>
<td>31</td>
</tr>
<tr>
<td>Mathematical statistics</td>
<td>31</td>
</tr>
<tr>
<td>Theory of probability</td>
<td>28</td>
</tr>
<tr>
<td>Algebraic geometry</td>
<td>17</td>
</tr>
</tbody>
</table>
Table 8 (continued)

<table>
<thead>
<tr>
<th>Course or topic</th>
<th>Per cent of departments reporting</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Studied</td>
</tr>
<tr>
<td>Calculus of finite differences</td>
<td>14</td>
</tr>
<tr>
<td>Hydrodynamics</td>
<td>14</td>
</tr>
<tr>
<td>Special theory of relativity</td>
<td>14</td>
</tr>
<tr>
<td>Modern computing methods</td>
<td>14</td>
</tr>
<tr>
<td>Elasticity</td>
<td>10</td>
</tr>
<tr>
<td>History of mathematics</td>
<td>7</td>
</tr>
<tr>
<td>Electromagnetic theory</td>
<td>7</td>
</tr>
<tr>
<td>General theory of relativity</td>
<td>7</td>
</tr>
<tr>
<td>Quantum mechanics</td>
<td>7</td>
</tr>
<tr>
<td>Actuarial mathematics</td>
<td>3</td>
</tr>
<tr>
<td>Aerodynamics</td>
<td>3</td>
</tr>
<tr>
<td>Hydrodynamics</td>
<td>3</td>
</tr>
</tbody>
</table>

topics are well distributed over the foundations of three major sub-fields of mathematics: algebra, analysis, and geometry. "Foundations of mathematics," a course usually devoted to a postulational development of mathematics, often with extensive use of symbolic logic, was marked by only slightly less than one-half of the total number of respondents. Because of the basic nature of this topic, it seems to be one which should form part of the foundation for graduate study of mathematics, even though it is not extremely widely studied.

Table 8 also shows that the topics marked by one-half or more of the department heads as necessary for the Ph.D.
form a relatively small list of topics. This may indeed be a true reflection of the opinions held in most graduate mathematics departments, due to the difficulty of saying what should be on a list of necessary topics, when the needs of individual students differ as they do. Several comments written in by the respondents as they considered this point serve to illustrate it further:

We offer all these courses, and some Ph.D. candidates take some; others take another set, according to their fields of special interest.

Subjects are required according to the student's particular field of mathematics.

... depends entirely upon the direction of specialization of the candidate.

The two columns in Table 8 agree fairly well in several respects. The topics reported as studied most in one-half or more of the departments include eleven of the first twelve topics considered necessary for the Ph.D. Those reported as necessary by one-half or more of the departments comprise the first five topics in the list of those studied most. Finally the two lists agree exactly, except for the order, in their first seven topics.

It is immediately apparent that geometry is not represented among the seven topics just noted. Although point set topology, differential geometry, and projective geometry
are studied by most Ph.D. candidates in one-half or more of the graduate mathematics departments answering this question, these topics are considered necessary by only 34, 24, and 14 per cent, respectively, of these departments. There is certainly not enough evidence here to conclude that this shows a trend away from the study of geometry in graduate mathematics departments. These data may be more suitably explained as another indication of the genuine difficulty of setting forth definitive requirements for graduate study in mathematics.

In keeping with the desire to get information to show what is desirable in Ph.D. programs in mathematics, the writer asked graduate mathematics department chairmen to indicate on their questionnaires the topics which they did not offer, but which, in their opinion, should be offered. These replies are summarized in Table 9. Although they represent a small percentage of the numbers of departments which replied to the first two parts of this question, these data are given because they indicate areas of recognized shortcomings in some graduate mathematics departments.

There was also an opportunity for the graduate mathematics chairmen to indicate the topics which they do not offer and which should not be offered. These data are pre-
Table 9

**MATHEMATICS COURSES FOR THE PH.D. DEGREE,**
**THOSE NOT OFFERED BUT WHICH SHOULD BE OFFERED**
**Reported by the chairmen of**
**29 graduate mathematics departments**

<table>
<thead>
<tr>
<th>Course or topic</th>
<th>Per cent of departments reporting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematical statistics</td>
<td>28</td>
</tr>
<tr>
<td>History of mathematics</td>
<td>21</td>
</tr>
<tr>
<td>Foundations of mathematics</td>
<td>17</td>
</tr>
<tr>
<td>Theory of probability</td>
<td>14</td>
</tr>
<tr>
<td>Combinatorial topology</td>
<td>10</td>
</tr>
<tr>
<td>Theory of numbers</td>
<td>10</td>
</tr>
<tr>
<td>Calculus of finite differences</td>
<td>10</td>
</tr>
<tr>
<td>Calculus of variations</td>
<td>7</td>
</tr>
<tr>
<td>Differential geometry</td>
<td>7</td>
</tr>
<tr>
<td>Projective geometry</td>
<td>7</td>
</tr>
<tr>
<td>Special theory of relativity</td>
<td>7</td>
</tr>
<tr>
<td>General theory of relativity</td>
<td>7</td>
</tr>
<tr>
<td>Hydrodynamics</td>
<td>7</td>
</tr>
<tr>
<td>Aerodynamics</td>
<td>7</td>
</tr>
<tr>
<td>Modern computing methods</td>
<td>7</td>
</tr>
<tr>
<td>Point set topology</td>
<td>7</td>
</tr>
<tr>
<td>Set theory</td>
<td>7</td>
</tr>
<tr>
<td>Electromagnetic theory</td>
<td>3</td>
</tr>
<tr>
<td>Quantum mechanics</td>
<td>3</td>
</tr>
<tr>
<td>Astronomy</td>
<td>3</td>
</tr>
<tr>
<td>Algebraic geometry</td>
<td>3</td>
</tr>
<tr>
<td>Field theory</td>
<td>3</td>
</tr>
<tr>
<td>Modern higher algebra</td>
<td>3</td>
</tr>
<tr>
<td>Harmonic functions</td>
<td>3</td>
</tr>
<tr>
<td>Infinite series</td>
<td>3</td>
</tr>
<tr>
<td>Vector analysis</td>
<td>3</td>
</tr>
</tbody>
</table>
sent below in Table 10.

Table 10

MATHEMATICS COURSES FOR THE PH.D. DEGREE, THOSE NOT OFFERED AND WHICH SHOULD NOT BE OFFERED
Reported by the chairmen of 29 graduate mathematics departments.

<table>
<thead>
<tr>
<th>Course or topic</th>
<th>Per cent of departments reporting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electromagnetic theory</td>
<td>14</td>
</tr>
<tr>
<td>Mathematical biology</td>
<td>10</td>
</tr>
<tr>
<td>Ergodic theory</td>
<td>10</td>
</tr>
<tr>
<td>Actuarial mathematics</td>
<td>10</td>
</tr>
<tr>
<td>Astronomy</td>
<td>10</td>
</tr>
<tr>
<td>Modern computing methods</td>
<td>10</td>
</tr>
</tbody>
</table>

Several comments were made concerning twelve topics in applied mathematics which were included in the list of topics presented in the questionnaire to graduate mathematics departments. Some chairmen said that they should be offered, but not in the mathematics department; others said that they were being offered, but in the division of applied mathematics. This seems to be typical of the division which has developed between "pure" and "applied" mathematicians. In discussing the training of industrial mathematicians, Thornton C. Fry, Mathematical Research Director of Bell Telephone Laboratories, suggested a means of bridging the gap
by recommending that advanced training in algebra, geometry, and analysis be taught in the following way:

... with an attitude sympathetic to their applications, and reinforced with theoretical courses in sound, heat, light, and electricity, and by heavy emphasis upon mechanics, elasticity, hydrodynamics, thermodynamics, and electromagnetic field theory. ... There is nowhere in America where this training can be acquired. No school has attempted to build a faculty of mathematics with such training in mind. Hence industry has had to make such shift as might with ersatz mathematicians culled from departments of physics and engineering.  

Besides the danger to the development of industrial mathematicians resulting from the situation as Fry described it, there is a similar danger to the development of college mathematics instructors. A great part of the student population taking mathematics in universities, and to some extent in colleges, is interested in mathematics as it is applied to the sciences and engineering. Mathematics instructors would be much more inclined to teach mathematics "with an attitude sympathetic to applications" if they have studied it that way. This attitude in teaching also has significance for teachers of mathematics for general education. Here one aim is to show the interrelationships of mathematics with present and past cultures of the world. Perhaps the

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5Commission on Post-War Plans of the National Council of Teachers of Mathematics, Guidance Pamphlet for High School Students, p. 18.
most important facet of these relationships reflects the impact of the applications of mathematics as an ideal system of thought to the problems which men have faced, are still facing, and will continue to face.

Courses in Areas Related to Mathematics

Fry and others would prefer to see graduate mathematics programs provide greater breadth. Rather than to explore specific ways in which advanced mathematics training could be widened, the author investigated the degree to which such breadth might be accomplished. To that end, three levels of breadth were defined as follows:

1. Graduate work entirely in mathematics
2. Graduate work partly in topics closely related to mathematics
3. Graduate work partly in topics not closely related to mathematics.

Courses in science are considered as closely related, and courses in fine arts and social studies, for example, are considered not closely related to mathematics. Such simplification is bound to ignore the fact that in some cases work entirely in mathematics can be much broader than appears from the titles of courses. These three levels, however, repre-
sent a framework upon which different programs may be placed for purposes of comparing extent of breadth.

Each questionnaire in this study included a question designed to discover the extent to which the graduate work of a prospective college mathematics instructor lay entirely in mathematics, and an expression of opinion of the desirability of this as a practice. The chairmen of graduate mathematics departments, when asked this question in a form somewhat different from that put to the other groups, made replies which are summarized in the table below:

Table 11

TIME SPENT BY PROSPECTIVE COLLEGE MATHEMATICS INSTRUCTORS IN THE STUDY OF MATHEMATICS
Reported by the chairmen of 29 graduate mathematics departments

<table>
<thead>
<tr>
<th></th>
<th>PRESENT PRACTICE</th>
<th>DESIRED PRACTICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per cent of academic schedule given to mathematics</td>
<td>100 95 90 85 80 75 70 65</td>
<td>No Reply</td>
</tr>
<tr>
<td>Per cent of departments reporting</td>
<td>17 0 21 3 17 7 10 0 24</td>
<td></td>
</tr>
<tr>
<td>Per cent of academic schedule given to mathematics</td>
<td>100 95 90 85 80 75 70 65</td>
<td>No Reply</td>
</tr>
<tr>
<td>Per cent of departments reporting</td>
<td>7 0 10 3 17 14 7 3 38</td>
<td></td>
</tr>
</tbody>
</table>
Although 17 per cent of the graduate mathematics chairmen reported that prospective instructors spend 100 per cent of their study in mathematics, only 7 per cent felt that this is desirable. The median of the replies for present practice was 90 per cent of the student's academic schedule; 80 per cent was the median of the replies for desired practice.

Table 12 summarizes the replies to the questions, "During your pre-doctoral graduate work, did you devote all your work to courses or seminars in advanced mathematics?" and "How desirable is this practice for a prospective college mathematics instructor?" It should be obvious from the entries in the table that the first of these questions was not asked of the chairmen of undergraduate mathematics departments or of the deans since it did not apply to them.

The "present practice" data in Table 12 show that 34 out of 80 instructors, or 43 per cent of them, have concentrated on mathematics to the exclusion of other areas in their graduate training. With the exception of the deans, each group felt that such a practice was of neutral desirability. The average opinion from the group of deans was that this is undesirable in the training of college mathematics instructors.
Table 12

THE EXTENT TO WHICH PROSPECTIVE COLLEGE MATHEMATICS INSTRUCTORS DEVOTE ALL OF THEIR GRADUATE WORK TO THE STUDY OF MATHEMATICS, AND RATINGS OF THIS PRACTICE

(Each entry is a per cent of its corresponding group.)

<table>
<thead>
<tr>
<th>Group</th>
<th>Total No.</th>
<th>Present Practice</th>
<th>Desirability Ratings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>I</td>
<td>178</td>
<td>4</td>
<td>49</td>
</tr>
<tr>
<td>II</td>
<td>179</td>
<td>16</td>
<td>58</td>
</tr>
<tr>
<td>IV</td>
<td>43</td>
<td>7</td>
<td>16</td>
</tr>
<tr>
<td>V</td>
<td>17</td>
<td>0</td>
<td>35</td>
</tr>
<tr>
<td>VI</td>
<td>16</td>
<td>13</td>
<td>25</td>
</tr>
<tr>
<td>VII</td>
<td>15</td>
<td>7</td>
<td>40</td>
</tr>
</tbody>
</table>

Key:
I - Chairmen, undergraduate mathematics
II - Deans, liberal arts
*IV - Beginning instructors, Ph.D.
V - Experienced instructors, Ph.D.
VI - Beginning instructors, M.A.
VII - Other instructors

6. Explanation of the 'Ave.' column, using Group I as an example:

- 4% gave a VU rating: (4)(-2) = -8
- 49% gave a U rating: (49)(-1) = -49
- 15% gave a N rating: (15)(0) = 0
- 18% gave a D rating: (18)(1) = 18
- 11% gave a VD rating: (11)(2) = 22

Total = -17

Since 2% did not reply, the average was computed on the base of 98%: (-17) + 98 = -0.17, or N, to the nearest rating.

*For data from group III, see Table II, p. 61.
Proceeding to the next level of breadth, Table 13 summarizes the replies to the question, "Should prospective college mathematics instructors devote part of their graduate work to the study of topics closely related to mathematics, and ratings of this practice".

Table 13

THE EXTENT TO WHICH PROSPECTIVE COLLEGE MATHEMATICS INSTRUCTORS DEVOTE PART OF THEIR GRADUATE WORK TO THE STUDY OF TOPICS CLOSELY RELATED TO MATHEMATICS, AND RATINGS OF THIS PRACTICE

(Each entry is a per cent of its corresponding group.)

<table>
<thead>
<tr>
<th>Group</th>
<th>Total No.</th>
<th>Present Practice</th>
<th>No Reply</th>
<th>Desirability Ratings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>178</td>
<td>128</td>
<td>46</td>
<td>5</td>
</tr>
<tr>
<td>II</td>
<td>179</td>
<td>110</td>
<td>49</td>
<td>6</td>
</tr>
<tr>
<td>III</td>
<td>29</td>
<td>86</td>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>IV</td>
<td>43</td>
<td>44</td>
<td>44</td>
<td>12</td>
</tr>
<tr>
<td>V</td>
<td>17</td>
<td>59</td>
<td>29</td>
<td>12</td>
</tr>
<tr>
<td>VI</td>
<td>16</td>
<td>44</td>
<td>50</td>
<td>6</td>
</tr>
<tr>
<td>VII</td>
<td>15</td>
<td>53</td>
<td>27</td>
<td>20</td>
</tr>
</tbody>
</table>

Key:
I - Chairmen, undergraduate mathematics
II - Deans, liberal arts
III - Chairmen, graduate department
IV - Beginning instructors, Ph.D.
V - Experienced Instructors, Ph.D.
VI - Beginning instructors, M.A.
VII - Other instructors
VU - Very Undesirable
U - Undesirable
N - Neutral
D - Desirable
VD - Very Desirable
mathematics?" Although not a large portion of the instructors in this study had spent part of their graduate study in this way, they, as well as the deans and the department heads, considered this a desirable practice.

The graduate mathematics departments, furnishing data in terms of the per cent of time spent by graduate students in areas closely related to mathematics, seem to agree with the above results. Table 14 shows that among the graduate mathematics chairmen reporting, 10 per cent was the median portion of time spent by prospective instructors in areas

Table 14

<table>
<thead>
<tr>
<th>PRESENT PRACTICE</th>
<th>DESIRED PRACTICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per cent of academic schedule given to closely related topics</td>
<td>30 25 20 15 10 5 0 No Reply</td>
</tr>
<tr>
<td>Per cent of departments reporting</td>
<td>3 3 17 7 28 0 17 24</td>
</tr>
</tbody>
</table>

Time spent by prospective college mathematics instructors in study of topics closely related to mathematics. Reported by the chairmen of 29 graduate mathematics departments.
closely related to mathematics, and that 15 per cent would be considered a desirable portion.

The third level of breadth in the academic schedule of prospective mathematics instructors did not receive much support from graduate mathematics departments, either in terms of present practice or in desirability ratings, as shown in Table 15. Five graduate mathematics chairmen reported that their prospective instructors do work in areas not closely related to mathematics, and 27 per cent regard some such work as desirable. Where 59 per cent of the

Table 15

<table>
<thead>
<tr>
<th>Present Practice</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Per cent of academic schedule given to not closely related topics</td>
<td>25</td>
</tr>
<tr>
<td>Per cent of departments reporting</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Desired Practice</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Per cent of academic schedule given to not closely related topics</td>
<td>25</td>
</tr>
<tr>
<td>Per cent of departments reporting</td>
<td>3</td>
</tr>
</tbody>
</table>
graduate chairmen reported that no time is given by their graduate students to this type of study, only 35 per cent felt that such a lack of emphasis is desirable. Thus, one can notice a slight shift toward considering work not closely related to mathematics as a desirable element in training instructors.

The first entry in both "Present Practice" and "Desired Practice" in Table 15 warrants comment and explanation, since it is a marked deviation from the rest of the data. This entry shows that one of the graduate mathematics departments reported that 25 per cent of the time spent by its graduate mathematics students was in fields not closely related to mathematics, and that this is a desirable relative emphasis. Reference to the questionnaire in which this fact was reported showed the writer that a possible explanation may lie in the fact that this department is part of an institution which is almost entirely devoted to the preparation of teachers for all levels of education. More emphasis than usual is evidently given there to general education at the graduate level.

The undergraduate mathematics department chairmen and the mathematics instructors, in replying to their questionnaires, took a neutral stand regarding the desirability of
work in areas not closely related to mathematics. The deans, on the other hand, felt that this is a desirable practice for prospective instructors. Less than 20 percent of the instructors reported that such work had been a part of their pre-doctoral graduate work. These facts are seen in Table 16.

Table 16

<table>
<thead>
<tr>
<th>Group</th>
<th>Total No.</th>
<th>Present Practice</th>
<th>Desirability Ratings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>I</td>
<td>178</td>
<td>6</td>
<td>21</td>
</tr>
<tr>
<td>II</td>
<td>179</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>III</td>
<td>29</td>
<td>14</td>
<td>28</td>
</tr>
<tr>
<td>IV</td>
<td>43</td>
<td>2</td>
<td>19</td>
</tr>
<tr>
<td>V</td>
<td>17</td>
<td>1</td>
<td>94</td>
</tr>
<tr>
<td>VI</td>
<td>16</td>
<td>1</td>
<td>81</td>
</tr>
<tr>
<td>VII</td>
<td>15</td>
<td>1</td>
<td>67</td>
</tr>
</tbody>
</table>

Key:

I - Chairmen, undergraduate mathematics
II - Deans, liberal arts
III - Chairmen, graduate mathematics
IV - Beginning instructors, Ph.D.
V - Experienced instructors, Ph.D.
VI - Beginning instructors, M.A.
VII - Other instructors
Some of the more salient facts to be obtained from the tabular data in this section are summarized here:

1. Approximately one-half of the instructors in this study, regardless of teaching experience or length of preparation, have taken graduate work in areas closely related to mathematics as part of their pre-doctoral preparation.

2. Graduate mathematics departments reported that, on the average, a prospective instructor spends 10 per cent of his academic schedule in work closely related to mathematics, and that 15 per cent would be desirable.

3. Deans, chairmen of undergraduate mathematics departments, and college instructors of mathematics concurred in rating as "desirable" work in areas closely related to mathematics.

4. With some exceptions, work not closely related to mathematics does not form a part of pre-doctoral preparation for college mathematics teaching, and received a desirability rating of "neutral" from all groups except the deans, who rated it "desirable".

5. Concentration on mathematics, to the exclusion of all other topics, was found to exist in five graduate mathematics departments and in the training of nearly half of the instructors. It was rated as "undesirable" by the deans and "neutral" by the other groups.

Since it has been shown that some work outside the area of mathematics is considered desirable by all groups involved in this study, it follows that some consideration should be given to the way in which this work may be pursued by prospective instructors. The chairmen of graduate mathematics departments were asked to indicate, among four
choices, the way in which this time would be best utilized. Table 17 shows their replies.

Table 17

PROPOSED WAYS OF UTILIZING TIME SPENT IN STUDY OUTSIDE THE FIELD OF MATHEMATICS BY PH.D. CANDIDATES IN MATHEMATICS
Reported by the chairmen of 29 graduate mathematics departments
(Each entry is a per cent of the total group.)

<table>
<thead>
<tr>
<th>Proposed Ways</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free electives</td>
<td>52</td>
</tr>
<tr>
<td>Required courses</td>
<td>3</td>
</tr>
<tr>
<td>Guided readings</td>
<td>7</td>
</tr>
<tr>
<td>Other ways</td>
<td>7</td>
</tr>
<tr>
<td>No reply</td>
<td>31</td>
</tr>
</tbody>
</table>

Credit Requirements for the Ph.D. Degree in Mathematics

So far in this study there has been little evidence of a pattern of study which all, or even most, college mathematics instructors follow in their graduate school preparation. This should be welcome news to those who fear the kind of regimentation suggested by the following quotation:

One dangerous direction that this current burning concern with the improvement of college teaching may take, and a thing that I am convinced we must avoid as the plague, is the direction of conviction that any attempt to pour all
our college teachers of the future into one mold, and to trim our present teachers down to a series of common denominators will be a capitulation to the less inspired educationists which we can ill afford to make.7

One might expect most of all to find such a pattern in requirements of subject matter courses. It was not evident there; in fact, it was difficult to detect a large common core of courses in the information secured. Another place where a set pattern might be recognized is in the credit-hour requirements for a degree. Do graduate mathematics departments set up any such requirements, and if so, do they form a "mould" in which college instructors are cast? The data in Table 18 provide the basis for a negative answer to this question. It is to be understood that these requirements are in addition to, and of course prior to, the requirement of the dissertation. Credit hours listed by institutions on the quarter plan were converted to semester hour equivalents by use of the relationship: one quarter hour is equivalent to two-thirds of a semester hour. The results are expressed to the nearest semester hour.

The very large range between the high and the low semester hour requirements in Table 18 is tempered somewhat by remarks which were added on many questionnaires when this

### Table 18

CREDIT HOUR REQUIREMENTS FOR THE PH.D. IN MATHEMATICS
Reported by the chairmen of 29 graduate mathematics departments

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Per cent of departments reporting</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. No reply.</td>
<td>7</td>
</tr>
<tr>
<td>2. No set requirement.</td>
<td>17</td>
</tr>
<tr>
<td>3. Qualifying examination in basic advanced mathematics, plus eight mathematics courses.</td>
<td>3</td>
</tr>
<tr>
<td>4. Two years of full-time graduate work.</td>
<td>3</td>
</tr>
<tr>
<td>5. Six semesters of full-time graduate work.</td>
<td>10</td>
</tr>
<tr>
<td>6. 12 semester hours graduate work.</td>
<td>3</td>
</tr>
<tr>
<td>7. 18 semester hours graduate work.</td>
<td>3</td>
</tr>
<tr>
<td>8. 30 semester hours graduate work.</td>
<td>7</td>
</tr>
<tr>
<td>9. 33 semester hours graduate work.</td>
<td>7</td>
</tr>
<tr>
<td>10. 54 semester hours graduate work.</td>
<td>3</td>
</tr>
<tr>
<td>11. 72 semester hours graduate work.</td>
<td>21</td>
</tr>
<tr>
<td>12. 74 semester hours graduate work.</td>
<td>3</td>
</tr>
<tr>
<td>13. 90 semester hours graduate work.</td>
<td>10</td>
</tr>
</tbody>
</table>

Information was given. Such remarks were:

1. This is a minimum. (12 semester hours)

2. Most students take or audit all advanced mathematics courses we offer.
3. Two years of work suffice in exceptional cases.

4. Usually 60-75 semester hours are taken.

5. The average is 50 semester hours, plus 24 required in a minor area.

6. Amount and kinds of courses are decided by each student together with a faculty committee.

7. A well-rounded grounding in all branches of mathematics is required.

Any attempt to translate the requirements which were not stated in terms of credit hours to such a basis would result in increasing the frequency of the higher requirements. A glance at Table 18 will show that a median might be located in the 70-75 semester hour range. This would correspond to approximately two and one-half academic years of full-time work, a period of time quite often given in "rule of the thumb" advice as the time needed to provide an adequate basis for work on a dissertation.
CHAPTER IV

PROFESSIONAL PREPARATION

The American college teacher is the only high-level professional man in the American scene who enters upon a career with neither prerequisite trial of competence nor experience in use of the tools of his profession. Motives other than the training of college teachers actually do result in pre-service experience of varying degrees of usefulness for fair percentages of those preparing to enter the field. The means is the graduate assistantship, a form of securing instructional services through subsidizing the needy graduate student.¹

This quotation is indeed an accusing one. It points up sharply an old question: Are college teachers born, or made? Walking into a veritable lion's den with an answer to this question, C. H. Judd said, in an address to the Association of Doctors of Philosophy of The University of Chicago in June, 1908:

There are apparently many of you who are persuaded that courses in pedagogy cannot contribute materially to the improvement of a graduate of a university. In the face of such settled views, backed up by the success that many of you have obtained in the teaching profession, it seems to be a bold and

¹ Theodore C. Blegen and Russell M. Cooper, The Preparation of College Teachers, p. 123.
from some points of view a useless undertaking to come before you as I must with the assertion that ability to teach is not a natural gift and that every Doctor of Philosophy would be improved by a careful consideration in a scientific and historical way of the problems of education. 2

Unfortunately there is no record of the reactions to Professor Judd's words. The evidence is clear, however, when graduate programs for the doctorate are examined, that specific preparation for their later teaching responsibilities is by no means universal for prospective instructors at the college level.

Professional preparation for teaching involves doing two things: teaching and thinking about teaching. In this over-simplified statement is the implication that the two acts must go hand in hand. Practice teaching, student teaching, apprentice teaching, assistant teaching, call it what you will, becomes dangerous trial and error experimentation with students as helpless subjects when there is no supervision or conference with an expert teacher as a guide. Courses in methods and principles of teaching fall short of the desired aims if they are not related to experience in the background of the person taking them.

There is little disagreement at the present time concerning the proposition that there is value in having a prospective teacher, regardless of the subject or the level, do some teaching before he assumes full-time teaching responsibility. In several universities where college teaching was included as part of the pre-doctoral program in mathematics, comments in the questionnaires suggested that teaching experience before graduate work often permits shortening or omitting that part of a student's graduate work which is given to teaching.

Persons who do some full-time teaching before entering upon graduate work for the doctor's degree do so for many reasons, such as for financial reasons or for the purpose of exploring the possibility of teaching as a profession. Some began teaching at the secondary level, only to decide later to do more graduate work and aim for teaching at a higher educational level. Interesting data which the present study reveals in Table 19 show the educational levels at which the instructors in the study taught before graduate work.

In the experienced Ph.D. group 35 per cent had not taught before doing their doctoral work; 23 per cent of the
Table 19

TYPES OF TEACHING DONE BY COLLEGE MATHEMATICS INSTRUCTORS PRIOR TO GRADUATE WORK ON THE PH.D. DEGREE

(Each entry is a per cent of its corresponding group.)

<table>
<thead>
<tr>
<th>Group</th>
<th>Total No.</th>
<th>Elementary</th>
<th>Secondary</th>
<th>Junior College</th>
<th>College</th>
<th>None</th>
<th>No Reply</th>
</tr>
</thead>
<tbody>
<tr>
<td>IV</td>
<td>43</td>
<td>19</td>
<td>33</td>
<td>16</td>
<td>67</td>
<td>23</td>
<td>0</td>
</tr>
<tr>
<td>V</td>
<td>17</td>
<td>6</td>
<td>30</td>
<td>0</td>
<td>47</td>
<td>35</td>
<td>6</td>
</tr>
<tr>
<td>VI</td>
<td>16</td>
<td>13</td>
<td>38</td>
<td>19</td>
<td>81</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>VII</td>
<td>15</td>
<td>40</td>
<td>20</td>
<td>20</td>
<td>60</td>
<td>20</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>91</td>
<td>19</td>
<td>30</td>
<td>14</td>
<td>65</td>
<td>22</td>
<td>3</td>
</tr>
</tbody>
</table>

Key:

IV - Beginning instructors, Ph.D.
V - Experienced instructors, Ph.D.
VI - Beginning instructors, M.A.
VII - Other instructors.

beginning Ph.D.'s had not; and 6 per cent of the beginning M.A.'s had not. This decreasing sequence of percentages shows that mathematics instructors are getting more of these types of teaching experience before beginning their doctoral work than formerly. It also appears that more of this teaching experience has been gained at the college level than formerly. The practice of breaking the sequence of university training by an interim period of teaching, usually after receiving the master's degree, resembles the situation described by a chairman of a graduate English
department as follows:

In the early decades of graduate training in this country, most candidates for the Ph.D. were already teachers of some experience before they took their degrees.

This observation was made by Bentley in contrast to present practice in the preparation of Ph.D.'s in English. The situation in mathematics, as shown in the present study, seems less in contrast.

Seeing the great variety of types of teaching done by mathematics instructors before work on their Ph.D. may cause one to wonder if their judgments of the value of that experience show any agreement. Table 20 shows that all instructors in this study have concurred in the opinion that such teaching experience has been desirable in terms of making later teaching easier. Only one per cent of the entire group felt that teaching before graduate school was "very undesirable", while only two per cent expressed a neutral opinion.

Classroom Teaching Experience during Graduate Work

Speaking of the need in graduate programs for more attention to the fact that most holders of the Ph.D. are

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Table 20

**DESIRABILITY OF TEACHING EXPERIENCE PRIOR TO WORK ON THE PH.D. Reported by mathematics instructors**

(Each entry is a per cent of its corresponding group.)

<table>
<thead>
<tr>
<th>Group</th>
<th>Total No.</th>
<th>VU</th>
<th>U</th>
<th>N</th>
<th>D</th>
<th>VD</th>
<th>Ave.</th>
<th>No Reply</th>
</tr>
</thead>
<tbody>
<tr>
<td>IV</td>
<td>43</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>14</td>
<td>58</td>
<td>VD</td>
<td>23</td>
</tr>
<tr>
<td>V</td>
<td>17</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>24</td>
<td>35</td>
<td>VD</td>
<td>41</td>
</tr>
<tr>
<td>VI</td>
<td>16</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>19</td>
<td>56</td>
<td>VD</td>
<td>19</td>
</tr>
<tr>
<td>VII</td>
<td>15</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>20</td>
<td>47</td>
<td>VD</td>
<td>33</td>
</tr>
<tr>
<td>Total</td>
<td>91</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>18</td>
<td>52</td>
<td>VD</td>
<td>27</td>
</tr>
</tbody>
</table>

Key:
- IV - Beginning instructors, Ph.D.
- V - Experienced instructors, Ph.D.
- VI - Beginning instructors, M.A.
- VII - Other instructors.
- VU - Very Undesirable
- U - Undesirable
- N - Neutral
- D - Desirable
- VD - Very Desirable

Robert M. Hutchins said that a doctoral candidate

... must be in touch with the most broad and recent successful movements in undergraduate education, of which he now learns officially little or nothing. How should he learn about them? **Not in my opinion by doing practice teaching upon the helpless undergraduate.** (This writer's underlines.)

The question may well have been put to Dr. Hutchins, "At what point does the teaching of the new college instructor become

---

so effective that the undergraduate is no longer 'helpless'?

Such a stand on practice teaching, taken in 1929, was not uncommon at that time, but not predominant. The data in Tables 21 and 22 show that the assumption, one learns by

Table 21

THE EXTENT TO WHICH PROSPECTIVE COLLEGE MATHEMATICS INSTRUCTORS ASSIST IN, BUT ARE NOT IN COMPLETE CHARGE OF, COLLEGE MATHEMATICS CLASSES WHILE IN GRADUATE TRAINING AND RATINGS OF THIS PRACTICE

(Each entry is a per cent of its corresponding group.)

<table>
<thead>
<tr>
<th>Group</th>
<th>Total No.</th>
<th>Present Practice</th>
<th>Desirability Ratings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Yes No No Reply</td>
<td>VU U N D VD Ave No Reply</td>
</tr>
<tr>
<td>I</td>
<td>178</td>
<td>3 8 24 40 16 D 8</td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>179</td>
<td>0 2 18 42 26 D 12</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>29</td>
<td>3 14 28 21 14 N 21</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>43</td>
<td>5 7 26 35 16 D 17</td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>17</td>
<td>0 18 18 35 29 D 0</td>
<td></td>
</tr>
<tr>
<td>VI</td>
<td>16</td>
<td>0 6 31 44 19 D 0</td>
<td></td>
</tr>
<tr>
<td>VII</td>
<td>15</td>
<td>7 20 27 33 13 N 0</td>
<td></td>
</tr>
</tbody>
</table>

Key:

I - Chairmen, Undergraduate mathematics
II - Deans, liberal arts
III - Chairmen, graduate mathematics
IV - Beginning instructors, Ph.D.
V - Experienced instructors, Ph.D.
VI - Beginning instructors, M.A.
VII - Other instructors.

VU - Very Undesirable
U - Undesirable
N - Neutral
D - Desirable
VD - Very Desirable
Table 22

THE EXTENT TO WHICH PROSPECTIVE COLLEGE MATHEMATICS
INSTRUCTORS TEACH IN COLLEGE MATHEMATICS CLASSES
WHILE IN GRADUATE TRAINING, AND RATINGS OF
THIS PRACTICE

(Each entry is a per cent of its corresponding group.)

<table>
<thead>
<tr>
<th>Group</th>
<th>Total No.</th>
<th>Present Practice</th>
<th>Desirability Ratings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
<td>No Reply</td>
</tr>
<tr>
<td>I</td>
<td>178</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>179</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>29</td>
<td>83</td>
<td>17</td>
</tr>
<tr>
<td>IV</td>
<td>43</td>
<td>95</td>
<td>5</td>
</tr>
<tr>
<td>V</td>
<td>17</td>
<td>88</td>
<td>12</td>
</tr>
<tr>
<td>VI</td>
<td>16</td>
<td>81</td>
<td>19</td>
</tr>
<tr>
<td>VII</td>
<td>15</td>
<td>87</td>
<td>13</td>
</tr>
</tbody>
</table>

Key:

I - Chairmen, undergraduate mathematics
II - Deans, liberal arts
III - Chairmen, graduate mathematics
IV - Beginning instructors, Ph.D.
V - Experienced instructors, Ph.D.
VI - Beginning instructors, M.A.
VII - Other instructors.

VU - Very undesirable
U - Undesirable
N - Neutral
D - Desirable
VD - Very desirable

Doing, is not entirely unacceptable to the persons reached in this study.

In addition to the data of Table 22, showing the extent to which prospective college mathematics instructors at the
present time engage in teaching, Table 23 shows how extensive this practice has been during the last five years.

Table 23

<table>
<thead>
<tr>
<th>Per cent of candidates who taught</th>
<th>0</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
<th>60</th>
<th>70</th>
<th>80</th>
<th>90</th>
<th>100</th>
<th>No Reply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per cent of departments reporting</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>7</td>
<td>0</td>
<td>21</td>
<td>62</td>
<td>3</td>
</tr>
</tbody>
</table>

For graduate students to obtain experience as teachers of college mathematics classes is considered a desirable practice, as shown in Table 22, and is widespread in present practice. Table 23 shows that in the last five years, the majority of the graduate mathematics departments in this study have had all of their Ph.D. candidates teach college mathematics at some time during their graduate training. This indicates a steady, if not increasing, trend. Even though the practice of having graduate students assist in college mathematics classes is not a popular practice, the data in Table 21 indicate that it is nevertheless regarded as a desirable practice by all groups except the graduate mathematics chairmen and the group of miscellaneous instructors. This indicates a climate of opinion which would be
receptive to the recommendation of leading the candidate into his teaching experience through a series of easy steps.

The observation of experienced and expert teaching is a well-established practice in the preparation of public school teachers. How is it regarded among the members of the profession in higher education? Data in Table 24 show that, of all the college mathematics instructors answering this question, only 12 per cent had observed undergraduate teaching, yet the group as a whole considers it a desirable practice, as do college deans and chairmen of undergraduate mathematics departments. Here again is an instance where a practice is not in use, yet there exists a favorable attitude toward it by most of the persons apt to be involved.

In all fairness to President Hutchins, his quotation begun on page 79 should be completed:

Rather should he learn about them through seeing experiments carried on in undergraduate work by members of the department in which he is studying for his degree, with the advice of the Department of Education. Upon the problem of undergraduate teaching his creative work should be done. 5

The point, "with the advice of the Department of Education", is evidently a sore one with several professors and departments of mathematics, as is witnessed by the following re-

5Ibid.
Table 24

THE EXTENT TO WHICH PROSPECTIVE COLLEGE MATHEMATICS INSTRUCTORS OBSERVE THE TEACHING OF EXPERIENCED MATHEMATICS PROFESSORS WHILE IN GRADUATE TRAINING, AND RATINGS OF THIS PRACTICE

(Each entry is a per cent of its corresponding group.)

<table>
<thead>
<tr>
<th>Group</th>
<th>Total No.</th>
<th>Present Practice</th>
<th>Desirability Ratings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>I</td>
<td>178</td>
<td>12</td>
<td>84</td>
</tr>
<tr>
<td>II</td>
<td>179</td>
<td>12</td>
<td>88</td>
</tr>
<tr>
<td>IV</td>
<td>43</td>
<td>12</td>
<td>84</td>
</tr>
<tr>
<td>V</td>
<td>17</td>
<td>12</td>
<td>88</td>
</tr>
<tr>
<td>VI</td>
<td>16</td>
<td>19</td>
<td>81</td>
</tr>
<tr>
<td>VII</td>
<td>15</td>
<td>27</td>
<td>60</td>
</tr>
</tbody>
</table>

Key:

I - Chairmen, undergraduate mathematics
II - Deans, liberal arts
IV - Beginning instructors, Ph.D.
V - Experienced instructors, Ph.D.
VI - Beginning instructors, M.A.
VII - Other instructors.

VU - Very undesirable
U - Undesirable
N - Neutral
D - Desirable
VD - Very desirable

marks written on questionnaires returned in this study:

Keep the educationists out of this.

I hope the "education people" will make no effort to require future college teachers to take courses in education or do practice teaching or observation.

Keep it out of the hands of the pedagogics.
It is natural, I suppose, for Educationalists [sic] to seek new fields to contaminate as they have education at the high school level.

Good teachers worthy of the Ph.D. degree are born, not made.

More objective evidence that the above quotations show that the consensus of opinion is against using the education faculty in the supervision of the teaching Ph.D. candidate appears in the ratings of the desirability of "visits by and/or conferences with an experienced teacher in the education department". This is the last item in Table 25, which shows the various types of supervision used by graduate mathematics departments with their teaching doctoral candidates.

It is clear that these graduate mathematics department chairmen are not in favor of a laissez-faire policy with regard to teaching experience for their doctoral candidates. Beyond the overall rating of "very undesirable" for an unsupervised practice teaching situation there is the fact that, with one exception, each department indicated that at least one of the forms of supervision listed was present practice. The department which did not reveal its present practice regarding "no supervision" gives a good clue to its position by rating it as "very undesirable". This makes agreement on this point practically unanimous.
Table 25

WAYS OF SUPERVISING TEACHING PH.D. CANDIDATES IN MATHEMATICS
Present practice and ratings of these practices as
reported by the chairmen of 29 graduate
mathematics departments.
(Each entry is a per cent of the total group.)

<table>
<thead>
<tr>
<th>Present Practice</th>
<th>Present Practice</th>
<th>Desirability Ratings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>No supervision.</td>
<td>0</td>
<td>97</td>
</tr>
<tr>
<td>Outlines and assignments given by department.</td>
<td>86</td>
<td>7</td>
</tr>
<tr>
<td>Coordination of sections by faculty.</td>
<td>55</td>
<td>34</td>
</tr>
<tr>
<td>Coordination of sections by group conferences of all section teachers.</td>
<td>48</td>
<td>38</td>
</tr>
<tr>
<td>Visits and/or conferences by a mathematics professor.</td>
<td>69</td>
<td>21</td>
</tr>
<tr>
<td>Visits and/or conferences by an education professor.</td>
<td>3</td>
<td>97</td>
</tr>
</tbody>
</table>

Key
VU - Very undesirable
U - Undesirable
N - Neutral
D - Desirable
VD - Very desirable
Further evidence of the considered value of supervision of embryo college teachers of mathematics is indicated by the fact that:

1. Four departments utilized one method of supervision.
2. Six departments utilized two methods of supervision.
4. Eight departments utilized four methods of supervision.

The deans, undergraduate mathematics chairmen, and mathematics instructors were not asked about supervision in quite the detail displayed above. It is clear from Table 26, however, that instructors and administrators share the opinion elicited above from the heads of graduate mathematics departments. The question which prompted the replies summarized in this table was of a very general nature, covering several alternatives not obvious from reading the table heading. The reader is referred to Appendix C, question No. 13, and Appendix G, question No. 27 to see these questions.

Two comments written in by heads of graduate mathematics departments on the subject of supervision of teaching assistants illustrate how shortages of time and staff often
Table 26

DESIRABILITY OF CORRELATING SUPERVISION AND/OR DISCUSSION OF TEACHING METHODS WITH THE CLASSROOM TEACHING EXPERIENCE OF PROSPECTIVE COLLEGE MATHEMATICS INSTRUCTORS

(Each entry is a per cent of its corresponding group.)

<table>
<thead>
<tr>
<th>Group</th>
<th>Total No.</th>
<th>VU</th>
<th>U</th>
<th>N</th>
<th>D</th>
<th>VD</th>
<th>Ave</th>
<th>No Reply</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>178</td>
<td>1</td>
<td>3</td>
<td>15</td>
<td>33</td>
<td>42</td>
<td>D</td>
<td>7</td>
</tr>
<tr>
<td>II</td>
<td>179</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>28</td>
<td>63</td>
<td>VD</td>
<td>4</td>
</tr>
<tr>
<td>IV</td>
<td>43</td>
<td>9</td>
<td>12</td>
<td>9</td>
<td>33</td>
<td>28</td>
<td>D</td>
<td>9</td>
</tr>
<tr>
<td>V</td>
<td>17</td>
<td>12</td>
<td>6</td>
<td>12</td>
<td>35</td>
<td>29</td>
<td>D</td>
<td>6</td>
</tr>
<tr>
<td>VI</td>
<td>16</td>
<td>0</td>
<td>6</td>
<td>6</td>
<td>31</td>
<td>50</td>
<td>D</td>
<td>6</td>
</tr>
<tr>
<td>VII</td>
<td>15</td>
<td>0</td>
<td>0</td>
<td>7</td>
<td>20</td>
<td>53</td>
<td>VD</td>
<td>20</td>
</tr>
</tbody>
</table>

Key:

I - Chairmen, undergraduate mathematics
II - Deans, liberal arts.
IV - Beginning instructors, Ph.D.
V - Experienced instructors, Ph.D.
VI - Beginning instructors, M.A.
VII - Other instructors

VU - Very undesirable
U - Undesirable
N - Neutral
D - Desirable
VD - Very desirable

penalize prospective college instructors during their training:

More supervision should be given but faculty members do not have time.

Our present set-up makes it impracticable to have complete supervision of graduate students teaching by a senior staff member. A couple of assistants would have been helped if we had maintained closer contact with them.

As regrettable as the second comment above makes the case...
appear, it becomes even more regrettable when one considers
the effect upon the mathematics students being taught by
those assistants. Unquestionably, they "would have been
helped" too.

Education Courses or Seminars

In 1930, Gordon J. Laing of the University of Chicago,
contributing to a conference on the preparation of college
teachers, recommended that, besides research and background
courses in his subject matter, a Ph.D. candidate should
have courses in methods of teaching, preferably by a pro­
fessor in the subject matter. In addition there should be
a course in conditions and trends in college education,
given by a professor of education.6

A chairman of an English department has advocated that
10 per cent of a Ph.D. candidate's time should be spent in
developing pedagogical skills, and has given a good descrip­
tion of how his department carries on such a program.7

At Oregon State College a three-hour seminar which

---
6William S. Gray, The Training of College Teachers,
Chapter V.
7Gerald Eades Bentley, op. cit.
functioned best with its membership equally divided between faculty and graduate students is based upon the assumption that the scholarship of a graduate student should extend into his teaching job. The course invites students from all subject matter areas, with individual studies beginning after a basic point of view has been developed.

In the fall of 1949 Cornell University offered for the first time a two-hour graduate course in college teaching by the School of Education. The course included the following topics: learning and motivation among college students; teaching by lecture, demonstration, discussion, and other methods; marks and grading; selection and organization of subject matter.

In 1949 a study was made of the types of courses in higher education provided in leading American universities. The following are a few of its findings:

Approximately four-fifths (78 per cent) of the fifty institutions for whom recent or current catalogues were available are offering one or more courses in higher education. More than two-thirds (69 per cent) of these graduate schools provide at least one course dealing with purposes, trends, and problems in higher education, and nearly three-fifths (59 per cent) offer one or more courses

---


9 "Cornell University Offers Course in 'College Teaching'", *Events, School and Society*, LXX (October 8, 1949), p. 235.
related to junior college problems. About half (51 per cent) list at least one course in the area of curriculum and instruction.10

This survey pointed out that considerable awareness of the need to prepare prospective college teachers is present among leading American universities, but that many of the courses appear to have been designed to provide general views of faculty, college, and university problems. True professional competence would require more penetration in specific classroom problems.

The Mathematical Association of America made the following recommendations concerning professional education for prospective teachers of college mathematics:

Guided readings in books and periodicals relating to the theory of teaching, testing methods, and educational research. This reading could be directed either by a member of the department of mathematics, or, perhaps, by a person outside the department who appreciates the viewpoint of teachers of mathematics.11

The commission making this report followed it in the same year by a list of readings recommended for the use described above.12


For the purposes of this study only the following four categories of professional education courses or seminars were presented in the questionnaires:

1. Methods of teaching college mathematics, for mathematics instructors only.
2. General methods of college teaching, for instructors of any subject.
3. The teaching-learning process.
4. Purposes of higher education.

Tables 27-30 show the extent to which courses and seminars of these types are used and the climate of opinion regarding their desirability.

It is unmistakably clear that graduate mathematics departments do not use to any great extent the courses or seminars in methods or principles of higher education which are being used by other graduate departments. The largest group of mathematics instructors in this study who took one of these courses or seminars is only 20 per cent of those responding. The largest number of graduate departments utilizing one of the four types of courses listed in Tables 27-30 is only 10 per cent of the total number involved. Eighteen (62 per cent) of these graduate mathematics departments are located in the group of universities which were reported to offer one or more courses in higher education. Lack of existing courses is therefore not the sole reason
Table 27

The extent to which prospective college mathematics instructors take courses or seminars in methods of teaching college mathematics, with a group of prospective mathematics teachers only, and ratings of this practice

(Each entry is a per cent of its corresponding group.)

<table>
<thead>
<tr>
<th>Group</th>
<th>Total No.</th>
<th>Present Practice</th>
<th>Desirability Ratings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Yes No No Reply</td>
<td>VU U N D VD Ave. No Reply</td>
</tr>
<tr>
<td>I</td>
<td>178</td>
<td>2 12 21 41 22 D 2</td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>179</td>
<td>1 6 24 34 27 D 9</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>29</td>
<td>3 90 7</td>
<td>10 10 24 38 7 N 7</td>
</tr>
<tr>
<td>IV</td>
<td>43</td>
<td>7 91 2</td>
<td>7 14 37 30 7 N 5</td>
</tr>
<tr>
<td>V</td>
<td>17</td>
<td>0 100 0</td>
<td>6 18 6 59 6 N 6</td>
</tr>
<tr>
<td>VI</td>
<td>16</td>
<td>19 81 0</td>
<td>6 6 38 44 6 N 0</td>
</tr>
<tr>
<td>VII</td>
<td>15</td>
<td>13 87 0</td>
<td>0 13 13 27 33 D 13</td>
</tr>
</tbody>
</table>

Key:

I - Chairmen, undergraduate mathematics
II - Deans, liberal arts.
III - Chairmen, graduate mathematics
IV - Beginning instructors, Ph.D.
V - Experienced instructors, Ph.D.
VI - Beginning instructors, M.A.
VII - Other instructors

VU - Very undesirable
U - Undesirable
N - Neutral
D - Desirable
VD - Very desirable
Table 28

THE EXTENT TO WHICH PROSPECTIVE COLLEGE MATHEMATICS INSTRUCTORS TAKE COURSES OR SEMINARS IN GENERAL METHODS OF COLLEGE TEACHING, WITH A MIXED GROUP OF PROSPECTIVE INSTRUCTORS, AND RATINGS OF THIS PRACTICE

(Each entry is a per cent of its corresponding group.)

<table>
<thead>
<tr>
<th>Group</th>
<th>Total No.</th>
<th>Present Practice</th>
<th>Desirability Ratings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>I</td>
<td>178</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>II</td>
<td>179</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>III</td>
<td>29</td>
<td>10</td>
<td>79</td>
</tr>
<tr>
<td>IV</td>
<td>43</td>
<td>2</td>
<td>98</td>
</tr>
<tr>
<td>V</td>
<td>17</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>VI</td>
<td>16</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>VII</td>
<td>15</td>
<td>0</td>
<td>100</td>
</tr>
</tbody>
</table>

Key:

I - Chairmen, undergraduate mathematics
II - Deans, liberal arts
III - Chairmen, graduate mathematics
IV - Beginning instructors, Ph.D.
V - Experienced instructors, Ph.D.
VI - Beginning instructors, M.A.
VII - Other instructors

VU - Very undesirable
U - Undesirable
N - Neutral
D - Desirable
VD - Very desirable
Table 29

THE EXTENT TO WHICH PROSPECTIVE COLLEGE MATHEMATICS INSTRUCTORS TAKE COURSES OR SEMINARS IN THE TEACHING-LEARNING PROCESS WHILE IN GRADUATE TRAINING, AND RATINGS OF THIS PRACTICE

(Each entry is a per cent of its corresponding group.)

<table>
<thead>
<tr>
<th>Group</th>
<th>Total No.</th>
<th>Present Practice</th>
<th>Desirability Ratings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
<td>No Reply</td>
</tr>
<tr>
<td>I</td>
<td>178</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>II</td>
<td>179</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>III</td>
<td>29</td>
<td>3</td>
<td>90</td>
</tr>
<tr>
<td>IV</td>
<td>43</td>
<td>12</td>
<td>88</td>
</tr>
<tr>
<td>V</td>
<td>17</td>
<td>6</td>
<td>76</td>
</tr>
<tr>
<td>VI</td>
<td>16</td>
<td>13</td>
<td>88</td>
</tr>
<tr>
<td>VII</td>
<td>15</td>
<td>20</td>
<td>80</td>
</tr>
</tbody>
</table>

Key:

I - Chairmen, undergraduate mathematics
II - Deans, liberal arts
III - Chairmen, graduate mathematics
IV - Beginning instructors, Ph.D.
V - Experienced instructors, Ph.D.
VI - Beginning instructors, M.A.
VII - Other instructors

VU - Very Undesirable
U - Undesirable
N - Neutral
D - Desirable
VD - Very desirable
Table 30

THE EXTENT TO WHICH PROSPECTIVE COLLEGE MATHEMATICS INSTRUCTORS TAKE A COURSE OR SEMINAR IN THE PURPOSES OF HIGHER EDUCATION WHILE IN GRADUATE TRAINING, AND RATINGS OF THIS PRACTICE

(Each entry is a per cent of its corresponding group.)

<table>
<thead>
<tr>
<th>Group</th>
<th>Total No.</th>
<th>Present Practice</th>
<th>Desirability Ratings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
<td>Reply</td>
</tr>
<tr>
<td>I</td>
<td>178</td>
<td>4</td>
<td>35</td>
</tr>
<tr>
<td>II</td>
<td>179</td>
<td>0</td>
<td>19</td>
</tr>
<tr>
<td>III</td>
<td>29</td>
<td>7</td>
<td>86</td>
</tr>
<tr>
<td>IV</td>
<td>43</td>
<td>9</td>
<td>91</td>
</tr>
<tr>
<td>V</td>
<td>17</td>
<td>0</td>
<td>94</td>
</tr>
<tr>
<td>VI</td>
<td>16</td>
<td>13</td>
<td>88</td>
</tr>
<tr>
<td>VII</td>
<td>15</td>
<td>20</td>
<td>80</td>
</tr>
</tbody>
</table>

Key:
I - Chairmen, undergraduate mathematics
II - Deans, liberal arts
III - Chairmen, graduate mathematics
IV - Beginning instructors, Ph.D.
V - Experienced instructors, Ph.D.
VI - Beginning instructors, M.A.
VII - Other instructors

VU - Very undesirable
U - Undesirable
N - Neutral
D - Desirable
VD - Very desirable
for their not being used by mathematics departments. The rating of "neutral" on all of these courses may imply that the graduate mathematics departments are suspending judgment on the matter.

Although the difference between the two ratings of "desirable" and "neutral" is not large, it is definitely of a positive character. The deans and undergraduate mathematics chairmen have taken the position that the four types of professional courses in Tables 27-30 are desirable preparation for college mathematics instructors. These two groups are well qualified to judge the value of these courses for college mathematics teachers, for they are able to see the results.

Among several means of developing teaching skills of Ph.D. candidates in English, Bentley has described how he has used the device of including a question on a teaching problem in every major course examination, and of how a candidate is given two hours before his final oral examination for the Ph.D. degree in which to prepare for a thirty-minute lecture on one of eight or ten topics.\footnote{Gerald Eades Bentley, \textit{op. cit.}, pp. 330-335.} Are there any practices of this nature being carried on today in graduate mathematics departments? Table 31 shows how this question
Table 31

THE EXTENT TO WHICH DISCUSSION OF TEACHING PROBLEMS IS CORRELATED WITH DISCUSSION OF MATHEMATICAL SUBJECT MATTER IN THE GRADUATE PROGRAM OF PROSPECTIVE COLLEGE MATHEMATICS INSTRUCTORS, AND RATINGS OF THIS PRACTICE

Reported by the chairmen of 29 graduate mathematics departments

(Each entry is a per cent of the total group.)

| Methods of teaching college mathematics correlated with subject matter in advanced mathematics classes. | Present Practice | Desirability Ratings |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Yes | No | Reply | VU | U | N | D | VD | Ave. | No | Reply |
| 17 | 76 | 7 | 3 | 17 | 24 | 24 | 7 | N | 24 |

| Questions on problems of teaching college mathematics included in examinations given to Ph.D. candidates. | Present Practice | Desirability Ratings |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Yes | No | Reply | VU | U | N | D | VD | Ave. | No | Reply |
| 10 | 86 | 3 | 17 | 31 | 28 | 7 | 7 | N | 10 |

**Key:**

- VU - Very undesirable
- U - Undesirable
- N - Neutral
- D - Desirable
- VD - Very desirable
was put before the graduate mathematics chairmen, and the nature of their replies.

The data in Table 31 show that 17 per cent of the graduate mathematics departments use "professionalized subject matter" in advanced courses. Perhaps one of the best uses of such a procedure is in reviewing the elementary concepts of mathematics from an advanced viewpoint, so that the graduate student gets a good understanding of the requirements of a rigorous argument at that level, and will begin to see when a rigorous, logical attack might be set aside in favor of an intuitive, perhaps psychological approach.

Are Standards of Certification for College Teachers Necessary?

It can be safely said that at the present time colleges are not influenced by direct requirements set by any outside agency when they decide to engage new members of their teaching staffs. They often seek Ph.D.'s in order to meet regional accrediting standards, yet these standards appear more as guiding principles than as rigid requirements.

On the other hand, the system of public education in this country is much more strictly governed in its selection
of teachers through standards of certification which are in force in all but a few states. Public education has become a function of the state and the authority to issue certificates to teach has moved from local town officials to the state departments of education, as the following summary shows:

The stimulation for concentrating the authority of certification came from teachers who wanted the profession to have a higher type certificate than was then issued by the local authorities and who hoped for a professional evaluation of persons desiring to teach. The local school governing authorities were laymen or small-salaried officials having interests in fields other than education. In many instances they permitted social, political, and religious considerations to influence their judgments of candidates for certificates. . . . Many of the early requirements for teaching simply stated that the candidates must possess "education and a good moral character." The interpretation of these items was left to local public and semi-public authorities. 14

A result of establishing certification standards, according to Woellner, has been to increase the amount of formal education by teachers, and a resultant upgrading of certification requirements to match this upward trend.

College education is not entirely a public charge, and so it is not at all a natural consequence to ask if college instructors should be certified to teach by requiring them

to meet standards comparable to those now used for teaching in public schools. This question was asked, however, on the questionnaires in each group of this study. It was asked for the sole purpose of determining how this sample of the higher education profession regards this question. There seemed to be no issue at stake, as far as the literature showed, nor was the author attempting to create one. Since, historically, public school certification standards grew out of the desire of teachers to raise professional standards, it seemed that the presence or absence of any such wish on the part of college mathematics instructors could be recognized in their reactions to the question.

No response to this question was received from 51 (11 per cent) of 477 respondents to the questionnaires in this study. Of the remaining 426, 75 per cent felt there was no need for setting up certification standards. As will be seen in Table 32, this percentage is fairly representative of all the groups in this study except the experienced Ph.D. group and the group of graduate mathematics chairmen. Both of these were over 90 per cent against standards of certification.

The data in Table 32 show very clearly the strong stand against establishing certification standards for college
Table 32

JUDGMENTS OF RESPONDENTS REGARDING THE NEED FOR CERTIFICATION OF COLLEGE INSTRUCTORS

<table>
<thead>
<tr>
<th>Group</th>
<th>Total No.</th>
<th>No Reply</th>
<th>Replies</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>I</td>
<td>178</td>
<td>22</td>
<td>28%</td>
</tr>
<tr>
<td>II</td>
<td>179</td>
<td>14</td>
<td>28%</td>
</tr>
<tr>
<td>III</td>
<td>29</td>
<td>3</td>
<td>8%</td>
</tr>
<tr>
<td>IV</td>
<td>43</td>
<td>4</td>
<td>21%</td>
</tr>
<tr>
<td>V</td>
<td>17</td>
<td>2</td>
<td>7%</td>
</tr>
<tr>
<td>VI</td>
<td>16</td>
<td>2</td>
<td>29%</td>
</tr>
<tr>
<td>VII</td>
<td>15</td>
<td>4</td>
<td>18%</td>
</tr>
<tr>
<td>Total</td>
<td>477</td>
<td>51</td>
<td>25%</td>
</tr>
</tbody>
</table>

Key:

I - Chairmen, undergraduate mathematics
II - Deans, liberal arts
III - Chairmen, graduate mathematics
IV - Beginning instructors, Ph.D.
V - Experienced instructors, Ph.D.
VI - Beginning instructors, M.A.
VII - Other instructors

Teaching. The minority, 25 per cent who felt that standards were necessary, went on to indicate very briefly the authorities who should set these standards. Table 33 shows these replies, 83 in all, grouped into eight categories. The table represents the thinking of 78 per cent of those who considered certification standards necessary.
Table 33

PROPOSED AUTHORITIES FOR SETTING UP STANDARDS OF CERTIFICATION FOR COLLEGE TEACHING

<table>
<thead>
<tr>
<th>Authorities</th>
<th>No. of persons reporting</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The profession of higher education: university and college mathematics professors, deans and educators.</td>
<td>21</td>
</tr>
<tr>
<td>2. Regional or national accrediting agencies.</td>
<td>18</td>
</tr>
<tr>
<td>3. State education agencies.</td>
<td>12</td>
</tr>
<tr>
<td>5. Each college, through its own deans and department heads.</td>
<td>10</td>
</tr>
<tr>
<td>6. Undecided.</td>
<td>4</td>
</tr>
<tr>
<td>7. Commission of college mathematics teachers.</td>
<td>3</td>
</tr>
<tr>
<td>8. The graduate schools.</td>
<td>3</td>
</tr>
</tbody>
</table>

Any attempt to convert the replies in Table 33 to a percentage basis would be defeated by virtue of the difficulty of choosing a significant base. It is interesting that the two replies given most often suggest certifying authorities of broadly representative character. The likelihood of domination by a single group is thus diminished.
Further comment on this question was invited and 186 persons (44 per cent of those replying to the question on standards of certification) gave comments. Deans, chairmen of undergraduate mathematics departments and of graduate departments contributed by far the greater number. These comments were almost equally divided between those who felt that certification was necessary and those who felt that it was not. Nearly every comment has its own very interesting and significant bearing upon the question. A wealth of attitudes were expressed, ranging from violently expressed emotionalism to a careful, rational search for an answer to the problem. Fourteen of these comments are reproduced below. They were selected to illustrate some of the attitudes expressed, some of the problems faced, some of the solutions suggested, and should indicate the general flavor of these reactions. They have not been chosen as typical, or representative of either majority or minority positions.

Undecided. Such standards would be difficult to enforce, but I think there should be something done to emphasize the "teaching degree", as well as the research degree. The work is entirely different. Eighty to ninety per cent of the students in college mathematics are not interested in pure mathematics, but in applied mathematics or science. (Chairman, undergraduate mathematics.)

No. When one sees the horrible results which have come from the certification of public high school teachers, one can only suppose that anyone who
suggests certification of college teachers has no concept of what a college education means. (Chairman, undergraduate mathematics.)

No. I would dislike very much to see "certificates" required for college teaching. I hope the "education people" will make no effort to require future college teachers to take courses in education or do practice teaching or observation. (Chairman, undergraduate mathematics.)

No. It is my opinion that my answer reflects the attitude of our entire department. If I err in this, it is that I have not stated adequately strongly our revulsion at the thought of certifying teachers at the college level. It is natural, I suppose, for educationalists to seek new fields to contaminate as they have education at the high school level. Unfortunately for them college communities are beginning to awaken to the peril these presumably well meaning, but misguided souls represent. We, indeed, understand even the questionnaire method of infiltration. (Chairman, graduate mathematics.)

No. I am afraid this may come, and we better get there before the College of Education does - otherwise we shall not have control and things might be in a mess. Do not misunderstand me. I believe we need to work with the schools of education - but I would like to keep control over my own field. . . . However, here is something that should be studied and developed and probably quicker than we think. The State Department of Education could demand certification for State Universities and Colleges - which could contain some undesirable elements. (Chairman, graduate mathematics.)

Yes. The Mathematics Societies . . . keep in hands of professional mathematicians - not state boards of ignoramuses. (Chairman, undergraduate mathematics.)

Yes. Uniform standards worked out by the colleges will be too traditional and will probably over-emphasize subject matter at first, but should get around to teaching methods after a few years. (Chairman, undergraduate mathematics.)
No. No, because I believe there is no organization set up which is competent to be final judge. . . . The Mathematical Associations and Societies would put too much emphasis on research work and not enough on teaching ability and general knowledge of field to be taught. Teachers Colleges or Organizations would put too much emphasis on courses in methods and not enough on subject matter. (Chairman, undergraduate mathematics.)

Yes. General agencies that would be more comprehensive than exclusive mathematical organizations, . . . That judgment is occasioned by my observations of the harm that sometimes has been done to colleges and universities by the maintenance of national professional standardizing agencies that have little knowledge or concern for the general needs and welfare of the colleges and universities. (Dean, liberal arts.)

Undecided. I am wary of standards and certificates but certainly believe that something more than a mere knowledge of the subject is essential in the preparation of college teachers. The "standards" should be set by the colleges and the graduate schools, both insisting on a greater breadth of preparation. Nor should we ignore the part which school or departments of Education can play in this important phase of preparation. (Chairman, undergraduate mathematics.)

Standards, yes; comparable to those in force, no. Competency as a mathematician and for as a teacher cannot be judged by courses taken or credit hours obtained. Examinations should be used to determine the former; observation for the second. I believe the first couple of years teaching should precede issuance of such a certificate. (Beginning instructor, Ph.D.)

No. I believe that the ability to teach should be judged within the departments, provided the head is willing to accept the responsibility. Regardless of the theoretical value of training in educational psychology, the field at present is in such bad repute that it is not practical to advocate such certification. (Dean, liberal arts.)

No. Good standards for instruction are of course necessary, but any mechanical set of standards is
too rigid - unnecessary for some. Careful selection of instructors by the college and intelligent supervision during first teaching seems to me the best method. (Chairman, undergraduate mathematics.)

No. I want an instructor who (1) will read and study to fill gaps in his background, (2) has observed good and bad points of teaching over 16-20 years of instruction, and (3) who can profit by the in-service training that should be the formal, or informal by-product of every department. (Chairman, undergraduate mathematics.)
CHAPTER V

RESEARCH AND THE DISSERTATION

The research accomplished by a doctoral candidate in mathematics in the preparation of his dissertation should come up to very rigid standards which mathematicians have set for publishable research. Because of nearly ideal standards, the amount of research in mathematics appears to be small and greatly overshadowed by the amount of research in other areas. Mathematical research, in the best sense of the word, should represent a definite advance of knowledge, a truly original contribution to existing theory. This is quite in contrast to standards for acceptable research in other fields, perhaps not so much in the sciences as in the humanities and social sciences. That the rigorous demands of mathematical research are responsible for the seemingly small output of the Ph.D. in mathematics is a point made by Richardson as he discussed the relationships between the Ph.D. degree and mathematical research.¹

¹ R. G. D. Richardson, op. cit.
If this insistence upon exploration into virgin territory of mathematics is a characteristic of mathematical research in general, and the dissertation in particular, then, since the unexplored territory of mathematics is extremely far advanced from the mathematics of the college level, one begins to question whether or not doctoral research and preparation for teaching are compatible. A recent conference on preparation of college teachers discussed this problem and raised the following questions:

This question of compatibility or incompatibility of research and teaching, as the participants well knew, serves as the focal point of much criticism of graduate schools. Has research become — as is so frequently maintained — an all-engrossing monster, consuming the vital energies of graduate faculties and burying the real purposes of universities beneath its own narrow demands? Can universities fulfill their central function as synthesizers and interpreters of culture if they are too much concerned with the peripheral frontiers of research? Can merely human men develop the broad understandings so necessary in teaching if they are continuously embroiled in the specialized intricacies of research?

Recognizing some of these issues as they affected doctoral programs in mathematics as early as 1935, the Mathematical Association of America noted the very narrow specialization in doctoral programs, especially in the research thesis, for which preparation took most of three years of graduate work and often was the result of the industry of

---

2 Theodore C. Blegen and Russell M. Cooper, *op. cit.*, p. 87.
the major professor. The Commission went on to recommend

two types of training in mathematics, one which might be
called the traditional, research-centered Ph.D. program, and
the other explicitly a program for preparing college mathe-

matics instructors. Among the suggested substitutes for
the research thesis in the second type program, the fol-

lowing were recommended:

One or more expository papers known as minor
theses in the existing requirements for the doc-
torate in mathematics in some universities. A
Thesis of this variety would require the candi-
date to give evidence of his ability to learn
independently and to present in good written
form, in a brief period of time, some specified
known mathematical results with which he was
previously unfamiliar.

A major thesis showing a mastery of some field
of mathematics and the candidate's expository
ability. This thesis would not necessarily be
of research caliber; it could be of a historical
nature.  

These recommendations seem to have resolved the ques-
tion of compatibility between teaching and research by modi-
ifying the requirements for the research of a prospective
college teacher. This decision has not been reflected in
recommendations made by others, notably by Howard Mumford
Jones and William Heard Kilpatrick, who declare that a

\footnote{3} Commission on the Training and Utilization of Advanced
Students in Mathematics, \textit{op. cit.}, pp. 267-268.

\footnote{4} Howard Mumford Jones, \textit{op. cit.}, p. 154.

\footnote{5} William Heard Kilpatrick, "Securing Better College
separate graduate school is needed for the sole purpose of preparing college teachers.

In the present study, an attempt was made to determine whether or not there has been implementation of the recommendation for doctoral research of an interpretative nature, on the history of mathematics, or on problems of teaching college mathematics. Tables 34 and 35 were compiled from replies to questions which contrasted the "old" and the "new" types of dissertations.

It is seen in Table 34 that the chairmen of the graduate mathematics departments, the beginning and the experienced instructors rated the pure, or applied, mathematics dissertation as "very desirable" on the average. In these three groups there were very few individual ratings below "desirable." This may be due in part to the close and recent association of the members of these groups with Ph.D. research of this nature in mathematics. The deans rated the pure, or applied, mathematics dissertation "neutral", the lowest rating given by any of the groups. This judgment no doubt reflects the preoccupation of the administrator with problems of general education, coordinated instruction, and the interrelated character of learning. Such an emphasis would influence one to characterize as "neutral" the desir-
Table 34

THE EXTENT TO WHICH THE EMPHASIS ON THE DISSERTATION
OF PROSPECTIVE COLLEGE MATHEMATICS INSTRUCTORS
IS UPON ORIGINAL WORK IN PURE (OR APPLIED)
MATHEMATICS, AND RATINGS OF THIS PRACTICE

(Each entry is a per cent of its corresponding group.)

<table>
<thead>
<tr>
<th>Group</th>
<th>Total No.</th>
<th>Present Practice</th>
<th>Desirability Ratings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Yes  No  No Reply</td>
<td>VU  U  N  D  VD  Ave</td>
</tr>
<tr>
<td>I</td>
<td>178</td>
<td>1    7   31</td>
<td>31  28 D 2</td>
</tr>
<tr>
<td>II</td>
<td>179</td>
<td>0    12  43</td>
<td>31  9 N 5</td>
</tr>
<tr>
<td>III</td>
<td>29</td>
<td>3    0   0</td>
<td>31  66 VD 0</td>
</tr>
<tr>
<td>IV</td>
<td>43</td>
<td>95   5   0</td>
<td>0    9 14 65 VD 12</td>
</tr>
<tr>
<td>V</td>
<td>17</td>
<td>82   0   18</td>
<td>0    6 24 53 VD 18</td>
</tr>
<tr>
<td>VI</td>
<td>16</td>
<td>38   19  44</td>
<td>6    6 31 19 D 38</td>
</tr>
<tr>
<td>VII</td>
<td>15</td>
<td>27   13  60</td>
<td>0    0 13 13 D 60</td>
</tr>
</tbody>
</table>

Key:

I - Chairmen, undergraduate mathematics
II - Deans, liberal arts  VU - Very undesirable
III - Chairmen, graduate mathematics U - Undesirable
IV - Beginning instructors, Ph.D. N - Neutral
V - Experienced instructors, Ph.D. D - Desirable
VI - Beginning instructors, M.A. VD - Very desirable
VII - Other instructors

ability of work which he considered narrow and specialized.
This is not meant to imply that the members of groups III, IV, and V in Table 34 are ignorant of or disregard problems of general education. This has not been, traditionally at
least, an area of vital concern in college mathematics teaching.

Table 35

The extent to which the emphasis on the dissertation of prospective college mathematics instructors is upon work of an interpretive nature, historical, or on the teaching of college mathematics, and ratings of this practice

(Each entry is a per cent of its corresponding group.)

<table>
<thead>
<tr>
<th>Group</th>
<th>Total No.</th>
<th>Present Practice</th>
<th>Desirability Ratings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>I</td>
<td>178</td>
<td></td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>179</td>
<td></td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>29</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>43</td>
<td>5</td>
<td>95</td>
</tr>
<tr>
<td>V</td>
<td>17</td>
<td>0</td>
<td>82</td>
</tr>
<tr>
<td>VI</td>
<td>16</td>
<td>6</td>
<td>50</td>
</tr>
<tr>
<td>VII</td>
<td>15</td>
<td>0</td>
<td>40</td>
</tr>
</tbody>
</table>

Key:

I - Chairmen, undergraduate mathematics
II - Deans, liberal arts
III - Chairmen, graduate mathematics
IV - Beginning instructors, Ph.D.
V - Experienced instructors, Ph.D.
VI - Beginning instructors, M.A.
VII - Other instructors

VU - Very undesirable
U - Undesirable
N - Neutral
D - Desirable
VD - Very desirable
In Table 35 the reactions to the question of the desirability of having a dissertation of a more general nature than in pure mathematics are not so completely reversed from those in Table 34 as one might expect since the two types of dissertations are so different. The average rating of the broad type dissertation is "neutral" when all groups are thrown together. Within this overall rating, the college deans, with a rating of "desirable", are found opposing the heads of the graduate departments and beginning Ph.D.'s who gave a rating of "undesirable". The difference here is marked enough to deserve comment, for it indicates the presence of an area of probable conflict between the "producers" and the "consumers" of college mathematics instructors. It might be argued that, since the undergraduate mathematics chairmen reported "neutral" on this question, the judgment of the deans would be the influencing factor in the hiring of new mathematics instructors. These data show rather definitely that the college administrators, as well as the graduate school department heads, need to have a part in determining the character of programs of instructor preparation. This is also supported by the following:

The posts to which many candidates will be appointed will be in smaller institutions than the universities which trained them. Liberal arts colleges, looking for replacements of retired professors, want a broader type of training than is customary
In many graduate schools. As a consequence, some of the Ph.D. dissertations should be more broadly conceived and more synthetic in character than has been the rule in recent years.⁶

In all questionnaires comments were invited concerning the part which pre-doctoral research should play in the preparation of instructors of college mathematics. Approximately one-third of the respondents felt moved to write in a sentence or two. Unfortunately it is impossible to reproduce all of them. Below are some which are more or less representative of the several types into which the comments can be arranged:

I do not think that research in mathematical history or in the teaching of college mathematics demonstrates the maturity in mathematics which should be required of those receiving the doctorate.

The Ph.D. degree creates research artists, not teachers. The worth of a teacher is one-half as effective after attaining the Ph.D.

The purpose of such research in my opinion is mainly to obtain a thorough understanding of subject matter in at least part of the broad field of mathematics along with methods of scholarly work. A dissertation which crosscuts subject matter lines such as mathematics and physics, or mathematics and economics, etc., would be acceptable and even desirable.

There should surely be included some research in mathematics education as well as in pure mathematics. Emphasis on mathematics education.

Sine qua non. [Research in pure mathematics]

Doubt that it has any value other than reducing the number of candidates.

⁶Theodore C. Blegen and Russell M. Cooper, op. cit., p. 67.
Predoctoral research for the prospective college mathematics instructor should be such as to make him conversant with the disciplines involved in the areas of research in mathematics; to give him a positively critical attitude toward research of other mathematicians and an intelligent understanding of what such research involves.

There may be no direct contribution by research experience to effective teaching as a process; however, in contributing to the understanding of mathematics the research experience is invaluable in making effective teaching possible. One may learn with humility how little he really knows as a result of his research experience. Research experience will not guarantee effective teaching.

No person really understands a field until he has done research in it.

Nearly one-third of the comments stated that research should be pointed toward the teaching of college mathematics rather than toward mathematics itself. One-fourth of the comments were in favor of research in pure or applied mathematics. Nearly one-fourth were in favor of letting the interest of each individual be the deciding factor, while a slightly smaller fraction felt that research is of little or no value. It should be emphasized that, since the deans and the undergraduate mathematics chairmen are by far the most numerous groups in this study, it is basically those groups which are represented by the remarks just quoted.

In view of the attitude which has just been shown to exist in the graduate mathematics departments toward the dissertation of the broad type, it is not surprising to
find that only one of the beginning Ph.D. instructors had written a dissertation of this type. One of the beginning M.A. instructors has one of this type under way. It is doubtful if this shows any tendency on the part of the graduate mathematics faculty consciously to steer candidates away from this type of graduate research.

Before passing to the question of the necessity of the Ph.D. degree for an instructor of college mathematics, one might look at another aspect of the teaching-research question, namely, How much mathematical research is being produced by mathematics instructors while they are carrying on their teaching duties? A study published in 1936 reported that:

... not more than one-third of the persons taking doctor's degrees in mathematics have made as substantial contributions to research as would be evidenced by the publication of three or more research articles; and that not more than one-fifth have really been consistently productive in their contributions. About 60 (or 5%) of the doctors are responsible for half of the published pages of research.

These data agree, in a qualitative way at least, with the employment data quoted earlier in this study from Hollis. The data in Table 36 also agree. If Dean Richardson's

8 See pp. 8-10.
criterion of "three or more research articles" were to be applied to the data of Table 36, 22 per cent of the beginning Ph.D. instructors would be considered to be "substantial" contributors to mathematical research, whereas 43 per cent of the experienced Ph.D. instructors would qualify. In these two percentages, books were considered to be "substantial" contributions. The latter group has the advantage of longer years of experience in which to have produced, so there is no real basis for comparison here.

It is quite common for extracts from, and abstracts of, doctoral dissertations in mathematics to serve as articles appearing in learned periodicals devoted to higher mathematics. Thus, some of the articles reported in Table 36 may not truly represent post-doctoral research. Taking the most severe position possible on this point, one could say that none of the articles reported as having been published on the subject of the instructor's dissertation should be admitted as evidence of the instructor's growth in research since receiving his doctoral degree. In this case it is seen that the largest portion of the beginning Ph.D. group to have published one or more articles of research is 50 per cent, while for the experienced instructors the portion is 30 per cent.
Table 36

RESEARCH PUBLISHED BY COLLEGE MATHEMATICS INSTRUCTORS
(Each entry is a per cent of its corresponding group.)

<table>
<thead>
<tr>
<th>Type of Research</th>
<th>No. of Articles</th>
<th>No. of Books</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>43 Beginning Instructors, Ph.D.</td>
<td>17 Experienced Instructors, Ph.D.</td>
</tr>
<tr>
<td></td>
<td>1 2 3 4 5 6 7 8</td>
<td>1 2 3 4 5 12</td>
</tr>
<tr>
<td>On dissertation</td>
<td>42 12 5 0 0 0 0 2</td>
<td>35 18 6 6 0 ... 0</td>
</tr>
<tr>
<td>Pure mathematics not closely related to dissertation</td>
<td>20 7 2 2 5 0 0 2</td>
<td>0 6 18 0 0 ... 6</td>
</tr>
<tr>
<td>Teaching of college mathematics</td>
<td>0 5 0 ... ... ... ... ... ... ...</td>
<td>... ... ... ... ... ... ... ...</td>
</tr>
<tr>
<td>Teaching of secondary mathematics</td>
<td>5 ... ... ... ... ... ... ...</td>
<td>... ... ... ... ... ... ...</td>
</tr>
<tr>
<td>Teaching of arithmetic</td>
<td>2 ... ... ... ... ... ... ...</td>
<td>... ... ... ... ... ...</td>
</tr>
<tr>
<td></td>
<td>No. of Books</td>
<td>No. of Books</td>
</tr>
<tr>
<td></td>
<td>1 2 ...</td>
<td>1 2 ...</td>
</tr>
<tr>
<td>On dissertation</td>
<td>2 0 ...</td>
<td>12 0 ...</td>
</tr>
<tr>
<td>Pure mathematics not closely related to dissertation</td>
<td>2 0 ...</td>
<td>0 0 ...</td>
</tr>
<tr>
<td>On the teaching of mathematics</td>
<td>0 0 ...</td>
<td>0 0 ...</td>
</tr>
<tr>
<td>No research published</td>
<td>28</td>
<td>41</td>
</tr>
</tbody>
</table>
It must not be overlooked in the data above that some research has been done in the area of mathematics education by these instructors. At least 12 per cent of the beginning Ph.D.'s have shown active interest in problems of teaching, 5 per cent being at the college level, as shown by publication of articles on these topics.

Another indication of the extent to which mathematics instructors continue to do mathematical research after receiving the doctorate is in the amount of research in progress. Table 37 shows how many of the instructors in this study are continuing to use the research ability developed in graduate school.

Table 37 appears to indicate more research activity on the part of beginning Ph.D.'s than is suggested by their output for the last three years. In fact, their reports indicate that 95 per cent of this group is at the present time engaged in one or more of the five types of research above. However it must be added, without any attempt to undervalue such work in progress, that working on research is no guarantee of its being worthy of publication, or of its being published.

It is interesting to note that where, in regard to research already published, the beginning Ph.D. group was equal
Table 37

RESEARCH IN PROGRESS BY COLLEGE MATHEMATICS INSTRUCTORS
(Each entry is a per cent of its corresponding group.)

<table>
<thead>
<tr>
<th>Type of Research</th>
<th>43 Beginning Instructors, Ph.D.</th>
<th>17 Experienced Instructors, Ph.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>On dissertation topic</td>
<td>61</td>
<td>12</td>
</tr>
<tr>
<td>In mathematics, not closely related to dissertation.</td>
<td>74</td>
<td>18</td>
</tr>
<tr>
<td>Teaching of college mathematics</td>
<td>7</td>
<td>18</td>
</tr>
<tr>
<td>Teaching of secondary mathematics</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Teaching of arithmetic</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>No research in progress</td>
<td>5</td>
<td>53</td>
</tr>
</tbody>
</table>

to or a little behind the experienced Ph.D. group; in research in progress the beginning group is far ahead. This is consistent with the following statement made by Woodburne:

The truth is that research is not a native drive, like hunger, but is a habit. It is, moreover, a habit which is broken rather easily. Many men returning to campuses after the war found it difficult to get back into the habit of impartial investigation.°

°Lloyd S. Woodburne, op. cit., p. 77.
Is the Ph.D. Degree Necessary?

The head of one of the largest graduate mathematics departments in the country included the following thoughtful comment in his reply to this question:

I should point out to you that our primary object in graduate work is to train mathematicians and that we do nothing in an organized way beyond this to prepare college teachers.

It seems to me that the college mathematics instructor does not need all the training and experience required for the Ph.D. in mathematics. If some of our colleges would be honest enough to admit this, they would employ on a permanent basis enough persons with sound mathematical training only up to the Master's level. In any case, the Ph.D. in mathematics should not become a degree in "education".

It was primarily because of the emphasis traditionally placed upon the proposition that the Ph.D. degree is a necessary step in becoming a college mathematics teacher that this was made explicitly a basic assumption at the beginning of this study. Readings in the literature and personal contacts with college teachers of mathematics led the writer to believe that such an assumption might be questionable. It was therefore made clear in each questionnaire that this assumption was being made.

Basing their replies on the assumption that the Ph.D.
degree is necessary for college teaching, the persons questioned in this study expressed general approval of a dissertation in pure or applied mathematics. It cannot be inferred from this, however, that they agree with the assumption. Their replies could have been the result of an academic exercise in logic. Whether or not they did agree was revealed by their replies to the question, "Do you agree with the assumption that a necessary requirement for mathematics instruction at the college level is the Ph.D. degree?" Twenty-six (5 per cent) of 477 returns did not indicate an answer. Of the remaining 451, 69 per cent said that the Ph.D. degree was not necessary. Table 38 shows the details of the responses.

The most surprising aspect of these data is that only one of the groups is more in favor of the Ph.D. requirement than against it. In that group, the graduate mathematics chairmen, the majority is only by a single person (4 per cent). This is the group which might have been predicted to favor the requirement rather strongly.

The data in Table 38 do not reflect the judgments of all mathematics department heads, undergraduate and graduate, or of all deans of liberal arts colleges in this country. This study is based upon replies from one-half of the gradu-
Table 38

JUDGMENTS OF RESPONDENTS REGARDING THE REQUIREMENT OF THE PH.D. DEGREE FOR MATHEMATICS INSTRUCTION AT THE COLLEGE LEVEL

<table>
<thead>
<tr>
<th>Group</th>
<th>Total No.</th>
<th>No Reply</th>
<th>Replies</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>I</td>
<td>178</td>
<td>13</td>
<td>26%</td>
</tr>
<tr>
<td>II</td>
<td>179</td>
<td>4</td>
<td>32%</td>
</tr>
<tr>
<td>III</td>
<td>29</td>
<td>4</td>
<td>52%</td>
</tr>
<tr>
<td>IV</td>
<td>43</td>
<td>3</td>
<td>32%</td>
</tr>
<tr>
<td>V</td>
<td>17</td>
<td>0</td>
<td>41%</td>
</tr>
<tr>
<td>VI</td>
<td>16</td>
<td>0</td>
<td>25%</td>
</tr>
<tr>
<td>VII</td>
<td>15</td>
<td>2</td>
<td>31%</td>
</tr>
<tr>
<td>Total</td>
<td>477</td>
<td>26</td>
<td>30%</td>
</tr>
</tbody>
</table>

Key:

I - Chairmen, undergraduate mathematics
II - Deans, liberal arts
III - Chairmen, graduate mathematics
IV - Beginning instructors, Ph.D.
V - Experienced instructors, Ph.D.
VI - Beginning instructors, M.A.
VII - Other instructors

Chairmen, one-fourth of the undergraduate chairmen, and one-fourth of the deans of liberal arts colleges. A short calculation shows that one-fourth of the graduate mathematics chairmen, about one-fifth of the undergraduate mathematics

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10 See pp. 21-22.
chairmen, and about one-sixth of the deans of liberal arts colleges in this country, from their own statements, are known not to agree with the assumption that the Ph.D. degree is a necessary requirement for college mathematics teaching. If, however, the percentages obtained from these samples are applied to the entire membership of these three groups, Table 38 shows that about one-half of the graduate chairmen, three-fourths of the undergraduate chairmen, and two-thirds of the deans do not consider the Ph.D. degree necessary for instructors of college mathematics. Perhaps the time is ripe for reviewing other assumptions about the preparation of instructors of college mathematics.
CHAPTER VI

SUMMARY AND RECOMMENDATIONS

The impetus for this study of the preparation of college mathematics instructors has come from two general sources. One is the evidence which appears in the writings of administrators of institutions of higher education, claiming that college teaching in general has not kept up with the changing aims and curricula of the present day. These administrators have been concerned with both the in-service and the pre-service aspects of college teacher preparation. Discussion of the latter topic inevitably leads to the question of preparation for research versus preparation for teaching. The issue of breadth versus depth in academic preparation arises also. These factors touch upon the heart of a graduate program leading to the doctoral degree.

The second influence furnishing motivation for this study came from the field of college mathematics teaching, through the author's own experience and through the writings of men dealing with the teaching of mathematics at the
college level. As shown earlier in this study, the published evidence of attempted solutions of the problem of improving college mathematics teaching by careful studies of graduate mathematics programs is not plentiful. ¹

This study provides information on what is being done in the preparation of college mathematics instructors and what is considered by the profession as the most desirable practices to be employed. The questionnaire method was used in obtaining the data. Subject to the limitations of replies to questionnaires, these data are a good representation of the ideas of those people most concerned with the preparation of instructors of college mathematics. They have been divided into the following groups:

1. Chairmen of mathematics departments in institutions offering doctoral programs in mathematics.
2. Deans of liberal arts colleges.
3. Chairmen of undergraduate mathematics departments.
4. Instructors of college mathematics.

The reliability of the conclusions drawn from this study depends largely upon how well the questionnaire returns represent the population of the four groups listed above. The way in which the groups were chosen and the percentage of returned questionnaires form the basis for the following

¹See pp. 11-19.
conclusions:

1. One-half of the departments which prepare Ph.D.'s in mathematics in this country furnished data.

2. These departments graduated one-half of the Ph.D.'s in mathematics in this country in the year 1949-50.

3. One-half of the institutions which grant the bachelor's degree in mathematics in this country furnished data, either through a dean or through an undergraduate mathematics department chairman, these two groups being equally represented.

4. The instructors who furnished data represent but a small sample of the population of college mathematics instructors in this country; for example, approximately 8 per cent of those who have earned the Ph.D. within the last three years are represented.

Analysis of the data in the preceding four chapters has led the writer to propose means by which graduate programs which prepare college mathematics instructors may become more effective. As each recommendation is presented it will be followed by a brief discussion of the data which seem most adequately to justify it.

1. Graduate mathematics courses of study for prospective college mathematics instructors should be flexible enough to prepare them to teach college mathematics at any level of instruction, from remedial through graduate courses.

This recommendation has been prompted by the conclusion that both the beginning instructors and the experienced instructors in this study teach essentially the same types of

courses, ranging from elementary college level through the graduate level. Although this was not true for all of the instructors in this study, the percentages involved are large enough to warrant the above recommendation. For example, slightly more than one-half of the beginning college mathematics instructors and of the experienced instructors in this study teach graduate students in mathematics and nearly one-fourth of them teach remedial mathematics and general mathematics. By far the majority of the instructors in this study teach elementary and advanced college mathematics, while only a small percentage offer courses in the teaching of mathematics.\(^3\) This recommendation holds significance for the officials responsible in hiring new mathematics instructors; they should consider carefully the dangers of assigning graduate courses to instructors who function best at the elementary levels, or, on the other hand, of hiring men who excel at directing graduate mathematics study and expecting them to teach at the remedial level without previously ascertaining whether or not they function well and comfortably at either level. This is not meant to suggest a narrow sort of specialization in instructor training, but suggests rather that the graduate student should be able to choose the level most appropriate to his interests and abilities. In turn, an administrator should use the instructor

\(^3\)See Table 1, p. 32.
insofar as possible to teach courses where he is most effective.

Although recommendation No. 1 stresses flexibility according to the individual needs of prospective instructors, it is not meant to imply that there cannot be some common ground upon which graduate graduate study in mathematics can be based. The next recommendation and the discussion following it will clarify this point.

2. Beyond requiring a broad understanding of the major subdivisions of advanced mathematics, there should be no rigid course or credit-hour requirements for the graduate study of prospective college mathematics instructors.

The nature of the replies made by chairmen of graduate mathematics departments to questions about courses to be taken by prospective college mathematics instructors is such that it is difficult, if not impossible, to select a list of "essential" courses. This is a reflection of the principle that a graduate student's course of study should be patterned after his own special needs, interests, and abilities.

Five mathematics courses were reported as studied by most Ph.D. candidates in 90 per cent of the graduate mathematics departments in this study. Sixty-two per cent or more of the departments reported the same five courses as

\[4\] See Table 8, p. 53.
necessary for the Ph.D. degree. From these two points of view the five courses listed below might form a "core" of essentials for prospective college instructors:

1. Functions of a real variable
2. Modern higher algebra
3. Matrix theory
4. Functions of a complex variable
5. Differential equations

These courses, however, do not form a good foundation in the major sub-divisions of mathematics. The list can be broadened by adding those courses which were studied by most Ph.D. candidates in 55 per cent or more of the graduate departments:

6. Group theory
7. Infinite series
8. Projective geometry
9. Differential geometry
10. Set theory
11. Field theory
12. Fourier series
13. Point set topology

These thirteen courses are representative of the basic areas of algebra, geometry, and analysis. They reflect the content of advanced mathematics courses of study in the majority of the graduate mathematics departments in this
country. Three additional courses may be added to this list, on the basis that one-fifth of the graduate departments said they were not offered, but should be offered.\textsuperscript{5} These courses are:

14. Mathematical statistics
15. History of mathematics
16. Foundations of mathematics

To conclude that these sixteen courses are necessary and sufficient to develop effective mathematics instructors is to ignore the comments made by graduate mathematics chairmen concerning the need to build courses of study for individuals, not for a mythical average. This list of sixteen courses, however, is the largest possible list of courses which could be considered as "essential" for the Ph.D. degree and which could pretend to reflect the consensus of graduate mathematics departments.

A final consideration which helps support recommendation No. 2 above is that there is no uniformity in the size of the requirements for the Ph.D. degree in mathematics.\textsuperscript{6} Most graduate mathematics departments have definite credit-hour requirements for the degree; the range is from no set number of hours to 90 semester hours. This is additional

\textsuperscript{5}See Table 9, p. 57.

\textsuperscript{6}See Table 18, p. 72.
evidence of the desire to retain the individual nature of advanced graduate study.

There is sufficient evidence in the data of this study to support a proposal that prospective college mathematics instructors go beyond the field of mathematics in their graduate study. The following statement and related discussion give general suggestions for the extent and nature of such proposed study:

3. The preparation of prospective college mathematics instructors should develop a broad acquaintance with fields closely related to mathematics.

Slightly less than one-half of the deans and undergraduate mathematics chairmen in this study included in responses to the questionnaire several points which they considered to be strengths and weaknesses of the college mathematics instructors under their supervision. Out of these can be seen to emerge areas which need emphasis in instructor preparation. For example, a strength commented upon was "a good background in mathematics and allied fields," while a sign of weakness was "cannot show applications of mathematics to other fields." These two comments call attention to the need for broad study in fields closely related to mathematics.

7 See Tables 3 and 4, pp. 39-41.
There are data in this study which give some quantitative measure to the amount of time which prospective instructors spend, and should spend, upon work of the kind proposed in recommendation No. 3. The median of the replies concerning present practice among graduate mathematics departments indicates that prospective mathematics instructors spend 90 per cent of their graduate study on mathematics and the rest in study of closely related topics. It is therefore possible, in the remaining 10 per cent of his time, for a graduate student to do work in "at least one field outside of mathematics" as was recommended in the 1935 report of the Mathematical Association of America. The graduate mathematics chairmen reported that such a division of time was a desirable one. Fifty-seven per cent of the instructors in this study reported having done some graduate work in areas outside of mathematics. Therefore slightly less than one-half of the instructors in this study have concentrated entirely upon mathematics during their graduate work. The deans considered this emphasis undesirable, while the instructors, graduate and undergraduate chairmen expressed a neutral opinion. All of the groups, however, felt that

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8See Table 11, p. 61.
9See Table 14, p. 65.
10See pp. 11-12.
11See Table 12, p. 63.
it is desirable for some graduate work to be done in areas closely related to mathematics. Therefore, the climate of opinion is favorable toward carrying out recommendations of the Mathematical Association of America in this regard.\textsuperscript{12}

The respondents in this study expressed little interest in having prospective mathematics instructors do graduate work in areas not closely related to mathematics. The median of the replies from graduate chairmen was zero per cent for present practice and zero per cent as a desirable practice.\textsuperscript{13} Very few instructors have had this sort of work as part of their graduate study. Furthermore, with the exception of the deans, who rated this practice as "desirable," all groups gave it a "neutral" desirability rating.\textsuperscript{14}

In a program designed to carry out recommendation No. 3, the student's attention should be directed rather specifically toward the interrelationships which exist between mathematics and related areas. Although it is possible for graduate students to carry out such study independently, it seems that one or two appropriately designed courses or seminars would accomplish more economically the same purpose. The lack of

\textsuperscript{12}See pp. 11-12.
\textsuperscript{13}See Table 15, p. 66.
\textsuperscript{14}See Table 16, p. 68.
existing courses is a difficulty which would have to be over-
come. If a graduate mathematics department became convinced
of the need, there is reason to hope that such courses would
be created within the department. Another effective way for
these purposes to be accomplished is to have these relation-
ships emphasized in the teaching of the mathematics courses
taken by the graduate students.

Up to this point this summary has dealt with the math-
ematical and closely related background considered necessary
for college mathematics instructors. It is the firm convic-
tion of many that instructors should be professionally pre-
pared as well, meaning that, before engaging in college
teaching as a life's work, they should have spent some time
in study of teaching and learning as they relate to college
mathematics. It is in this spirit that the following recom-
mandation is made:

4. Prospective college mathematics instructors
should be required to study problems and methods
of teaching college mathematics. This work
should develop an awareness and an understand-
ing of:

a. The fact that the source of many problems
of teaching is found in the student and
not always in the subject.

b. The purposes of higher education, recent
findings in the psychology of learning,
and their implications for college math-
ematics teaching.
c. **The advantages to effective teaching of good personality, enthusiasm for teaching, and continued professional growth.**

Of the problems which are particularly troublesome to beginning college mathematics instructors, those met most frequently do not center upon subject matter, but upon student-instructor relationships. For example, two-thirds of all instructors in this study have encountered difficulties due to the backgrounds with which students came to college. Slightly more than one-fourth had difficulties in relating the subject matter being taught to other areas of knowledge. Further evidence than this in support of recommendation No. 4 above is seen in the qualities which college administrators consider to be strengths or weaknesses in their mathematics instructors. Some strengths are: enthusiasm about mathematics and about teaching it; willingness to work with students; and previous high school teaching. Characteristics which were regarded as signs of weakness are: tendencies to be theoretical, too specialized, too "research-minded," often at the expense of the students; lack of enthusiasm for or understanding of teaching; and lack of previous classroom experience. Although these strengths and weaknesses do

15 See Table 2, pp. 35-36.
16 See Table 3, p. 39.
17 See Table 4, pp. 40-41.
not represent a large sampling of opinion, the fact that they come from voluntary comments of those responding to the questionnaires tends to make them authentic.

Competency in research and good preparation in the field of mathematics, while considered desirable, were not rated by college deans and mathematics chairmen as highly as some other characteristics in college mathematics instructors. Those characteristics rated "very desirable" were as follows:

1. A good personality
2. An enthusiasm for teaching
3. A willingness to grow professionally
4. Breadth in general education
5. A broad understanding of men and women of college age
6. An understanding of the teaching-learning process

The judgments reflected in the ratings of these six characteristics furnish additional support for recommendation No. 4 above.

Although it did not seem feasible to go into great detail in describing possible kinds of courses which can contribute to the professional background of an instructor, it

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18 See Table 5, pp. 43-44.
did seem necessary to direct the attention of the respondents to the questionnaires toward four types of courses or seminars in education. They are the following:

1. Methods of teaching college mathematics, for mathematics instructors only.

2. General methods of college teaching, for instructors of any subject.

3. The teaching-learning process.

4. Purposes of higher education.

Replies from the graduate mathematics departments and from the mathematics instructors in this study show conclusively that professional education courses or seminars have been used very little in the past few years and are being used very little at the present time in graduate programs for prospective college mathematics instructors.¹⁹

Judgments of the desirability of professional education courses in this study fell into two groups: the deans and undergraduate chairmen considered them desirable; the graduate mathematics chairmen and the college mathematics instructors considered them to be of neutral desirability.²⁰ If it were not for the rating given by the undergraduate mathematics chairmen, one could conclude that this is evidence of administrators aligning themselves against subject

¹⁹See Tables 27-30, pp. 93-96.

²⁰Ibid.
matter specialists. Since most undergraduate mathematics department chairmen have earned the Ph.D. degree in mathematics, they represent a combination of administrator and mathematics specialist. Their college teaching and administrative experience place them in a position to be very well qualified to say what training their mathematics instructors should have. For this reason, their judgment that mathematics instructors would be more effective after having had formal training in the principles of teaching is held to be reliable.

In carrying out this recommendation No. 4 a major difficulty, for which graduate departments should be prepared, lies in the danger of permitting such study to become concentrated upon minor techniques and methods of teaching. In lecture, seminar, or individual study, whatever the means used, careful judgment is needed to maintain a desirable ratio between illustrative techniques and guiding principles so that the prospective instructor is left with resources upon which he can continue to build his own methods of teaching. Out of such study could well come the beginnings of needed investigations of problems of teaching higher mathematics.

The responses to the question of the need for establish-
ing standards of certification for college teaching were in a strong majority (75 per cent) against setting up such standards. The majority of those who favored certification standards felt that the standards should be set up by authorities representing university and college professors, deans, educators, and accrediting agencies in higher education.

While it is difficult for much to be done in a formal way to develop "good personality," or even "enthusiasm for teaching," it is fair to assume that a program which promotes the three general aspects of recommendation No. 4 will inevitably affect even such intangibles as personality and enthusiasm. Since these factors are considered important in teaching, there should be some attention given to them in the process of selection of candidates for instructor preparation.

One of the major outcomes of the study suggested in recommendation No. 4 should be sensitivity to the learning difficulties of students and understanding of the principles which have proved successful in helping them to overcome these difficulties. The kinds of learning experiences which

21 See Table 32, p. 102.
might be provided to develop these outcomes are varied. Attendance at lectures, taking part in courses or seminars dealing with these topics, and directed reading in this area are examples. Such experiences are vicarious by nature and can at best stimulate only academic interest in these vital problems of teaching. More penetrating insights and more valuable understanding would result when these experiences are reinforced by college teaching experience at the same time. This leads to the following proposal:

5. With the possible exception of individuals who have had extensive prior teaching experience, prospective college mathematics instructors should be required to observe, assist, and finally teach in college mathematics classes during graduate training.

The majority (75 per cent) of the college mathematics instructors in this study had taught at some level from elementary school to college before beginning graduate work leading to the Ph.D. degree. Sixty-five per cent of these instructors obtained this teaching experience at the college level.22 The group of instructors as a whole rated this experience "very desirable" in terms of making subsequent teaching easier.23

Teaching during graduate training was done by the great

22 See Table 19, p. 77.
23 See Table 20, p. 79.
majority of the instructors in this study. This appears to be a steady trend, for 83 per cent of the graduate departments said that 90 to 100 per cent of their Ph.D. candidates teach college mathematics at some time during their graduate training. This practice was rated "desirable" by all but three groups who rated it "very desirable." All groups felt that it was desirable for prospective college mathematics instructors, while in graduate training, to observe experienced college mathematics teaching. All but two groups felt that it was desirable to assist in, but not take complete charge of, a college mathematics class. Very few graduate departments offer the latter type of experience, and very few of the instructors in this study have had such experience. This kind of experience is commonly present in public school teacher-training programs, and it is designed to introduce prospective teachers gradually into the new experience of teaching. Such experiences are of demonstrated value in producing effective teachers. There is reason to believe that the same kind of exploratory experiences would result in more effective college mathematics instructors. Additional advantage would be gained by adjust-

24 See Table 22, p. 81.
25 See Table 23, p. 82.
26 See Table 22, p. 81.
27 See Table 24, p. 84.
28 See Table 21, p. 80.
ing the level of this teaching to the level for which the prospective instructor is preparing.

Recommendation No. 5 is made with the realization that the majority of graduate mathematics departments provide opportunity for prospective college mathematics instructors to teach while studying for the Ph.D. degree. This desirable practice should be continued, preceded, however, by exploratory experiences. Such experiences can well serve in helping a graduate student decide upon the relative emphases to place on preparation for mathematical research or for college teaching.

6. **The teaching done by prospective college mathematics instructors should be supervised, preferably through visits and conferences by a mathematician who is also an accomplished teacher of undergraduate mathematics.**

Previous teaching experience notwithstanding, teaching Ph.D. candidates are given one or more of the following types of supervision by their mathematics departments at the present time:

1. Outlines and assignments given by the department.
2. Coordination of sections by the faculty.
3. Coordination of sections by group conferences of all section teachers.
4. Visits and/or conferences by a mathematics professor.  

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29 See Table 25, p. 86.
The mathematics departments providing supervision range from 48 per cent using the third type above to 86 per cent of the group using the first type. An unsupervised situation was rated as "very undesirable." The graduate mathematics departments, on the average, feel that supervision through visits and/or conferences by an education professor is undesirable. Their actions reflect this judgment, for only 3 per cent of the graduate mathematics departments utilize supervision by an education professor.\textsuperscript{30} Correlation of classroom teaching experience with some sort of supervision or discussion of teaching methods was rated as "very desirable" by the deans and one group of instructors and "desirable" by the undergraduate chairmen and the rest of the instructors.\textsuperscript{31} These judgments support recommendation No. 6.

The six recommendations made above do not propose radical changes in graduate mathematics programs. As these programs affect prospective college instructors, however, there are elements which are either new or not widely used. These elements may prompt some to question whether or not it will be necessary to change the emphasis upon research, the kind of research, the dissertation, or even the degree which is usually expected in a college mathematics instruc-

\textsuperscript{30}Ibid.

\textsuperscript{31}See Table 26, p. 88.
tor. Consideration of the data obtained relating to these questions has led the writer to make the following recommendation:

7. **Graduate mathematics departments should consider the advisability of creating, for prospective college mathematics instructors, either a new degree at the doctoral level or an advanced master's degree if the present master's degree lacks the breadth and depth required to produce an effective college teacher.**

Each group in this study was asked the question, "Is the Ph.D. degree a necessary requirement for mathematics instruction at the college level?" Ninety-five per cent of the entire number replied to this question, which is evidence of the interest which it aroused. Only one group, the chairmen of graduate mathematics departments, was more in favor of the Ph.D. degree than against it, and this only slightly. The chairmen of undergraduate departments of mathematics and instructors who have the Ph.D. degree were against making it a requirement in a ratio of almost three to one. The deans were against such a requirement in a ratio of two to one. Many qualifying remarks added by the respondents to the questionnaires served to emphasize this point more strongly and to bring out the fact that they felt this degree is not a necessary requirement for mathematics teaching at the undergraduate level.

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32See Table 38, p. 124.
In considering recommendation No. 7, it is imperative that one go beyond merely assigning a name to a degree. The name must be a symbol for the experiences which led up to the degree and a forecast, perhaps, of abilities to be put to productive use in the future. One of the elements which help to characterize the Ph.D. in mathematics is the dissertation and research ability. Traditionally, the emphasis in both pre-doctoral and post-doctoral research has been upon original, creative work in mathematics, either pure or applied, far out on the boundaries of existing mathematical knowledge.

Most of the instructors and the graduate mathematics chairmen felt that it is very desirable for the emphasis in the dissertation of prospective college mathematics instructors to be upon original work in mathematics. From 80 to 95 per cent of the instructors with the Ph.D. gave this as present practice during their own training. Undergraduate chairmen considered this a desirable practice, while the deans reported a neutral opinion. When asked about the desirability of a dissertation of an interpretive nature, historical, or on the teaching of college mathematics, ratings went from "undesirable", given by graduate chairmen and beginning instructors with the Ph.D., to "desirable" by

33 See Table 34, p. 112.
Only three instructors had written dissertations of this nature. There has evidently been no move towards adopting the recommendation of the 1935 report of the Mathematical Association of America which advocated theses of this nature.35

The fact that only a small portion of the Ph.D.'s in mathematics continue to produce research beyond their dissertations is indicated by data from the present study, for only 22 per cent of the beginning Ph.D. group of instructors has published three or more articles of mathematical research.36 A much larger percentage reports research projects under way, but completion of these projects in form acceptable for publication does not necessarily follow.37 In view of these facts, it can be concluded that work on the dissertation in mathematics is not producing mathematics instructors who are at the same time substantial contributors to mathematical research. That one purpose of graduate mathematics departments is to produce persons capable of carrying on mathematical research is not a debatable issue. That this is their chief purpose, as was the charge made in 1935 by the

34 See Table 35, p. 113.
35 See pp. 11-12.
36 See Table 36, p. 119.
37 See Table 37, p. 121.
Mathematical Association of America,⁴⁸ may now be debatable, but is not intended to be an issue in this study.

Many people believe that research experience and ability can greatly reinforce teaching ability. This may be true. It appears to this writer that it is even more apt to be true if the research were directed toward the solution of problems of teaching college mathematics than toward mathematics itself. However, the evidence in this study will not support a recommendation to this effect. Yet there appear to be advantages to changing the emphasis in doctoral dissertations from research in mathematics per se to research more inclined toward the teaching of college mathematics. For example, a doctoral candidate might choose to investigate the possibility of replacing the traditional freshman mathematics sequence of college algebra, trigonometry, and analytic geometry by a course which unifies the subject matter of these three areas. Such an investigation could be a comparison of the effectiveness of the traditional sequence with that of the new, unified presentation. The new course could be one devised by the instructor, or could be patterned after any of several recent textbooks. On the other hand, such a study could take the form of a careful inspection of the content of the traditional sequence for the purpose of determining what is or

⁴⁸ See p. 7.
is not essential, from the point of view of forming a good foundation for the study of calculus.

Thorough treatment of problems similar to the one above would require both thorough understanding of undergraduate and graduate mathematics and penetrating insight into principles, purposes, and problems of teaching collegiate mathematics. Engaging in doctoral research of this sort would not necessarily guarantee that instructors would continue to produce research of this type in any greater proportion than they do at present in purely mathematical research. Yet the closer relationship between this type of research and the daily tasks of college mathematics instructors can provide greater motivation to continue producing this type of research after leaving graduate school.

The student working in the field of graduate mathematics is not ordinarily equipped to do this kind of research. "Equipment" for such work is not so much in the realm of specific skills, but in the realm of understandings and attitudes, coupled with a willingness to regard teaching as a worthwhile endeavor. In a graduate program which makes an early and continuous effort to guide mathematics students into research or teaching, depending on their interests and abilities, there should be ample time to prepare individuals to engage in this type of research.
The evidence provided in this study shows that the majority of the college officials who participated are in accord with the recommendations which have just been made. It is hoped that leaders in the field, as they consider additions to their teaching staffs, will be guided by the principles suggested in the preceding recommendations. By doing so they can become contributing factors in shaping programs which prepare more effective mathematics instructors.

A critical examination of the data leading to the seven recommendations which have been made suggest additional problems related to the improvement of mathematics teaching on the college level. It has been shown, for example, that only a minor portion of the mathematics instructors in this study have contributed in significant amounts to published mathematical research. A great deal of prestige has been built up in the college teaching profession around the ability of instructors to produce research. While some judgments regarding the desirability of research have been obtained, further investigation is needed to determine the role of research in relation to college mathematics teaching. Is an instructor who consistently produces mathematical research, whether or not it is published, more effective as a teacher than one who does not? This question cannot be raised without considering the level of teaching. Certainly the subject
matter and the rigor of thought required in graduate mathematics is on a level closely approximating that of modern mathematical research. Here research and teaching go hand in hand. There would undoubtedly be more of an issue raised in answers to the question, Is an instructor of undergraduate mathematics more effective as a teacher when he is at the same time engaged in mathematical research? Are there any clear-cut ways in which it can be demonstrated that research ability or the research attitude can be used by an instructor to enrich his teaching of undergraduate mathematics?

A long-standing requirement for advanced degrees in any subject has been the requirement of proficiency at reading one or more foreign languages. This problem has not been considered in this study. Does the ability to read French, German, or other languages help make a college mathematics instructor more effective as a teacher? If so, what languages are most helpful? As in the case of research, the level of teaching, graduate or undergraduate, may be an important factor here. Does the graduate instructor have a greater need to keep abreast of modern mathematical developments from all over the world? Does the undergraduate instructor have a greater need to keep abreast of modern curricular and pedagogical trends all over the world? Aid toward answering some of these ques-
tions can be obtained from data showing the extent to which mathematics instructors at each level use their foreign language ability. Information revealing the extent and availability of published materials which would contribute to their teaching should also be obtained. It may be that ignorance of sources of information in foreign writings is the main reason that an instructor does not use his reading ability.

The data of this study have shown that 90 per cent of the candidates for the Ph.D. degree in mathematics in the graduate mathematics departments reporting are planning to become college teachers of mathematics. In the past five years, 80 per cent of the Ph.D.'s in mathematics have taken teaching positions. A follow-up study is needed to determine whether or not those Ph.D.'s who took teaching positions immediately after graduation are still teaching, and whether or not the plans of the present candidates bear fruit. The need for research mathematicians in industry and in the armed forces is steadily growing and is in constant competition with the needs of the colleges and universities. The force of the recommendations herein made would be considerably lessened should it be discovered that graduates of Ph.D. programs are not going into the college teaching field in the proportions reported here.
APPENDICES

Appendix A: Letter to deans of liberal arts colleges. p. 155
Appendix B: Letter to chairmen of undergraduate mathematics departments. p. 156
Appendix C: Questionnaire sent both to deans and to undergraduate mathematics chairmen. p. 157
Appendix D: Letter to chairmen of graduate mathematics departments. p. 162
Appendix E: Questionnaire sent to graduate mathematics chairmen. p. 163
Appendix F: Letter to college mathematics instructors. p. 172
Appendix G: Questionnaire sent to college mathematics instructors. p. 173
Office of the Dean

My dear Sir:

The problems involved in college teaching and in the preparation of college teachers have received careful scrutiny in the past few years by authoritative groups in higher education. A small but vital part of these larger problems lies in the preparation of instructors of college mathematics. I am requesting your help in an attempt to judge, by means of the enclosed questionnaire, the desirability of certain practices in the preparation of these instructors.

Data from this questionnaire, gathered from colleges and universities of the United States, will be used to call attention to strengths and weaknesses of present graduate programs in preparation of college mathematics instructors, and to desirable ways of improving them. It is hoped that this purpose will justify the time needed to answer these questions.
You will not be quoted.

This study is restricted to what can be done in the preservice preparation of instructors of college mathematics, and is based on the assumption that such preparation involves the securing of the Ph.D. degree.

May I request that this questionnaire not be forwarded to your mathematics department for its completion? Replies from mathematics departments are being solicited directly from them. The purpose of this questionnaire is to get the administrator's viewpoint.

Thank you for your time and consideration. I shall be greatly indebted to you for your cooperation. A stamped, addressed envelope is enclosed for your convenience in returning the questionnaire.

Sincerely yours,

Lyman C. Peck
Assistant Professor
School of Education
The Florida State University
Tallahassee

May 4, 1952

Chairman of the Mathematics Department

My dear Sir:

The problems involved in college teaching and the preparation of college teachers have received careful scrutiny in the past few years by authoritative groups in higher education. A small but vital part of these larger problems lies in the preparation of instructors of college mathematics. I am requesting your help in an attempt to judge, by means of the enclosed questionnaire, the desirability of certain practices in the preparation of these instructors.

Data from this questionnaire, gathered from colleges and universities of the United States, will be used to call attention to strengths and weaknesses of present graduate programs in preparation of college mathematics instructors, and to desirable ways of improving them. It is hoped that this purpose will justify the time needed to answer these questions. You will not be quoted.

This study is restricted to what can be done in the pre-service preparation of instructors of college mathematics, and is based on the assumption that such preparation involves the securing of the Ph.D. degree.

Thank you for your time and consideration. I shall be greatly indebted to you for your cooperation. A stamped, addressed envelope is enclosed for your convenience in returning the questionnaire.

Sincerely yours,

Lyman C. Peck
Assistant Professor
School of Education
The following are some characteristics which many college administrators expect or desire in college teachers. Will you indicate your judgment of the degree of desirability of these traits for a college mathematics instructor?

An effective college mathematics teacher should:

1. Possess good preparation in the entire field of mathematics.

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<thead>
<tr>
<th>Very Undesirable</th>
<th>Undesirable</th>
<th>Neutral</th>
<th>Desirable</th>
<th>Very Desirable</th>
</tr>
</thead>
</table>

2. Have breadth in his general education, resulting in the ability to see, to interpret, and to teach the significance of mathematics in its relation to wider areas of learning.

<table>
<thead>
<tr>
<th>Very Undesirable</th>
<th>Undesirable</th>
<th>Neutral</th>
<th>Desirable</th>
<th>Very Desirable</th>
</tr>
</thead>
</table>

3. Be competent in research, either creative or interpretive.

<table>
<thead>
<tr>
<th>Very Undesirable</th>
<th>Undesirable</th>
<th>Neutral</th>
<th>Desirable</th>
<th>Very Desirable</th>
</tr>
</thead>
</table>

4. Possess a good personality.

<table>
<thead>
<tr>
<th>Very Undesirable</th>
<th>Undesirable</th>
<th>Neutral</th>
<th>Desirable</th>
<th>Very Desirable</th>
</tr>
</thead>
</table>

5. Show a broad understanding of human nature as found in men and women of college age.

<table>
<thead>
<tr>
<th>Very Undesirable</th>
<th>Undesirable</th>
<th>Neutral</th>
<th>Desirable</th>
<th>Very Desirable</th>
</tr>
</thead>
</table>

6. Have a sincere enthusiasm for and devotion to teaching as a profession.

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<th>Very Undesirable</th>
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<th>Neutral</th>
<th>Desirable</th>
<th>Very Desirable</th>
</tr>
</thead>
</table>

7. Understand the teaching-learning process and its implications for the teaching and learning of college mathematics.

<table>
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<tr>
<th>Very Undesirable</th>
<th>Undesirable</th>
<th>Neutral</th>
<th>Desirable</th>
<th>Very Desirable</th>
</tr>
</thead>
</table>
8. Possess a certain "immunity to neglect", demonstrated by a willingness continuously to survey, repair, and supplement his general and professional education.

Very Undesirable Undesirable Neutral Desirable Very Desirable

9. Demonstrate his capacity for democratic living by participating in the life of the college and the community.

Very Undesirable Undesirable Neutral Desirable Very Desirable

10. Understand the role of mathematics in higher education and the place of higher education in our democratic society.

Very Undesirable Undesirable Neutral Desirable Very Desirable

11. Understand the dual contribution of mathematics to education: mathematics for general education, and mathematics for vocational and professional education.

Very Undesirable Undesirable Neutral Desirable Very Desirable

Experience in the Classroom

In judging the desirability of the following practices, consider each on its own merits; i.e., how desirable would it be if it were the only such practice being followed?

12. While in his graduate training, a prospective college mathematics instructor should:

A. Teach college mathematics classes.

Very Undesirable Undesirable Neutral Desirable Very Desirable

B. Assist in, but not be in complete charge of, college mathematics classes.

Very Undesirable Undesirable Neutral Desirable Very Desirable

C. Observe the teaching of experienced mathematics professors in college mathematics classes.

Very Undesirable Undesirable Neutral Desirable Very Desirable

Is there a combination of the above practices which you would prefer? Please indicate by circling the appropriate letters:

A B C

13. If one or more of the practices mentioned above in question 12 are desirable, how desirable is it to correlate such experiences with supervision by and conference with an experienced professor, with a teaching methods course, with a teaching methods seminar, or with some such means of encouraging reflective thinking about problems of teaching?

Very Undesirable Undesirable Neutral Desirable Very Desirable
14. While in his graduate training, a prospective instructor of college mathematics should take a course or seminar in:

A. Methods of teaching college mathematics, with a group of prospective college mathematics instructors only.
   - Very Undesirable Undesirable Neutral Desirable Very Desirable

B. General methods of college teaching, with a mixed group of prospective college instructors.
   - Very Undesirable Undesirable Neutral Desirable Very Desirable

C. The teaching-learning process.
   - Very Undesirable Undesirable Neutral Desirable Very Desirable

D. The purposes of higher education.
   - Very Undesirable Undesirable Neutral Desirable Very Desirable

Is there a combination of the above courses which you would prefer? Please indicate by circling the appropriate letters:

A B C D

Subject Matter Courses

15. Setting aside for the moment the possibility of some work in education courses, how desirable is it for a prospective college mathematics instructor to devote all of his graduate work to advanced mathematics?

   - Very Undesirable Undesirable Neutral Desirable Very Desirable

16. How desirable is it to have a definite portion of his graduate work in areas closely related to mathematics, such as in science?

   - Very Undesirable Undesirable Neutral Desirable Very Desirable

17. How desirable is it to have a portion of his graduate work in areas not closely related to mathematics, such as in fine arts, liberal arts, social studies, etc.?
18. How desirable is it in the dissertation of a prospective college mathematics instructor to have the emphasis upon production of original work in pure (or applied) mathematics?

<table>
<thead>
<tr>
<th>Very Undesirable</th>
<th>Undesirable</th>
<th>Neutral</th>
<th>Desirable</th>
<th>Very Desirable</th>
</tr>
</thead>
</table>

19. How desirable is it in the dissertation of a prospective college mathematics instructor to have the emphasis upon production of work of an interpretive nature, of a historical nature, or of work on problems of teaching college mathematics?

<table>
<thead>
<tr>
<th>Very Undesirable</th>
<th>Undesirable</th>
<th>Neutral</th>
<th>Desirable</th>
<th>Very Desirable</th>
</tr>
</thead>
</table>

20. Do you have any comments to make on the part that predoctoral research should play in the preparation of a college mathematics instructor? Use the space below, and the reverse side of this sheet if necessary:

Miscellaneous

In the following, "beginning mathematics instructor" is defined to mean a person who has received the Ph.D. degree in mathematics within the last three years, and who is now teaching college mathematics.

21. Are there some mathematics courses which beginning mathematics instructors hired in your department recently have not had, but have needed in their teaching?

Yes  No  

If "yes", please list them below:

22. What strengths and/or weaknesses in the preparation of beginning mathematics instructors have you found that are worth noting? Please use the space below:
23. Do you agree with the assumption that a necessary requirement for mathematics instruction at the college level is the Ph.D. degree? 

Yes ___  No ___

Any comments?

24. Do you feel that there is a need for setting up standards of certification for teaching at the college level, comparable to those now in force for teaching in public elementary and secondary schools?

Yes ___  No ___

If so, who should set the standards?

Any further comments?

25. Another part of this study is a questionnaire to beginning college mathematics instructors, designed to determine some of the difficulties encountered in beginning teaching of college mathematics. Since it is difficult to reach these persons directly, I am asking you to give the names and addresses of any such instructors whom you may know. This help will be greatly appreciated.

Name                      Address

________________________________________________________

Name                      Address

________________________________________________________

Name                      Address

________________________________________________________

Name                      Address

________________________________________________________

Name                      Address
My dear Sir:

The problems involved in college teaching and the preparation of college teachers have received careful scrutiny in the past few years by authoritative groups in higher education. A small but vital part of these larger problems lies in the preparation of instructors of college mathematics. I am requesting your help, by means of the enclosed questionnaire, in determining what are some of the present practices employed by mathematics departments as they prepare teachers of college mathematics, and in judging what practices would be considered as ideal, or desirable.

Data from this questionnaire, gathered from colleges and universities of the United States, will be used to call attention to strengths and weaknesses of present programs in preparation of college mathematics instructors, and to desirable ways of improving them. It is hoped that this purpose will justify the time needed to answer these questions. You will not be quoted.

This study is restricted to what can be done in the preservice preparation of instructors of college mathematics, and is based on the assumption that such preparation involves the securing of the Ph.D. degree.

Thank you for your time and consideration. I shall be greatly indebted to you for your cooperation. A stamped, addressed envelope is enclosed for your convenience in returning the questionnaire.

Sincerely yours,

Lyman C. Peck
Assistant Professor
School of Education
1. Is your university on the semester plan? __ the quarter plan? __

2. During the last five years, approximately what percent of your students who received the Ph.D. degree in mathematics have taken positions primarily in teaching college mathematics?

3. How many candidates for the Ph.D. degree in mathematics do you have at this time?

4. How many of your present group of Ph.D. candidates are definitely planning to become college mathematics instructors?

5. During the last five years, what percent of your Ph.D. candidates have taught college mathematics at some time during their graduate training?

In the following sections, procedures are mentioned which are being followed by graduate schools in this country as they prepare college instructors. Please consider each from two points of view:

A. Is the procedure present practice at your university?

B. Whether it is your present practice or not, what is your judgment of the desirability of the procedure in a program of preparing college mathematics instructors?

Teaching Experience at the College Level

6. As a usual practice, the Ph.D. candidate receives teaching experience as:

   A. An assistant, not in complete charge of a class.

   Present Practice: Yes ___ No ___

   Very Undesirable Undesirable Neutral Desirable Very Desirable
A. A teacher of one or more college classes. 

Present Practice: Yes ___ No ___

Very Undesirable Undesirable Neutral Desirable Very Desirable

7. On the average, how many classes does a Ph.D. candidate in your institution teach during his entire graduate training?

____ Classes

8. What, on the average, would be a desirable total number of classes which each prospective college mathematics instructor should teach during his graduate training?

____ Classes

In judging the desirability of the following practices, consider each on its own merits; i.e., how desirable would it be if it were the only practice being followed?

9. A Ph.D. candidate who teaches regularly during his graduate work receives the following supervision:

A. None. 

Present Practice: Yes ___ No ___

Very Undesirable Undesirable Neutral Desirable Very Desirable

B. Course outlines and assignment sheets supplied by the department or by a senior faculty member. 

Present Practice: Yes ___ No ___

Very Undesirable Undesirable Neutral Desirable Very Desirable

C. Coordination with other sections by a faculty coordinator. 

Present Practice: Yes ___ No ___

Very Undesirable Undesirable Neutral Desirable Very Desirable

D. Coordination with other sections by regularly scheduled conferences among all other instructors of these sections. 

Present Practice: Yes ___ No ___

Very Undesirable Undesirable Neutral Desirable Very Desirable

E. Visits by and/or conferences with an experienced teacher in the mathematics department. 

Present Practice: Yes ___ No ___

Very Undesirable Undesirable Neutral Desirable Very Desirable
Visits by and/or conferences with an experienced teacher in the education department.

Present Practice: Yes__ No__

Very Undesirable Undesirable Neutral Desirable Very Desirable

Is there a combination of the above practices which you would prefer? Please indicate by circling the appropriate letters:

A B C D E F

Do your Ph.D. candidates counsel or advise undergraduate students?

Present Practice: Yes__ No__

Very Undesirable Undesirable Neutral Desirable Very Desirable

Do you have additional comments to make on that phase of the preparation of a college mathematics instructor which gives him first-hand experience at the job of college teaching? Please write below and on the reverse side of this sheet if more space is needed.

Professional Education Courses

In judging the desirability of the following four types of courses, consider each on its own merits; i.e., how desirable would it be if it were the only course being taken?

12. A course or seminar in methods of teaching college mathematics, with a group of prospective college mathematics instructors only.

Present Practice: Yes__ No__

Very Undesirable Undesirable Neutral Desirable Very Desirable

13. A course or seminar in general methods of college teaching, with a mixed group of prospective college instructors.

Present Practice: Yes__ No__

Very Undesirable Undesirable Neutral Desirable Very Desirable

14. A course or seminar in the teaching-learning process.

Present Practice: Yes__ No__

Very Undesirable Undesirable Neutral Desirable Very Desirable
15. A course or seminar in the purposes of higher education.
    Present Practice: Yes ___ No ___
    Very Undesirable Undesirable Neutral Desirable Very Desirable

Is there a combination of the above courses which you would prefer? Please indicate by circling the appropriate numbers:

12 13 14 15

16. Do you correlate discussion of methods of teaching college mathematics, or of any of the items in questions 12 - 15, with the teaching of your graduate mathematics classes?
    Present Practice: Yes ___ No ___
    Very Undesirable Undesirable Neutral Desirable Very Desirable

17. Some universities are using the device of including, in examinations given to Ph.D. candidates, questions touching upon problems, issues, and trends in the teaching of college subject matter.
    in all courses? Yes ___ No ___
    in most courses? Yes ___ No ___
    in some courses? Yes ___ No ___
    in no courses? Yes ___ No ___
    Present Practice: ___

18. How desirable is the device described in question 17?
    Very Undesirable Undesirable Neutral Desirable Very Desirable

19. Use the space below and on the reverse side of this sheet, if necessary, for additional comments on the subject of professional education for prospective college mathematics instructors.

Course Work Outside of Mathematics

20. Prospective college mathematics instructors take course work in areas closely related to mathematics, such as in science.
    Present Practice: Yes ___ No ___
    Very Undesirable Undesirable Neutral Desirable Very Desirable
21. Some coursework in areas not closely related to mathematics, such as in fine arts, liberal arts, social studies, etc., for the purpose of broadening his intellectual outlook.

Present Practice: Yes ___ No ___

Very Undesirable Undesirable Neutral Desirable Very Desirable

22. Consider the academic schedule of a prospective college mathematics instructor:
   A. What percent of his time is spent in the field of mathematics?
   B. What percent of his time is spent in closely related areas?
   C. What percent of his time is spent in areas not closely related to mathematics?
   D. What percents would be most desirable in:
      Mathematics?
      Closely related areas?
      Areas not closely related?

23. If it is deemed desirable to have part of a Ph.D. candidate's time spent in study of areas outside of mathematics, please check the way in which this time would be best utilized:
   A. In free electives. ___
   B. In required courses. ___
   C. In guided readings. ___
   D. In some other way. ___ Please describe below:

24. Please enter below your university's requirements, in credit hours earned in mathematics courses or seminars, beyond the Bachelor's degree, for the Ph.D. in mathematics:

   ___ Quarter hours.   ___ Semester hours.

If your requirements are flexible, will you please describe them briefly below, and on the reverse side if necessary?
Below is a list of topics in advanced mathematics and closely related subjects. These topics may or may not coincide with the titles of courses or seminars which your mathematics department offers. However, by checking "Yes" or "No", will you indicate those topics which:

A. Are studied by most of your Ph.D. candidates?

B. Are regarded as necessary, if not required, for the Ph.D. degree?

C. Are not offered, but should, in your opinion, be offered?

<table>
<thead>
<tr>
<th>Topic</th>
<th>Studied by most Ph.D. candidates</th>
<th>Necessary for the Ph.D.</th>
<th>Should be offered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functions of a real variable</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Functions of a complex variable</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Differential equations</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Vector analysis</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Infinite series</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Fourier series</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
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<td>Harmonic functions</td>
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<tr>
<td>Set theory</td>
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<td>Yes</td>
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<tr>
<td>Ergodic theory</td>
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<td>No</td>
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<tr>
<td>Number theory</td>
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</tr>
<tr>
<td>Modern higher algebra</td>
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</tr>
<tr>
<td>Matrix theory</td>
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<td>Group theory</td>
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<td>No</td>
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<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Foundations of mathematics</td>
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<td>No</td>
<td>Yes</td>
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<tr>
<td>Mathematical statistics</td>
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<td>No</td>
<td>Yes</td>
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<tr>
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<tr>
<td>Mathematical economics</td>
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<td>No</td>
<td>Yes</td>
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<tr>
<td>Theory of probability</td>
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<td>No</td>
<td>Yes</td>
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<tr>
<td>Actuarial mathematics</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
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<tr>
<td>Calculus of finite differences</td>
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<td>Calculus of variations</td>
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<td>Yes</td>
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<tr>
<td>Astronomy</td>
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</tr>
<tr>
<td>Modern computing methods</td>
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<td>No</td>
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<td>Necessary for the Ph.D.</td>
<td>Should be offered</td>
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<td>Hydrodynamics</td>
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<td>Yes _ No _</td>
<td>Yes _ No _</td>
</tr>
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<td>Yes _ No _</td>
<td>Yes _ No _</td>
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<td>Elasticity</td>
<td>Yes _ No _</td>
<td>Yes _ No _</td>
<td>Yes _ No _</td>
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<tr>
<td>Plasticity</td>
<td>Yes _ No _</td>
<td>Yes _ No _</td>
<td>Yes _ No _</td>
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<tr>
<td>Optics</td>
<td>Yes _ No _</td>
<td>Yes _ No _</td>
<td>Yes _ No _</td>
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<td>Yes _ No _</td>
</tr>
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<td>Yes _ No _</td>
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<tr>
<td>Statistical mechanics</td>
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<tr>
<td>Theory of relativity</td>
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<td>Yes _ No _</td>
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<tr>
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<tr>
<td>General theory</td>
<td>Yes _ No _</td>
<td>Yes _ No _</td>
<td>Yes _ No _</td>
</tr>
</tbody>
</table>

Other topics or courses not listed above. (Please list below:)

26. Authoritative groups, such as The President's Commission on Higher Education, have recommended that graduate curricula be broadened and liberalized to avoid narrow specialization, especially in the doctoral programs, since these programs make up the preparation of most of our college instructors.

Will you comment on this recommendation, as it affects the preparation of instructors of college mathematics?

Research

27. Is it desirable in the dissertation of a prospective college mathematics instructor to have the emphasis upon production of original work in pure (or applied) mathematics?

<table>
<thead>
<tr>
<th>Very Undesirable</th>
<th>Undesirable</th>
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28. Is it desirable in the dissertation of a prospective college mathematics instructor to have the emphasis upon production of work of an interpretive nature, of a historical nature, or of work on problems of teaching college mathematics?

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29. Do you have any comments to make on the part that predoctoral research should play in the preparation of a college mathematics instructor? Use the space below, and the reverse side if necessary:

Miscellaneous

30. Does your university have a faculty committee on the preparation of college instructors? Yes No

31. If you have such a committee, is it:
   A. Departmental? __
   B. College-wide? __
   C. University-wide? __
   D. Differently organized? Please describe below:

32. Do you agree with the assumption that a necessary requirement for mathematics instruction at the college level is the Ph.D. degree in mathematics? Yes No

   Any comments?

33. Do you feel that there is a need for setting up standards of certification for teaching at the college level, comparable to those in force now for teaching in the public elementary and secondary schools? Yes No

   If so, who should set the standards?

   Any further comments?
34. What important aspects of the problem of preparing instructors of college mathematics have been omitted in these questions? Please comment below and on the reverse side of the sheet if necessary.

35. Another part of this study is a questionnaire to "beginning mathematics instructors" in college - those who have received the Ph.D. degree within the last three years. Since it is very difficult to reach these persons directly, I am asking you to furnish me with names and addresses of some, either those who may be on your own faculty, or those on other faculties. The main purpose in questioning these persons is to find what difficulties they have encountered in their beginning teaching, and whether some treatment of those problems during graduate study would result in better teaching in the future by beginning mathematics instructors.

Space is left below for five names and addresses. If you can give more it will be greatly appreciated.

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My dear Sir:

The problems involved in college teaching and in the preparation of college teachers have received careful scrutiny in the past few years by authoritative groups in higher education. A small but vital part of these larger problems lies in the preparation of instructors of college mathematics. I am requesting your help in an attempt to judge, by means of the enclosed questionnaire, the desirability of certain practices in the preparation of these instructors.

Data from this questionnaire, gathered from colleges and universities in the United States, will be used to call attention to strengths and weaknesses of present graduate programs in preparation of college mathematics instructors, and to desirable ways of improving them. It is hoped that this purpose will justify the time needed to answer these questions. You will not be quoted.

This study is restricted to what can be done in the preservice preparation of instructors of college mathematics, and is based on the assumption that such preparation involves the securing of the Ph.D. degree.

(NAME OF PERSON SUPPLYING INSTRUCTOR'S NAME)

has replied to a more extensive questionnaire on this subject, and has given me your name as a beginning college mathematics instructor who may offer valuable assistance, in the light of problems or difficulties which you may have faced in your recent teaching.

Thank you for your time and consideration. I shall be greatly indebted to you for your cooperation. A stamped, addressed envelope is enclosed for your convenience in returning the questionnaire.

Sincerely yours,

LYMAN C. PECK
Assistant Professor
School of Education
Below is a list of problems encountered by college teachers in their beginning year of teaching. Will you check those problems which you consider to have been particularly troublesome in the mathematics teaching which you have done since receiving the Ph.D. degree?

Lack of preparation in all areas of mathematics.
Lack of physical facilities in the classroom.
Arranging the units of the courses in the proper sequence.
Interpreting the results of tests for measuring achievement.
Relating the subject being taught to other areas of knowledge.
Difficulties due to lack of administrative understanding of teaching problems.
Heavy teaching duties.
Lack of training for college level teaching.
Difficulties due to background of training and experience with which the students come to college.
Organizing and presenting materials within the ability range of students.
Getting students to relate material being taught to current problems and situations.
Developing student interest and stimulating student thinking.
Utilizing students' interests in planning and conducting classwork.
Adapting instruction to differences found in the personnel of a class.
Developing in students the ability to do straight thinking.
Developing proper student-teacher relationships.
Understanding the needs and objectives of the students.
Counseling and giving individual advice to students.
Other problems not listed above:

20. When did you receive your Ph.D. degree?

21. How many years have you taught college mathematics since receiving the Ph.D. degree?
22. Had you had part time or full time teaching experience in any subject before you began work on the Ph.D. degree?

   A. At the elementary school level? Yes ___ No__
   B. At the secondary school level? Yes ___ No__
   C. At the junior college level? Yes ___ No__
   D. At the college level? Yes ___ No__

23. If you answered "Yes" in question 22, how desirable would you rate that experience as a means of making subsequent teaching easier?

   | Very Undesirable | Undesirable | Neutral | Desirable | Very Desirable |
   --- | --- | --- | --- | --- | --- |

In the following sections, procedures are mentioned which are being followed by graduate schools in this country as they prepare college instructors. Please consider each from two points of view:

   A. Did you engage in the procedure listed during your graduate work for the Ph.D. degree?
   B. Whether you engaged in the procedure or not, what is your judgment of the desirability of the procedure in a program of preparing college mathematics instructors?

Teaching Experience at the College Level

   In judging the desirability of the following three practices, consider each on its own merits; i.e., how desirable would it be if it were the only practice being followed?

24. Teaching in college mathematics classes. Engaged in: Yes ___ No__
   | Very Undesirable | Undesirable | Neutral | Desirable | Very Desirable |
25. Assisting in, but not in complete charge of, college mathematics classes. Engaged in: Yes ___ No__
   | Very Undesirable | Undesirable | Neutral | Desirable | Very Desirable |
26. Observing, as a graduate student, the teaching of an experienced mathematics professor in undergraduate college mathematics classes. Engaged in: Yes ___ No__
   | Very Undesirable | Undesirable | Neutral | Desirable | Very Desirable |
Is there a combination of the above practices which you would prefer? Please indicate by circling the appropriate numbers:

24 25 26

27. If one or more of the practices mentioned in 24 - 26 are desirable, how desirable would it be to correlate such experience with supervision by and conference with an experienced professor, with a teaching methods course, with a teaching methods seminar, or with some such means of encouraging reflective thinking about problems of teaching?

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Professional Education Courses

In judging the desirability of the following four courses, consider each on its own merits; i.e., how desirable would it be if it were the only such course being taken?

28. While in your graduate training, did you take a course or seminar in:

A. Methods of teaching college mathematics, with a group of prospective college mathematics instructors only?

   Engaged in: Yes No

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B. General methods of college teaching, with a mixed group of prospective college instructors?

   Engaged in: Yes No

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C. The teaching-learning process?

   Engaged in: Yes No

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D. The purposes of higher education?

   Engaged in: Yes No

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Is there a combination of the above courses which you would prefer? Please indicate by circling the appropriate letters:

A B C D
Subject Matter Courses

29. During your pre-doctoral graduate work, did you devote all of your work to courses or seminars in advanced mathematics?  
   Yes  No

   Very Undesirable  Undesirable  Neutral  Desirable  Very Desirable

30. Did you devote a portion of your graduate work to areas closely related to mathematics, such as in science?  
   Yes  No

   Very Undesirable  Undesirable  Neutral  Desirable  Very Desirable

31. Did you devote a portion of your graduate work to areas not closely related to mathematics, such as in fine arts, liberal arts, the social studies, etc.?  
   Yes  No

   Very Undesirable  Undesirable  Neutral  Desirable  Very Desirable

32. Are there some mathematics courses which you have not had, but have needed in your teaching since receiving your Ph.D. degree?  
   Yes  No

   If "Yes", list them below:

Research

33. Was your dissertation a piece of original work in pure (or applied) mathematics?  
   Yes  No

   Very Undesirable  Undesirable  Neutral  Desirable  Very Desirable

34. Was your dissertation a piece of work of an interpretive nature, of a historical nature, or of work on problems of teaching college mathematics?  
   Yes  No

   Very Undesirable  Undesirable  Neutral  Desirable  Very Desirable

35. Since receiving your Ph.D. degree, how much research have you published?  
   State the number of:

   | Articles | Books |

   A. On the subject of your dissertation. 
   B. In pure (or applied) mathematics, but not closely related to your dissertation. 
   C. In the teaching of college mathematics. 
   D. In the teaching of secondary mathematics. 
   E. In the teaching of arithmetic.
**36. Are you at present engaged in research:**

A. On the subject of your dissertation? Yes No

B. In pure (or applied) mathematics, but not closely related to your dissertation? Yes No

C. In the teaching of college mathematics? Yes No

D. In the teaching of secondary mathematics? Yes No

E. In the teaching of arithmetic? Yes No

**Miscellaneous**

**37. Since receiving your Ph.D. degree, have you been teaching:**

A. Remedial courses, such as arithmetic, beginning algebra, or beginning plane geometry? Yes No

B. General mathematics, i.e., mathematics for liberal arts? Yes No

C. College algebra, trigonometry, and analytic geometry, or the equivalent in a first year course of college mathematics? Yes No

D. Methods of teaching arithmetic? Yes No

E. Methods of teaching junior high school mathematics? Yes No

F. Methods of teaching high school mathematics? Yes No

G. The calculus sequence? Yes No

H. Undergraduate courses not requiring calculus, such as theory of equations, college geometry, advanced algebra, etc.? Yes No

I. Undergraduate courses for which calculus is required? Yes No

J. Graduate courses in mathematics? Yes No

K. Or directing graduate theses and/or dissertations? Yes No

L. Courses not listed above? (Please list below:)

38. Do you agree with the assumption that a necessary requirement for mathematics instruction at the college level is the Ph.D. degree?  

Yes  No 

Any comments? 

39. Do you feel that there is a need for setting up standards of certification for teaching at the college level, comparable to those now in force for teaching in the public elementary and secondary schools?  

Yes  No 

If so, who should set the standards? 

Any further comments? 

40. Will you name two or three aspects of your graduate training which contributed most toward making you effective at your subsequent teaching? Please use the reverse side of this sheet if there is not enough space below: 

41. Now will you name two or three aspects of your graduate training which contributed least toward making you effective at your subsequent teaching? Please use the reverse side if necessary: 

42. Do you have any suggestions as to ways of improving the preparation of college mathematics instructors, in the light of your replies to the preceding questions? Use the space below and the reverse side if necessary:
BIBLIOGRAPHY


Armentrout, W. D. "Is College Teaching a Profession?" School and Society, LXXIII (June 16, 1951), 373-374.


"Cornell University Offers Course in 'College Teaching'," *School and Society*, LXX (Oct. 8, 1949), 235.


"Duke Seminar on College History Teaching," *Higher Education*, VIII (December 1, 1951), 86.


I, Lyman Colt Peck, was born in Lebanon, Ohio, December 10, 1920. I received my elementary and secondary school education in the public schools of Lebanon, Ohio. My undergraduate training was obtained at Yale University, from which I received the degree Bachelor of Science in 1942. From The University of Chicago I received the Certificate of Competence in Meteorology in 1942. From 1942 to 1946 I served as a commissioned officer in the United States Army Air Forces as a meteorologist and as an aircraft pilot. From The University of Chicago I received the degree Master of Science in 1947. While in residence at The University of Chicago I acted in the capacity of teaching assistant in the department of mathematics. During the years 1947-48 and 1948-49 I held the position of instructor in mathematics at Ohio University. During the years 1949-50 and 1950-51 I completed the requirements for candidacy for the degree Doctor of Philosophy at The Ohio State University. While in residence at The Ohio State University I held the position of assistant instructor, part-time, in mathematics, and acted in the capacity of assistant to Dr. Earl W. Anderson in education during the year 1949-50. During the year 1951-52 I served as assistant professor in education at Florida State University, and in 1952-53 the position of instructor in mathematics at Iowa State Teachers College. The requirements for the degree Doctor of Philosophy were completed during these two years.