CARTOGRAPHIC EDUCATION IN U.S. COLLEGES AND UNIVERSITIES

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Abstract

This study of cartographic education in U.S. institutions of higher education is based chiefly upon a review of 1975-1976 college catalogs. Course enrollment data, and information about dissertations and theses on cartographic topics were also useful. Cartographic offerings are strongly concentrated in departments of geography. Offerings of one or two courses per school are widespread, reflecting in part the service role cartography plays in geography departments. Programs of nine or more hours are found in 36 schools. The number of degree and certificate programs is slowly increasing.

The vertical development of cartographic programs has been focused upon a small number of schools. This growth has taken place in departments with two or more cartographic faculty and with well equipped laboratories. The production of graduate degrees with cartographic specialization has been strongly concentrated, particularly at the doctorate level. Three universities--Wisconsin, Washington, and Kansas--produced over 56% of all doctorates granted since 1950.

Much more data are needed before a complete analysis of cartographic education in the U.S. is possible. Models of cartographic education need to be developed and tested. This will make possible the development of models of continuing education for which there is an urgent need. Programs for training cartographic technicians are exceedingly few and the potential role which the two-year colleges could play in this area appears great.

"Cartographic Education in U.S. Colleges and Universities"

Introduction

Any attempt to summarize the status of cartographic education in a universe as large as the U.S. system of colleges and universities is likely to be a frustrating one. The difficulty of obtaining data that are both current and complete is great. The data base for this study is far from complete. Although the American Congress on Surveying and Mapping Committee on Education is currently conducting a comprehensive nation-wide survey of courses offered in surveying and mapping subjects, the survey is not yet complete. (1) When those results are available, the present study will be revised. This study does not cover cartographic training in governmental agencies or in commercial firms (2) or "on-the-job" training. The task of characterizing cartographic education is made especially difficult because of the swiftness of changes both in cartography and in American institutions of higher education.

The principal sources of data utilized were: 1) files of 1975-1976 college catalogs, 2) 1975-1976 college catalogs on micro-fiche (3), 3) various issues of the Directory of College Geography in the United States... (4), and 4) various finding lists of dissertations and theses (5). The report "Surveying and Mapping Education" by the ACSM Task Committee on Education issued in 1971 was of great value in preparing the present study (6). Also valuable was the chapter on "Education and Training" from John A. Wolter's Ph.D. dissertation "The Emerging Discipline of Cartography " (7). The several earlier surveys, dating as far back as 1950-1951, are cited in the references (8).

College and University Courses and Programs

Geography Department Base

Geography continues to be the principal departmental home of cartography courses and programs. The 1971 ACSM Task Committee study reported that cartography courses were offered by 93 units in 89 schools (9). Of these units, 81% were geography departments. The remaining 19% were distributed over six areas. The 1971 study included only institutions offering a total of nine or more semester hours of coursework in all categories of surveying and mapping courses. For the most part, geography departments offering only one or two courses were not reported because the institutional total was less than the nine hour minimum.

The present survey reviewed cartography offerings in all schools reporting cartography offerings in the 1971 survey. In addition, catalogs of all schools reporting enrollments in cartography courses offered by geography departments were reviewed. The data set is not yet complete and is biased in the sense that

geography offerings are better represented in the survey than non-geography ones. A review of 1975-1976 catalogs reveals courses offered by 242 units in 237 schools. Of these units, 94% were geography departments. The remaining 6% were distributed over four areas (i.e., engineering, technology, cartography and others). Courses on map reading or map interpretation were excluded from the study.

Types of Institutions

In an analysis of types of institutions offering cartography courses, John Wolter reported the following distribution for 1972-1973: 66% universities, 24% state colleges, 8% other colleges, and 2% community or two-year colleges (10). Clearly, the community college does not play an important role in cartographic education for the country as a whole.

Course Enrollments

The neglect of cartography during the pre-WW II period in American institutions of higher education has been well documented elsewhere. The first decade following WW II witnessed a sharp growth of course offerings in cartography (see Fig. 1) from a small base. This growth continued to be healthy though somewhat less rapid for period since 1955.

Enrollment data in cartography courses offered by geography departments during 1975-1976 indicate that cartography was taught in 258 schools or in 21.5% of the 1200 schools teaching geography courses (see Table 1). If one looks at the total universe of institutions of higher education in the U.S., approximately one school in ten offered cartography courses. In these 258 schools a total of 372 courses were given with a total enrollment of nearly 10,000. This averages 1.4 courses/school and 26 students/course. The states of Wisconsin, California and New York accounted for 25% of the total enrollment. Nine states accounted for 52% of the enrollments and 17 states accounted for 74%. The State of Wisconsin ranked at the head of the list, an unusually high position in comparison to either total geography enrollments or total population.

Titles of Courses Offered

An analysis of course titles provides many insights into the nature of cartographic offerings. Introductory level courses numbered 182 or 39% of the total number found in the survey (see Table 2). Courses labeled as "advanced" numbered 73 or 16% of the total. The title "Cartography" was clearly the most common one, with a frequency of 148 or 32% of the total (see Table 3). This was followed by "Advanced Cartography" with a frequency of 62 or 13%. The next 10 titles had frequencies between 5 and 16. The number of course titles with frequencies between 1 and 4 was 144. The total of 156 different course titles indicates the diversity of content of cartography courses.

A frequency table of key words in cartography course titles was compiled

Fig. 1

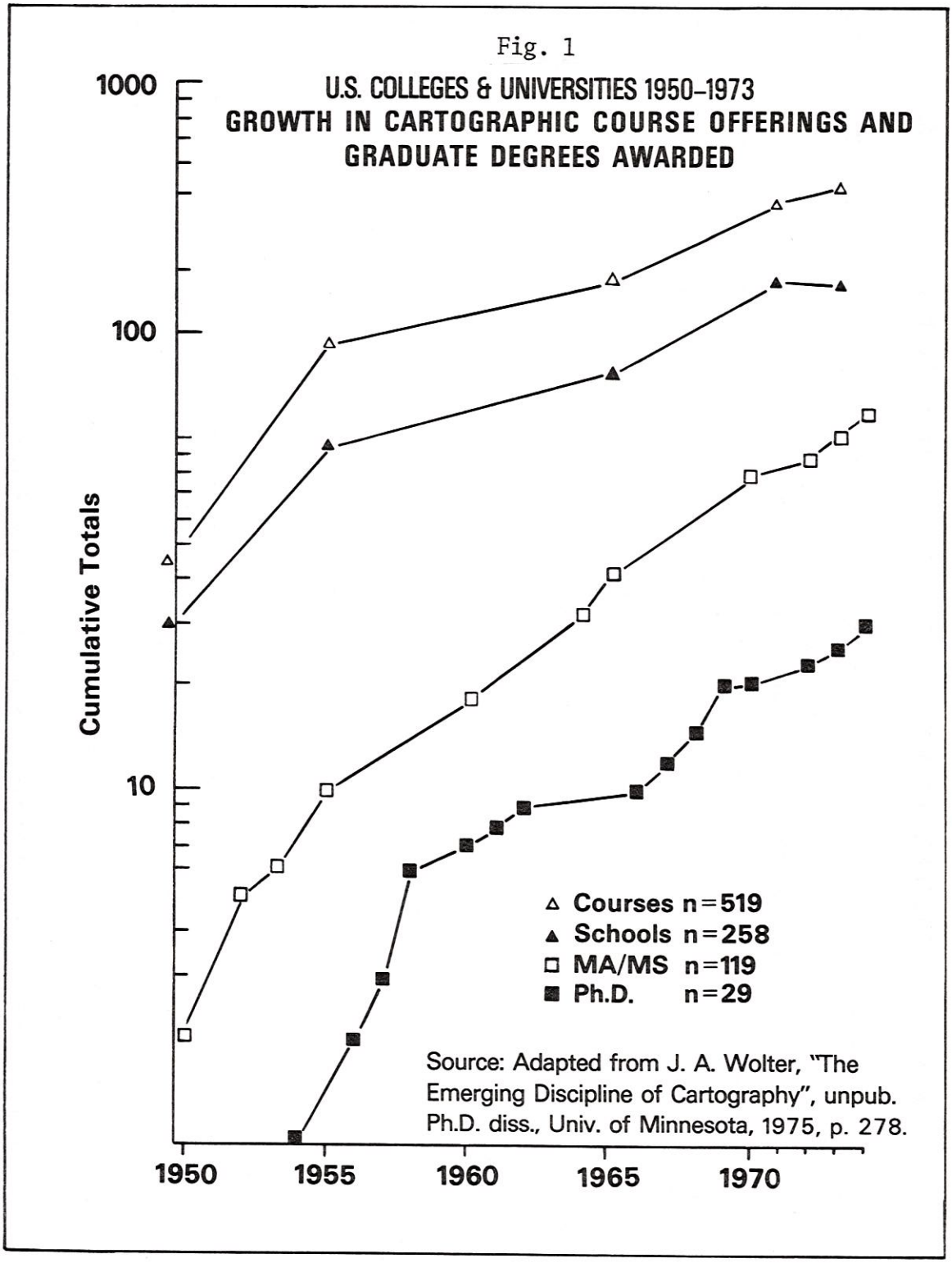
U.S. COLLEGES & UNIVERSITIES 1950–1973
GROWTH IN CARTOGRAPHIC COURSE OFFERINGS AND GRADUATE DEGREES AWARDED
1000
100
10
Cumulative Totals
1950
1955
1960
1965
1970
△ Courses n=519
▲ Schools n=258
□ MA/MS n=119
■ Ph.D. n=29
Source: Adapted from J. A. Wolter, "The Emerging Discipline of Cartography", unpub. Ph.D. diss., Univ. of Minnesota, 1975, p. 278.

TABLE I

U.S. COLLEGES & UNIVERSITIES
1975-76

CARTOGRAPHY ENROLLMENTS IN GEOGRAPHY DEPARTMENT COURSES RANKED BY STATE TOTALS

	Enrollments	Cumulative Total Enrollments	No. of Schools	No. of Courses
Wisconsin	845	845	17	28
California	815	1660	19	26
New York	762	2422	19	27
Illinois	582	3004	13	21
Minnesota	450	3454	9	14
Washington	442	3896	5	13
Maryland	387	4283	8	19
Ohio	384	4667	11	17
North Carolina	346	5013	8	10
Michigan	342	5355	6	9
Pennsylvania	342	5697	13	16
Massachusetts	333	6030	8	13
Oregon	260	6290	3	4
Colorado	250	6540	5	6
Texas	241	6781	9	10
Kansas	207	6988	4	12
South Dakota	188	7176	1	1
35 other states*	2482	9658	100	126
TOTALS	9658		258	372

*Includes all states with total enrollments less than the state mean of 186.

Source: Compiled from Directory of College Geography of the United States, Academic Year 1975-1976, J. R. Schwendeman, Jr. and Sr., eds., Richmond, Kentucky, April 1976.

TABLE 2

U.S. COLLEGES & UNIVERSITIES
1975-76

CARTOGRAPHY COURSES CLASSIFIED
ACCORDING TO COURSE LEVEL

Course Level and Titles	Frequency
Introductory Courses	
Cartography	135
Cartography I	9
Basic Cartography	1
Elements of Cartography (or Elementary Cartography)	11
Fundamentals of Cartography	1
General Cartography	1
Introduction to Cartography (or Introductory Cartography)	24
	182
Intermediate Courses	
Intermediate Cartography	2
Cartography II	9
Senior Cartography	1
	12
Advanced Courses	
Cartography III	1
Advanced Cartography	72
	73
TOTAL	267

Source: Compiled from selected 1975-76 entries in College Catalog Collection 76-77 & 75-76 (San Diego: National Microfilm Library).

TABLE 3

U.S. COLLEGES & UNIVERSITIES
1975-76

TITLES OF CARTOGRAPHY COURSES
OFFERED* RANKED BY FREQUENCY OF OCCURRENCE

Course Titles	Frequency of Occurrence
Cartography	148
Advanced Cartography	62
Cartography & Graphics	16
Introductory Cartography	12
Introduction to Cartography	10
Principles of Cartography	8
Elements of Cartography	7
Cartographic Techniques	6
Computer Cartography	6
Seminar in Cartography	6
Thematic Cartography	6
Computer Mapping	5
144 other course titles*	175
TOTAL	467

*Includes all course titles with frequency of occurrence of four or less.

Source: Compiled from selected 1975-76 entries in College Catalog Collection 76-77 & 75-76 (San Diego: National Microfilm Library).

(see Table 4). Key words with especially high frequencies were: "cartography" or "cartographic," "advanced," and "maps." The words "graphics" or "graphing," "mapping" or "map making," and "introduction" or "introductory" had high frequencies. Words that are perhaps more indicative of course content were: design (f=15), computer (f=15), thematic (f=8), compilation (f=7), history (f=7), projection (f=6), and reproduction (f=6). The combined frequency of computer and automated was 18, of drafting and drawing was 11. Words with low frequencies were: theory (f=1), urban or city (f=2), marine (f=1), mathematical (f=1), military (f=1), generalization (f=1), geology or petroleum (f=3).

The analysis of titles reveals several interesting characteristics of cartographic offerings. The geography affiliation of cartography courses is very apparent. Interest in map design is growing. It is apparent that there is much more emphasis on applications than on theory (11). Despite a rich literature there are very few courses devoted entirely to either map projections or the history of cartography. In view of the strong orientation of university cartography in the U.S. towards small-scale, special-purpose maps, the title "Thematic" is used with surprising restraint (12). Though computer mapping has attracted a great deal of interest in American universities, one would not suspect this from the analysis of course titles. It appears that computer mapping is dealt with in advanced geography courses as well as in numerous cartography courses which do not carry the word computer in the title.

Credit Hours Offered

The distribution of credit hours offered in cartography courses by school is a very interesting one (see Fig. 2 and Table 5). Of the 237 schools offering cartography courses, 97 or 41% offered only one course (1-3 hrs.). Schools offering 4-6 hours (generally two courses) numbered 84 or 35%. Thus, 181 or 76% of the schools offered only one or two courses. This is highly revealing of the service role of cartography in geography programs. In most of these schools there is very little opportunity for students to develop a specialization in cartography. In schools offering 7-9 hours of cartographic work some specialization is apparent. 32 or 13.5% of the schools fall into this class. The vertical development of cartography programs is found chiefly in the 36 schools offering 9 or more hours and finds its fullest development in schools like Ohio State University, the University of Wisconsin--Madison, the University of Kansas, and the University of Washington which offer between 25 and 37 credit hours in cartographic courses (see Table 6).

An important characteristic of the schools at and near the top of the list of credit hours offered is that they have two or more faculty members involved in the teaching of cartography. Of the 9 schools offering more than 15 hours of cartographic course work, at least 6 have two or more faculty specializing in cartography and 7 of the schools offer Ph.D. degrees in geography with cartographic specializations.

The distribution of credit hours offered by state, like the distribution of enrollments, is skewed (see Table 7). The top four states (Ohio, New York,

TABLE 4

U.S. COLLEGES & UNIVERSITIES
1975-76

KEY WORDS IN CARTOGRAPHY COURSE TITLES RANKED
ACCORDING TO FREQUENCY OF OCCURRENCE

Key Word	Frequency of Occurrence
Cartographic, Cartography	418
Advanced	73
Map	55
Graphics, Graphing	32
Mapping, Map Making	29
Introduction, Introductory	27
Computer	15
Design	15
Interpretation	14
Techniques	14
Elements, Elementary	13
Drafting, Drawing	11
Principles	11
Application, Applied	9
Problems	9
Analysis	8
Thematic	8
Air Photo	7
Compilation	7
History	7
Seminar	7
Projection	6
Reproduction	6
Geography, Geographic	5
Methods, Methodology	5
Production	5
Special, Specialized	5
68 other key words*	103

*Include key words occurring less than five times in course titles.

Source: Compiled from selected 1975-76 entries in College Catalog Collection 76-77 & 75-76 (San Diego: National Microfilm Library)

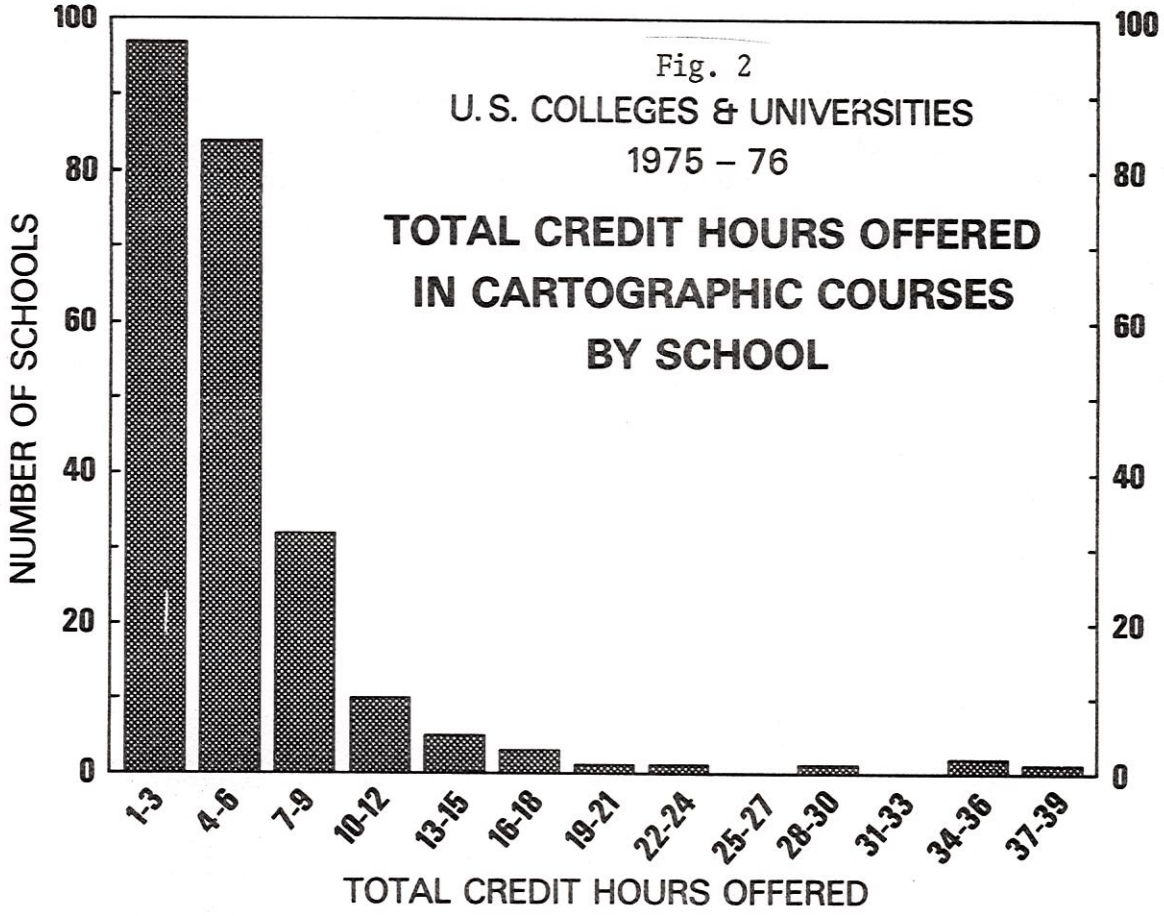
Fig. 2
U.S. COLLEGES & UNIVERSITIES
1975 – 76
TOTAL CREDIT HOURS OFFERED
IN CARTOGRAPHIC COURSES
BY SCHOOL
NUMBER OF SCHOOLS
100
80
60
40
20
0
1-3
4-6
7-9
10-12
13-15
16-18
19-21
22-24
25-27
28-30
31-33
34-36
37-39
TOTAL CREDIT HOURS OFFERED

TABLE 5

U.S. COLLEGES & UNIVERSITIES
1975-76

TOTAL CREDIT HOURS OFFERED IN CARTOGRAPHIC COURSES BY SCHOOL

Total Credit Hours* Offered	Number of Schools	Cumulative Total Number of Schools
1-3	97	97
4-6	84	181
7-9	32	213
10-12	10	223
13-15	5	228
16-18	3	231
19-21	1	232
22-24	1	233
25-27	0	233
28-30	1	234
31-33	0	234
34-36	2	236
37-39	1	237
TOTAL	237	

*Semester hours or semester-hour equivalents.

Source: Compiled from selected 1975-76 entries in College Catalog Collection 76-77 & 75-76 (San Diego: National Microfilm Library).

TABLE 6

U.S. COLLEGES & UNIVERSITIES
1975-76

SCHOOLS OFFERING NINE OR MORE HOURS OF COURSEWORK IN CARTOGRAPHY RANKED ACCORDING TO NUMBER OF HOURS OFFERED

College or University	Credit Hrs.* Listed in 1975-76 Catalog
Ohio State University (Columbus)	34.8-37.4
University of Wisconsin (Madison)	35-36
University of Kansas (Lawrence)	25-36
University of Washington (Seattle)	25.9-29.2
Georgia State University (Atlanta)	23.1
George Washington University (District of Columbia)	21
Clark University (Worcester)	18
University of Michigan (Ann Arbor)	18
University of Minnesota (Minneapolis)	16.2
California State University (Northridge)	15
University of Maryland (College Park)	15
Briarcliff College (Briarcliff Manor)	15
East Central University (Ada, Oklahoma)	15
Syracuse University	13
California State University (San Francisco)	12
Miami University (Oxford)	12
University of Wisconsin (Milwaukee)	12
Michigan State University (East Lansing)	10.8
University of Georgia (Athens)	10.6
Southern Illinois University (Edwardsville)	10.6
WesternWashington State College (Bellingham)	9-10.6
State University of New York (Albany)	10
University of Toledo	9.9
University of Utah (Salt Lake City)	9.9
Kent State University	9.3
University of Akron	9.3
University of Illinois (Urbana)	9
Northern Illinois University (DeKalb)	9
Eastern Michigan University (Ypsilanti)	9
University of Southern Mississippi (Hattiesburg)	9
State University of New York (Binghamton)	9
Ohio University (Athens)	9
Southwest Texas State University (San Marcos)	9
Virginia Polytechnic Institute & State University (Blacksburg)	9
University of Wisconsin--Stevens Point	9
University of Wisconsin--Oshkosh	9
201 Other Schools**	884.6-896.3
TOTAL	1402-1421.2

*Semester hours or semester-hour equivalents.
**Includes all schools with credit hour totals between one and 8.
Source: Compiled from selected 1975-76 entries in College Catalog Collection 76-77 & 75-76 (San Diego: National Microfilm Library).

TABLE 7

U.S. COLLEGES & UNIVERSITIES
1975-76

TOTAL CREDIT HOURS OFFERED IN CARTOGRAPHY COURSES RANKED BY STATE

	No. of Credit Hrs.*	Cumulative Total No. of Credit Hrs.	Number of Schools	Number of Courses
Ohio	109-111.6	109-111.6	10	37
New York	110.5	219.5-222.1	19	35
California	108.5	328-330.6	20	34
Wisconsin	107.2-108.2	435.2-438.8	14	36
Michigan	79.5	514.7-518.3	9	24
Illinois	66.2	580.9-584.5	11	23
Washington	52.4-57	633.3-641.5	5	21
Maryland	48	681.3-689.5	8	16
Minnesota	47.8	729.1-737.3	9	18
Texas	47	776.1-784.3	11	15
Kansas	32-43	808.1-827.3	3	14
North Carolina	36.7	844.8-864.0	7	12
Pennsylvania	34	878.8-898	10	12
Georgia	33.7	912.5-931.7	2	11
Massachusetts	32	944.5-963.7	5	10
Kentucky	30	974.5-993.7	6	10
Florida	29	1003.5-1022.7	6	9
Indiana	27.4	1030.9-1050.1	5	9
34 other states**	371.1	1402-1421.2	77	123
TOTALS	1402-1421.2		237	469

*Semester hours or semester-hour equivalents.
**Includes all states with credit hours totals less than the state mean of 27.2
Source: Compiled from selected 1975-76 entries in College Catalog Collection 76-77 & 75-76 (San Diego: National Microfilm Library).

California, and Wisconsin) offer 31% of the national total of credit hours. Nine states offer 52% of the total and 18 states offer 74% of the national total.

Degree and Certificate Programs

Cartography has been slow to achieve the kind of visibility that arises from degree and certificate programs which are specifically labeled cartographic. The recent establishment of both bachelor's and master's degrees in cartography at the University of Wisconsin--Madison was indeed a salutary sign (13). In Table 8 a tentative list of degree and certificate programs for U.S. schools is presented (14). The list identifies one master's program, three bachelor's level programs, six programs at the associate level, one certificate program and two undergraduate minors, a total of 13 programs.

Graduate Programs

Graduate degrees in geography with a cartographic specialization have been summarized for the 1950-1975 time frame in Table 9. Although these data are not necessarily complete, a general pattern emerges rather clearly. The pronounced concentration of these specialized cartographic training programs in a small number of schools evident in this data set is also apparent in Tables 5-7 and Fig. 2 describing the distribution of credit hours offered by school and by state. Three universities that emerge as unusually productive centers of both doctorate and masters degrees with cartographic specializations are the University of Wisconsin--Madison, the University of Washington, and the University of Kansas. Together they account for 56% of Ph.D. production and 27% of master's production during the 26 year time frame. 37 of the 39 Ph.D.'s granted were awarded by 12 schools with 22 being granted by the top 3. Production of M.A./M.S. degrees was less concentrated than the Ph.D. production as one would expect. Of the 142 master's degrees granted, 85 or 60% were granted by 16 schools. The 8 schools granting 5 or more master's degrees awarded 64 degrees representing 45% of the total.

The production of Ph.D. degrees with specializations in cartography is of special interest in a review of this type because of the key role these specialists play in future training programs. Table 10 summarizes the production of Ph.D.'s over a 31-year period by five-year intervals. The growth during the decade 1965-1974 is especially pronounced, representing 28 degrees or 72% of the 31-year total. In contrast, only 9 degrees or 23% were produced in the 20-year period 1945-1964.

Interpretation of the U.S. Cartographic Education System

The dominant affiliation of cartography with departments of geography clearly has shaped the nature of education in this field (15). The recognition of cartography as a tool or technique subject important in geographic training

TABLE 8

DEGREE AND CERTIFICATE PROGRAMS IN CARTOGRAPHIC FIELDS IN U.S. COLLEGES AND UNIVERSITIES 1976

M.A./M.S. Program in Cartography

University of Wisconsin--Madison

B.A./B.S. Programs in Cartography

Briarcliff College (Briarcliff Manor, N.Y.)
University of Wisconsin--Madison

B.S. Program in Geodetic and Cartographic Science

George Washington University (District of Columbia)

Associate Programs in Cartography

Briarcliff College
Lansing Community College (Michigan)

Associate Programs in Cartographic Technology

Jefferson Community College (Louisville, Kentucky)
Longview Community College (Lee's Summit, Missouri)
Penn Valley Community College (Kansas City, Missouri)

Associate Program in Cartography, Community Planning and Geography

Montgomery College--Rockville Campus (Maryland)

Certificate Program in Cartography

Lansing Community College (Michigan)

Undergraduate Minor Programs in Cartography

East Central Oklahoma State University (Ada)
University of Illinois at Chicago Circle

Sources: The College Blue Book, Vol. 3: Degrees Offered by College and Subject. 15th ed. NY: Macmillan Information, 1975; "New Degree Programs in Cartography at Wisconsin," Association of American Geographers Newsletter, Vol. 9, No. 8 (Oct. 1974), pp. 2, 4.

TABLE 9

GRADUATE DEGREES WITH CARTOGRAPHIC
SPECIALIZATION GRANTED BY U.S. INSTITUTIONS
1950-1975

Institution	Ph.D. Degrees		M.A./M.S. Degrees		Total Degrees		Cumulative Total Degrees	
	No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent
University of Wisconsin--Madison	9	23.1	16	11.3	25	13.8	25	13.8
University of Washington (Seattle)	8	20.5	14	9.9	22	12.2	47	26.0
University of Kansas (Lawrence)	5	12.8	8	5.6	13	7.2	60	33.2
Syracuse University	2	5.1	5	3.5	7	3.9	67	37.0
University of Michigan (Ann Arbor)	1	2.6	6	4.2	7	3.9	74	40.9
University of California, Los Angeles	2	5.1	5	3.5	7	3.9	81	44.8
Ohio State University (Columbus)	1	2.6	5	3.5	6	3.3	87	48.1
Clark University (Worcester)	2	5.1	4	2.8	6	3.3	93	51.4
Arizona State University	0	0	5	3.5	5	2.8	98	54.1
University of Chicago	1	2.6	3	2.1	4	2.2	102	56.4
University of Maryland (College Park)	0	0	4	2.8	4	2.2	106	58.6
University of Minnesota (Minneapolis)	3	7.7	1	0.7	4	2.2	110	60.8
Catholic University (Washington, D.C.)	0	0	3	2.1	3	1.7	113	62.4
Kent State University (Kent)	0	0	3	2.1	3	1.7	116	64.1
Southern Illinois University (Carbondale)	1	2.6	2	1.4	3	1.7	119	65.8
Pennsylvania State University (University Park)	2	5.1	1	0.7	3	1.7	122	67.4
Other Schools	2	5.1	57	40.1	59	32.6	181	100.0
TOTALS	39	100.0	142	99.8	181	100.3		

Sources: Data for 1950-1973 based upon John A. Wolter, "The Emerging Discipline of Cartography," unpublished Ph.D. dissertation, University of Minnesota, 1975, p. 279. Additional data for 1971-1975 from: Comprehensive Dissertation Index, 1973 Supplement, Comprehensive Dissertation Index, 1974 Supplement, Ann Arbor: Xerox Univ. Microfilms, 1974, 1975; "Recent Geography Dissertations and Theses Completed," The Professional Geographer, Vol. XXVII, No. 1 (Feb. 1975), pp. 79-110 and Vol. XXVIII, No. 1 (Feb. 1976), pp. 71-93.

TABLE 10

Ph.D. DEGREES WITH CARTOGRAPHIC SPECIALIZATIONS GRANTED BY U.S. INSTITUTIONS BY FIVE-YEAR PERIODS, 1945-1975

Five Year Periods	Ph.D. Degrees		Cumulative Totals	
	No.	Per Cent	No.	Per Cent
1945-1949	1	2.6	1	2.6
1950-1954	1	2.6	2	5.1
1955-1959	3	7.7	5	12.8
1960-1964	4	10.3	9	23.1
1965-1969	13	33.3	22	56.4
1970-1974	15	38.5	37	94.9
1975	2	5.1	39	100.0
TOTALS	39	100.1		

Sources: Comprehensive Dissertation Index 1861-1972, Vol. 16: Geography and Geology, Ann Arbor: Xerox University Microfilms, 1973; Comprehensive Dissertation Index, 1973 Supplement, 1974; Comprehensive Dissertation Index, 1974 Supplement, 1975; "Recent Geography Dissertation and Theses Completed," The Professional Geographer, Vol. XXVII, No. 1 (Feb. 1975), pp. 79-110 and Vol. XXVIII, No. 1 (Feb. 1976), pp. 71-93.

has resulted in a pattern of offerings in which many schools offer only one or two courses in cartography. Thus, the cartographic education pyramid has a broad base in the U.S.

Through their geographic training most students taking cartography courses have a fairly comprehensive knowledge of environment and landscapes. They are accustomed to working with an exceedingly broad and diverse range of variables. The resulting emphasis upon small-scale, special-purpose maps is entirely understandable.

The growing emphasis in geography upon modeling and prediction has similarly affected courses in cartography. Consequently, cartographic courses increasingly emphasize topics such as numerical mapping, taxonomic systems, class interval choices, spatial analysis, cognitive maps, computer graphics, and computer programming. The present social science emphasis of American geography is vividly reflected in a thematic cartography which has an economic and social bias.

A well recognized pattern on U.S. college and university campuses is that discipline-oriented departmental structures restrict interaction among disciplines. The marked concentration of cartography courses and programs in geography departments thus promotes cartography-geography ties and inhibits cartography-non-geography interactions. Students in engineering, forestry, and planning fields are unlikely to gain exposure to either the broad field of cartography or to small-scale, special-purpose mapping. Thus, the dichotomy, noted by Salishchev in his 1962 study of "Cartography in the Universities of the United States " (16), between a geographic cartography with little or no exposure to topographic mapping, surveying, or photogrammetry and an engineering cartography with little or no exposure to thematic mapping still holds true.

Although cartographic laboratories in the U.S. have blossomed as never before, they still do not provide students with sufficient access to production quality equipment. Very few data on laboratory facilities are available at this time. Yet feedback from students who have gone into the cartographic marketplace as well as from employers indicates clearly that students need fuller exposure to such standard production techniques as scribing, screening, and proofing. The equipment requirements arising from the advent of automation in cartography have placed great pressure on departmental resources and only a few geography departments have succeeded in acquiring the necessary equipment.

For many years the broad base for a pyramidal model of cartographic education has existed in the U.S. Yet, the vertical development of this model was slow in forming. Departments which were willing and able to hire two or more competent cartographers and to provide modern laboratory facilities achieved the combination necessary for successful vertical development. We are presently witnessing the development and flowering of specialized graduate training programs in cartography at a limited number of sites. Recent elaborations of programs and growth in graduate student numbers at the University of Wisconsin--Madison, the University of Washington, the University of Kansas, and at Ohio State Uni-

versity has been impressive and made more apparent than ever the importance of achieving a critical mass (17).

Conclusions

The conclusions given below derive partly from an analysis of the data gathered especially for this paper and partly from the author's experience.

1) The data base for studies of cartographic education in the U.S. is weak. More data are needed concerning curricula, enrollments, laboratory facilities, and faculty. Also, data on training in the commerical and governmental sectors are lacking as well as data describing "on-the-job" training.

2) Models for cartographic education are needed. Though some are in the process of development, the need is urgent. These models need to be tested and articulated so that feedback from all sectors of the cartographic community as well as from the using public can be obtained and incorporated into the models.

3) Once models of cartographic education have been developed, it will be possible to develop models of continuing education in cartography. The needs for continuing education in a technical field undergoing development as rapidly as cartography are both obvious and urgent. Yet, at the present-time, only piecemeal efforts to meet these needs are in evidence.

4) The education establishment has not really responded to the need to train cartographic technicians. The obvious place to provide this training is in the two-year colleges which numbered over 1200 in 1974 (total enrollments 3.5 million).

5) Interaction among several disciplines, and certainly between geography and engineering, should be encouraged to strengthen and balance existing cartography programs. Some encouraging signs are evident but much remains to be accomplished.

6) Within the higher educational system, cartographers must exercise vigorous leadership to shape the growth of computer-assisted cartography and to build strong cartographic foundations for the various information systems rapidly being created.

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