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Inter-Field Cooperation in GIS Education in the US

Mizuki Kawabata*, Rajesh Bahadur Thapa**, and Takashi Oguchi*

*Center for Spatial Information Science, The University of Tokyo, Japan

** Graduate School of Life and Environmental Sciences, University of Tsukuba, Japan

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Abstract

Cooperation among different fields of study is important in developing a systematic method of GIS education. We examined inter-field cooperation, particularly that between geography-related and computer/information-related fields for education programs at US colleges and universities that award GIS-related degrees or certificates. Academic fields were classified using ten major classes of the Dewey Decimal Classification system. In the 2007-08 academic year, about 40% of GIS education programs were based on cooperation between two or more different fields, and about 20% involved cooperation among more than three fields. Approximately 10% of GIS education programs were based on cooperation between geography-related and computer/information-related fields, most of which also involved some other fields in various disciplines. Inter-field cooperation in GIS education in the US is considerably more advanced than that in Japan.

Keywords: GIS education programs, inter-field cooperation, geography-related field, computer/information-related field, US colleges and universities

1. Introduction

Developing human resources for GIS has become increasingly important in recent years. For example, articles in *Nature* point out that the demand for GIS professionals is booming since geotechnology is an emerging and evolving field (Butler, 2006; Gewin, 2004). In Japan, the Basic Plan of Promoting Geospatial Information Use, which was approved by the Cabinet in 2008, advocates that human resources for GIS are essential for developing a "Geospatially Enabled Society" (Cabinet Secretariat, 2008).

Thus far, systematic GIS education has rarely been provided at universities in Japan. One reason for this is the barriers between traditional fields, which tend to impede inter-field cooperation. Since GIS is highly interdisciplinary, such cooperation is important for developing systematic GIS education (Murayama, 2008; Okabe, 2006). In particular, cooperation between geography-related and computer/information-related fields is essential although it is challenging (Okabe, 2006). Therefore, in the research area of GIS education, professionals from different fields and affiliations have been collaborating to establish systematic curricula and methods of GIS education in Japan. One example is the research project entitled "Development of Curricula for Geographic Information Science and a Sustainably Collaborative Web Library System for Serving the Materials of the Curricula", carried out for three consecutive fiscal years 2005-2008 (http://curricula.csis.u-tokyo.ac.jp/). In this project, each of the geography-related and information-related groups developed a GIS core curriculum (Arikawa *et al.*, 2008; Oguchi *et al.*, 2008), and the two curricula were integrated into a general curriculum (Okabe, 2008). Another example is the research project entitled "Establishment of Education Methods of Geographic Information Science: How to Teach GIS at Universities Effectively", which is currently in operation for four consecutive fiscal years 2005-2009 (http://gis.sk.tsukuba.ac.jp/). In this project, professionals from various fields have been developing effective methods of GIS education (Murayama, 2007). In the current GIS education provided at Japanese colleges and universities, however, successful cooperation among different fields is still limited.

In the case of the US, a large number of colleges and universities already offer academic programs that award GIS-related degrees and certificates (hereafter referred to as GIS education programs), which often involve cooperation among departments in different fields (Kawabata *et al.*, 2006; Wikle and Finchum, 2003). Understanding such advanced GIS education in the US will be valuable for developing GIS education programs in Japan and other countries. Therefore, in this paper, we examine GIS education programs at US colleges and universities, with attention to inter-field cooperation, particularly that between geography-related and computer/information-related fields.

2. Methods

This study deals with GIS education programs at US colleges and universities for the academic years 2006-07 and 2007-08. We first obtained the list of *Colleges and Universities with Existing GIS Certificate Programs* from the Urban and Regional Information System Association (URISA) web site (http://urisa.org/career/colleges). This list includes GIS education programs that award GIS-related degrees (degree programs) as well as certificates (certificate programs). From the list, we selected GIS education programs that were offered in the US and whose curriculum information was available online. As a result,

we chose 116 programs in 75 US colleges and universities for 2006-07 and 163 programs in 108 US colleges and universities for 2007-08.

Second, we invesitaged the curriculum, departments, and courses of each GIS education program and compiled them into a database. Next, we examined the following three aspects of the GIS education programs using this database: (1) the number of degree and certificate programs; (2) composition of academic fields and inter-field cooperation; and (3) cooperation between geography-related and computer/information-related fields. Data for both 2006-07 and 2007-08 were used in the first part of the examination, and data for 2007-08 were used in the second and third parts. In this paper, *inter-field cooperation* indicates that mutiple departments from different fields provide courses comprising a GIS education program; hence a program with inter-field cooperation includes multiple fields. Academic entities like departments, schools, and centers are all referred to as *departments*, and both Geographic Information System(s) and Geographic Information Science are referred to as *GIS*.

For the classfication of fields, we used the Dewey Decimal Classification (DDC) (OCLC, 2003). The DDC is the most widely used classification system in libraries all over the world, and its first summary contains the following ten main "classes":

- 000: Computer science, information & general works (CSIG)
- 100: Philosophy & psychology
- 200: Religion
- 300: Social sciences
- 400: Language
- 500: Science
- 600: Technology
- 700: Arts & recreation
- 800: Literature
- 900: History & geography

In the DDC system, each of these main classes is divided into ten "divisions", each of which is further divided into ten "sections". In this study, departments were classified into the ten major classes (fields) based on their names. When a department name indicates more than one field, the following criteria were applied. Departments whose names include "computer" or "information system(s)" are classified into the field of computer science, information & general works (CSIG); similarly, departments with names that include "technology" or "engineering" are classified into the technology field, those whose names include "geography" are classified into the history & geography field, and those whose names include "GIS" as well as departments whose names are difficult to be classified are classified into the category *others*. Each course in a GIS education program is classified into the field of the department that provides the course.

We also defined the geography-related and computer/information-related fields. The former is defined as the geography part of the history & geography field of the DDC. That is, when a department name includes "geography", the department and its courses are classified into the geography-related field. The latter—computer/information—field is equivalent to the CSIG field of the DDC.

3. Results

3.1 Number of degree and certificate programs

The number and proportion of GIS education programs offering degrees or certificates for the 2006-07 and 2007-08 academic years are shown in Figure 1. Of the 163 GIS education programs in the 2007-08 academic year, 45 (28%) are degree programs: 18 for graduate degrees, 11 for bachelor's degrees, and 16 for associate degrees. The remaining 118 programs (72%) are certificate programs, indicating that the majority of the GIS education programs are certificate programs.

In the academic year 2007-08, the number of GIS education programs increased dramatically over the previous academic year, from 116 to 163 (a 40% increase). The increase occurred in both degree and certificate programs, and the increase for degree programs was more distinct—their proportion to all programs increased from 22% to 28%.

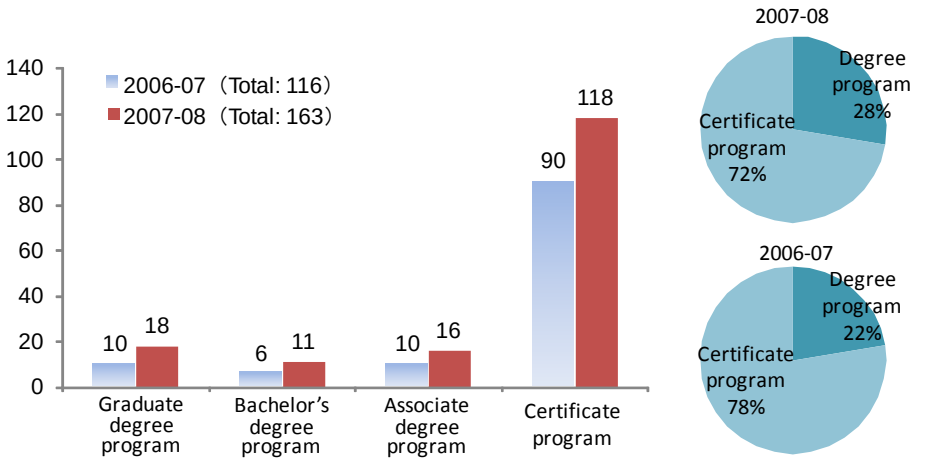
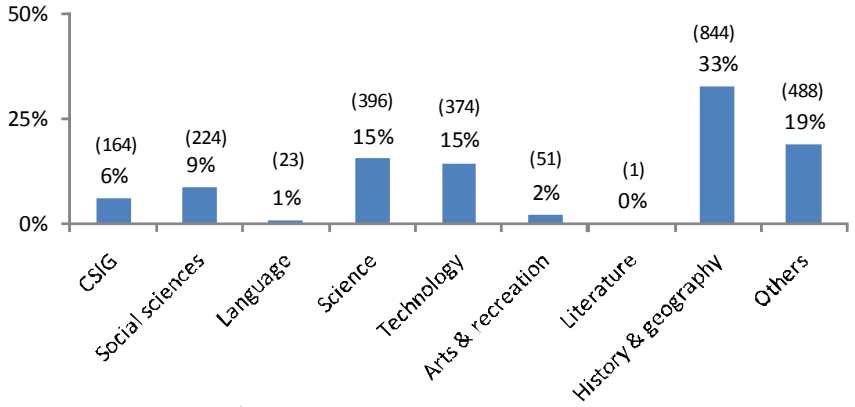


Figure 1. Number and proportion of GIS education programs offering degrees and certificates (2006-07 & 2007-08)

3.2 Composition of academic fields and inter-field cooperation

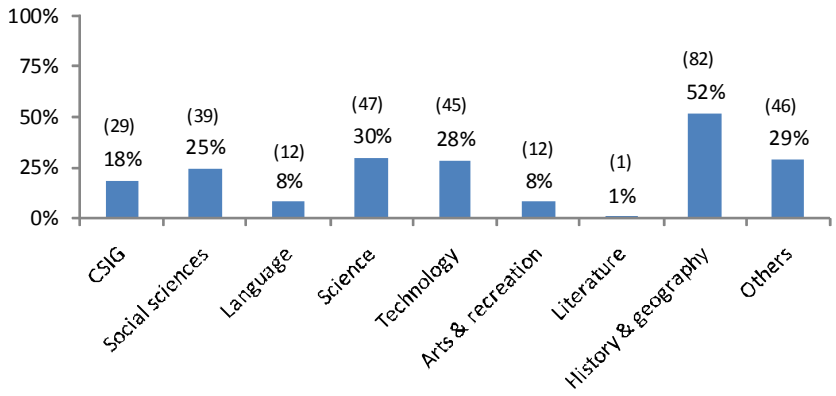
Among the 163 GIS education programs in the 2007-08 academic year, 159 have courses with field information, and the total number of the courses is 2,565. Figure 2 shows the proportion of each field in the 2,565 courses. The history & geography field accounts for the largest proportion (33%) of the total. The second largest proportion is that of the science and technology fields (15%). The social sciences and CSIG fields account for 9% and 6%, respectively, and the other three fields of arts & recreation, language, and literature account for small proportions (2% or less). Since no course belongs to philosophy & psychology and religion, these two fields do not appear in the present and subsequent results.



CSIG: Computer science, information & general works
Note: The numbers of courses are in parentheses.

Figure 2. Proportion of each field in all courses of GIS education programs (2007-08)

The proportion of each field included in the 159 GIS education programs is shown in Figure 3. Note that a GIS education program can have multiple fields, and therefore the total of the proportions exceeds 100%. More than half (52%) of the programs include the history & geography field. Further, approximately 30% include the science, social sciences, and technology fields, and about 20% include the CSIG field. Both the arts & recreation and language fields are included in approximately 10% of the GIS education programs. The literature field is included in only 1% of the programs.

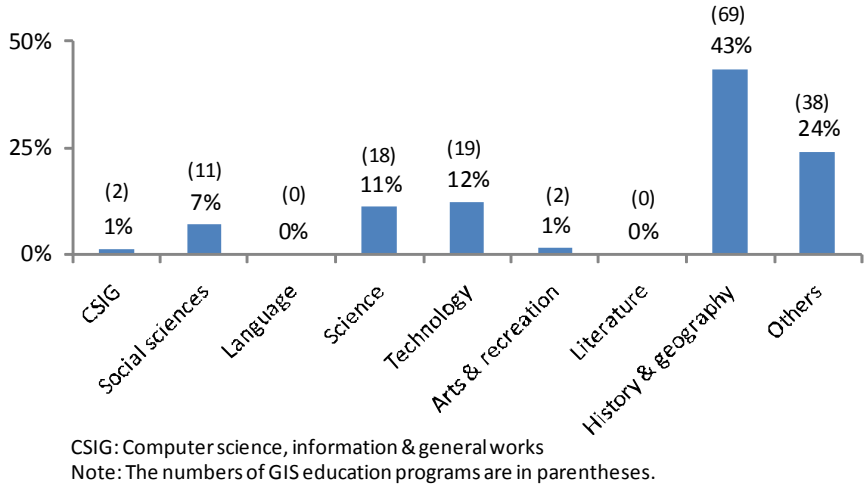


CSIG: Computer science, information & general works
Note: The numbers of GIS education programs are in parentheses. A GIS education program can include multiple fields.

Figure 3. Proportion of each field included in GIS education programs (2007-08)

Next, we examine the composition of a main field in the 159 GIS education programs (Figure 4). Here, a main field is defined as the field that provides the largest number of courses in each GIS education program. If multiple fields in a program provide the same largest number of courses, the value of one divided by the number of main fields was added to the composition of each main field; for instance, if a program has two main fields, 0.5 was added. The history & geography field is the most common main field (43%) of the

GIS education programs. This proportion is considerably higher than that for the other fields. The fields of science, social sciences, and technology account for about 10% each. The fields of arts & recreation, CSIG, and literature rarely are main fields.



CSIG: Computer science, information & general works
Note: The numbers of GIS education programs are in parentheses.

Figure 4. Proportion of each main field in GIS education programs (2007-08)

Figure 5 shows the number and proportion of the 159 GIS education programs by the number of fields comprising each program; the number of fields indicates the level of inter-field cooperation. The level varies widely, from no cooperation (i.e., single-field programs) to cooperation among eight fields. Although a majority of the GIS education programs are based on a single field, a noticeable proportion (38%) is offered with cooperation between multiple fields, and almost 20% of the GIS education programs are based on cooperation among four or more fields.

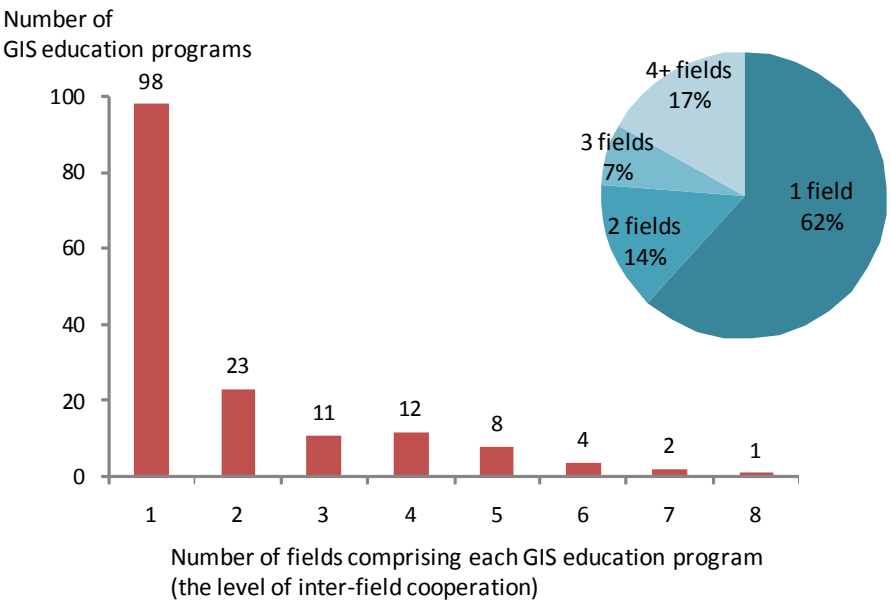


Figure 5. Number and proportion of GIS education programs by the level of inter-field cooperation (2007-08)

The proportion of the GIS education programs by the level of inter-field cooperation varies considerably depending on whether they award degrees and certificates (Figure 6). The proportion of programs involving cooperation between multiple fields is relatively small for the graduate degree and certificate programs (22% and 32%, respectively; note that the values of the proportions in Figure 6 have been rounded off), whereas it is relatively high for the bachelor's degree and associate degree programs (73% and 81%, respectively). This result suggests that inter-field cooperation is relatively inactive in the graduate degree and certificate programs as compared to the bachelor's degree and associate degree programs. In particular, the proportion of cooperation among four or more fields is markedly high (63%) in the associate degree programs, which may suggest that the need for inter-field cooperation is higher and more necessary for community colleges.

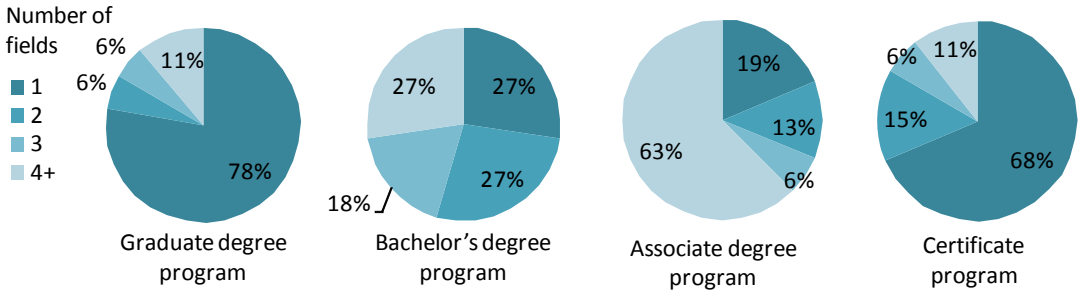
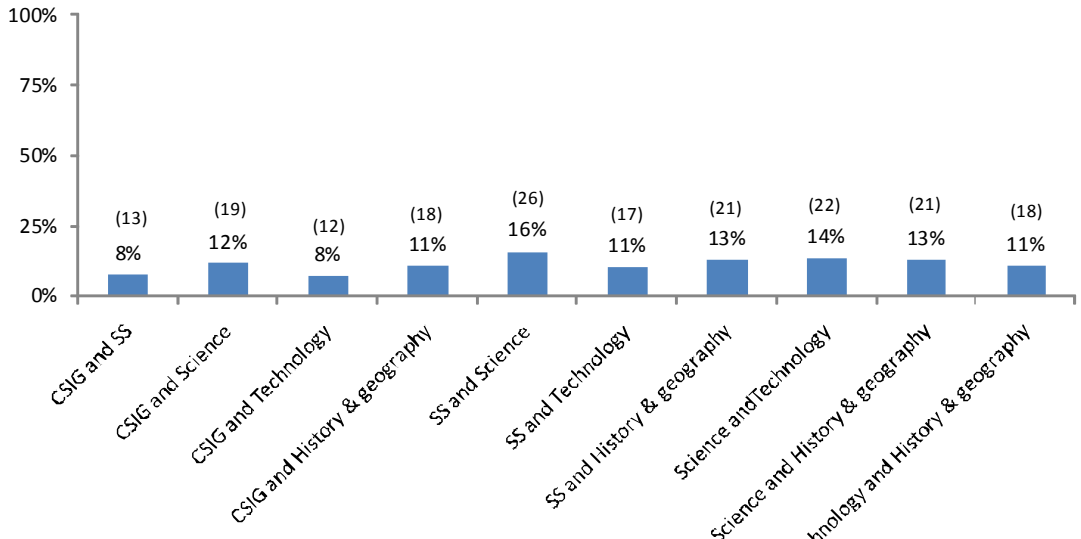


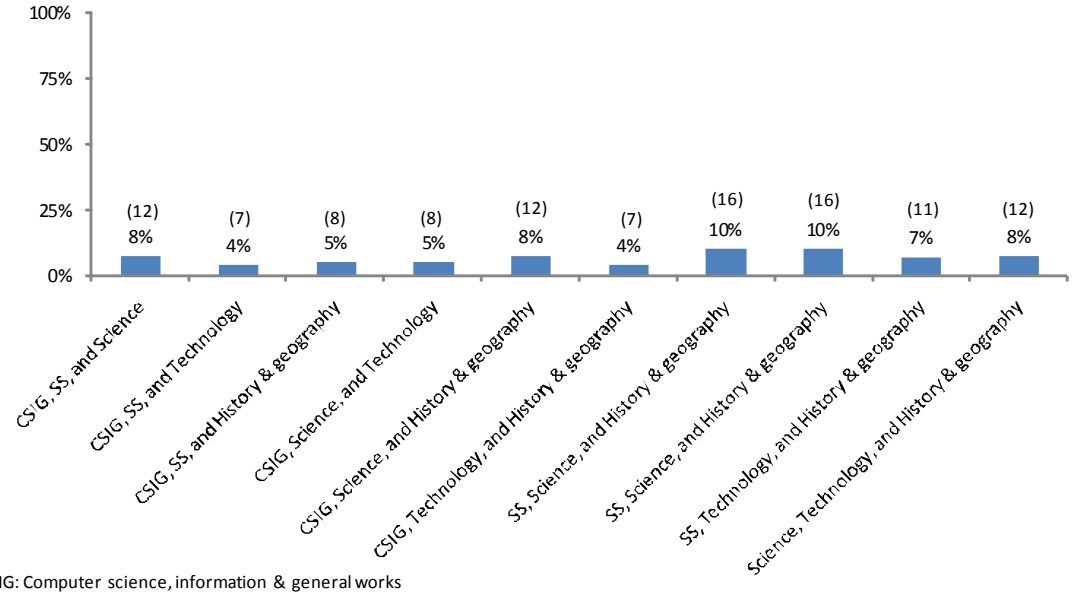
Figure 6. Proportions of GIS education programs by the level of inter-field cooperation depending on whether they are degree or certificate programs (2007-08)

As shown in Figure 3, CSIG, history & geography, science, social sciences, and technology were the five most dominant fields in the GIS education programs. We therefore examined inter-field cooperation among these fields for the 159 GIS education programs. Figure 7 shows the proportions of GIS education programs that involve cooperation between two of the five fields. Interestingly, all the proportions are around 10%, ranging from 8% to 16%. The highest proportion of 16% is for cooperation between science and social sciences. The lowest proportion of 8% is for cooperation between CSIG and social sciences and between CSIG and technology. Figure 8 further presents the proportions of GIS education programs that involve cooperation among three of the five fields. The proportions are around 8%, ranging from 4% to 10%. The highest proportion of 10% is for cooperation among science, social sciences, and technology and among science, social sciences, and history & geography. The lowest proportion of 4% is for cooperation among CSIG, social sciences, and technology and among CSIG, history & geography, and technology. Figures 7 and 8 suggest that there is no common pattern of inter-field cooperation in the GIS education programs and that various types of cooperation have been attempted.



CSIG: Computer science, information & general works
SS: Social sciences
Note: The numbers of GIS education programs are in parentheses.

Figure 7. Proportions of GIS education programs that involve cooperation between two of five fields of CSIG, history & geography, science, social sciences, and technology (2007-08)



CSIG: Computer science, information & general works
SS: Social sciences
Note: The numbers of GIS education programs are in parentheses.

Figure 8. Proportions of GIS education programs that involve cooperation among three of five fields of CSIG, history & geography, science, social sciences, and technology (2007-08)

3.3 Cooperation between geography-related and computer/information-related fields

Finally, we present results for cooperation between the geography-related and computer/information-related fields. Tables 1 and 2 show the departments and courses that belong to the two fields. Of the 2,565 courses, the geography-related and computer/information-related fields provide 841 and 163 courses, respectively. The number of courses for the geography-related field is considerably larger than that for the computer/information-related field; however, the computer/information-related field accounts for 6% of the total number of courses.

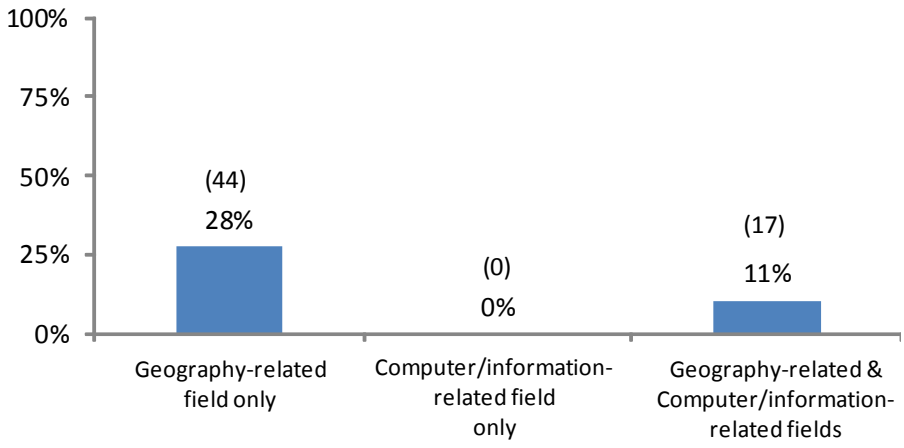
Table 1. Departments and courses of geography-related field (2007-08)

Department	Number of departments	Number of courses
Applied geography	1	7
Geography	58	550
Geography & anthropology	2	15
Geography & environmental studies	1	8
Geography & geology	4	35
Geography & geosciences	1	5
Geography & geospatial science	3	45
Geography & planning	8	113
Geography, planning & recreation	2	21
Geography & regional planning	3	42
Total	83	841

Table 2. Departments and courses of computer/information-related field (2007-08)

Department	Number of departments	Number of courses
Computer aided design	1	4
Communication, information & library studies	1	2
Computer information science	3	9
Computer Information system(s)	5	27
Computer information technology	2	5
Computer science	16	72
Computer science & engineering	1	7
Computer science & information systems	2	21
Computer science & mathematics	1	2
Management information Systems	1	2
Management science & information systems	2	5
Mathematics & computer science	1	4
Multimedia	1	3
Total	37	163

Figure 9 exhibits the proportions of the GIS education programs offered by only the geography-related field, only the computer/information-related field, and both fields. Of the 159 GIS education programs, 28% are based solely on the geography-related field, whereas no program is based solely on the computer/information-related field. GIS education programs that include both the geography-related and computer/information-related fields account for 11%. This result indicates that while the computer/information-related field hardly comprises GIS education programs as a single field, the field is more likely to cooperate with the geography-related field to comprise a GIS education program.



Note: The numbers of GIS education programs are in parentheses.

Figure 9. Proportion of GIS education programs offered only by the geography-related field, only by the computer/information-related field, and by both fields (2007-08)

Table 3 presents more detailed information about the 17 GIS education programs based on cooperation between the geography-related field and computer/information-related field. Only 4 (24%) of the 17 programs are based on cooperation only between the two fields, whereas the rest (76%) involves cooperation with some other fields in various subject disciplines, such as civil engineering, economics, and urban planning & policy development.

A good example of cooperation between the geography-related and computer/information-related fields is the GIS certificate program at San Diego State University (Table 4). This program is developed through joint efforts of the Department of Geography and the Department of Computer Science. The program awards GIS certificates for those who complete a total of 27 units with a grade point average of 2.5, including 12~15 units from the Department of Geography and 12~15 units from the Department of Computer Science.

Table 3. GIS education programs with cooperation between geography-related and computer/information-related fields (2007-08)

University/College	Degree/Certificate	Geography-related department	Computer/information-related department	The other-field departments
Bismarck State College	Associate	Geography	Computer information science Computer science	Economics English GIS Management Mathematics Political science
Clackamas Community College	Associate	Geography	Computer science	Drafting Math
Clackamas Community College	Certificate	Geography	Computer science	Drafting Math
Columbus State Community College	Associate	Geography	Computer information technology	Communication skill English Environmental technology GIS Landscape design/build Mathematics Social science Surveying
Community College of Philadelphia	Associate	Geography	Computer information system	Architecture design & construction English GIS Mathematics Social science
Cosumnes River College	Certificate	Geography	Computer science	Agriculture Anthropology Architecture Biological sciences Business Fire technology Geology Sociology
Bluegrass Community & Technical College	Certificate	Geography	Computer information technology	Architectural technology Civil engineering technology Environmental science technology
Mesa Community College	Certificate	Geography	Computer information system Mathematics & computer science	n/a
Oklahoma State University	Certificate	Geography	Computer science Management science & information systems	Biosystem engineering Civil & environmental engineering Plant & soil science Forestry General technology
Rowan University	Certificate	Geography & anthropology	Computer science Management & MIS	Mathematics
Rutgers University	Certificate	Geography	Computer science Management science & information systems Communication, information & library studies	Earth & environmental sciences Ecology Statistics Marine & coastal sciences Urban planning & policy development
San Diego State University	Certificate	Geography	Computer science	n/a
Temple College	Certificate	Geography	Computer aided design Computer information systems	n/a
Temple College	Associate	Geography	Computer aided design Computer information systems	English Environmental science Geology Sociology
University of Minnesota	Masters	Geography	Computer science & engineering	Forest resources
University of Texas at Dallas	PhD	Geography & geospatial science	Computer science	Electrical science Geoscience Economic, political & policy Management
University of Utah	Certificate	Geography	Computer science	n/a

Table 4. Courses in GIS certificate program at San Diego State University (2007-08)

Department of Geography	Department of Computer Science
Geographic information science and spatial reasoning Computerized map design Geographic information systems (required) Cartographic design Internet mapping and distributed GIServices Geographic information systems applications Quantitative methods in geographic research Remote sensing of the environment Intermediate remote sensing of the environment GIS-based decision support methods Advanced topics in GIScience	Visual basic programming Introduction to computer programming (required) Intermediate computer programming (required) Unix and the c programming language Data structures Programming languages Scientific database techniques Database theory and implementation Advanced programming languages Object-oriented programming and design Component GIS architecture User interface environments Super computing for the sciences Advanced topics in geocomputation Spatial databases

4. Conclusion

In the US, a large number of colleges and universities offer GIS education programs. Between the 2006-07 and 2007-08 academic years, the number of the GIS education programs notably increased, and the increase was greater for degree programs than certificate programs. These trends indicate a growing demand for academic programs that impart GIS skills and knowledge.

Using the first summary level of the DDC system, we have classified departments and courses into ten major fields and examined inter-field cooperation. In the 2007-08 academic year, approximately 40% of the GIS education programs were based on cooperation between two or more different fields, and about 20% involved cooperation among four or more different fields. Among the ten major fields, the history & geography field played the most important role, as it accounted for the largest proportion in the total number of courses and had the largest proportion as the main field in the GIS education programs. Among the other nine fields, the CSIG, science, social sciences, and technology fields played relatively significant roles, as they accounted for relatively high proportions in the total number of courses and were frequently included in the GIS education programs. Examining inter-field cooperation among the above five fields, we found that all possible combinations of two or three of the five fields occurred with similar frequencies, around 10% of the all programs.

Further, we have examined cooperation between the geography-related and computer/information-related fields and found that about 10% of the GIS education programs were based on cooperation between these two fields. Although no GIS education program was based solely on the computer/information-related field and the field was the main field of only 1% of the GIS education programs, the field was included in about 20% of the GIS education programs. These results suggest that the computer/information-related field is more likely to cooperate with other fields than to act solely in developing GIS education programs. In fact, we found that most of the GIS education programs with cooperation between the geography-related and computer/information-related fields involved additional

cooperation with some other fields in various disciplines.

Our study has confirmed that inter-field cooperation in GIS education is considerably more advanced in the US than in Japan. The promotion of inter-field cooperation should be a key factor for developing effective GIS education programs in Japan.

Acknowledgements

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