Transactions in GIS

Research Article

Transactions in GIS, 2013, ••(••): ••–••

GIS Course Planning: A Comparison of Syllabi at US College and Universities

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Abstract

Despite the enormous growth of college courses dealing with spatial information, curriculum planning involving geographic information science (GIS) courses and programs has received little attention within the GIS literature. As the number and variety of GIS courses expands, so too does the importance of both systematic and inclusive planning and campus-wide coordination. In this article we explore course planning through an exploration of 312 GIS course syllabi used at US colleges and universities with the goal of characterizing the degree to which learning resources, student evaluation methods, and course topics have become standardized across institution types, academic levels, and disciplines. Our findings reveal a consensus in the use of GIS software across courses but no similar agreement in the use of textbooks. Hands-on activities were used as evaluation methods in nearly every course in the sample regardless of institution type or academic level. However, quizzes, tests and final exams were used more often in community colleges while papers and projects were used more frequently in four-year and comprehensive research universities. The frequency of topic categories listed on syllabi was relatively consistent across institutions, academic levels and disciplines with a few topics such as vector analytic operations, data models, and data creation/acquisition/editing included on more than 50% of syllabi.

1 Introduction

College and university courses involving the analysis of spatial information continue to grow in number and diversity. In addition to greater topical breadth, geographic information systems (GIS) coursework is increasingly available at multiple levels, ranging from freshman courses to advanced graduate seminars and at an expanding range of institution types from research universities to community colleges. As the number of courses expands, so too does the need for systematic course planning that involves cooperation and coordination among instructors. The absence of planning and collaboration may contribute to inefficiencies such as nearly identical material being taught in two or more courses, gaps in critical subject matter needed to prepare students for more advanced coursework, and ineffective mechanisms for assessing what students understand or are capable of achieving. Coordination can be especially difficult at large universities where GIS courses are taught within more than one college or department. As larger numbers of students transfer GIS credit earned at community colleges to four-year institutions or comprehensive universities, the importance of collaboration involving curriculum planning and design becomes even greater.

The term "course planning" is often used to describe the design of course curricula falling within the larger programmatic process of academic planning. In a general sense, course planning can be defined as a set of systematic decisions made by course instructors with the goal of

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 doi: 10.1111/tgis.12048

achieving desired learning outcomes. Basic elements of course planning include the selection of content, sequencing of topics, choice of pedagogy used to connect students with course material, and identification of methods for evaluating student performance. At a more detailed level, GIS course planning must consider the design of laboratory exercises; the choice of resources used by students, especially the GIS software package; and the selection and weight assigned to evaluation methods ranging from exams to exercises, projects, and papers. In addition, course planning involves pedagogical choices such as balancing lecture material with class discussion or individual versus collaborative work. At the individual course level, course planning defines the environment where learning will take place by articulating expectations and establishing a positive atmosphere for instructor and student interaction. Most important, course planning involves the selection of subject matter and activities most important for achieving learning outcomes. Transparent and thoughtful course planning can limit redundancy and strengthen pathways for students as they progress to more advanced coursework or transition to full-time employment.

While effective course planning is a systematic process, it operates in different modes across courses with diverse goals, pedagogical styles and instructional formats. For example, while freshman courses and graduate seminars each have specific learning outcomes, introductory courses are often highly structured compared with graduate seminars where students themselves participate in defining course subject matter. Likewise, the process of course planning will vary depending on an instructor's background and experience and the discipline through which the course is taught. Along with defining learning outcomes for students, course planning has campus-wide implications since individual courses serve as gateways to more advanced coursework and as building blocks for larger academic programs.

Although course planning and design are important factors in the success of academic programs, most college and university GIS instructors have few opportunities to see how the courses they offer compare with those taught by counterparts at other institutions. We may wonder if courses sharing titles such as "Introduction to GIS" are similar across institutions in terms of content and organization and if the subject matter we see as appropriate for an introductory course is viewed in the same way in other disciplines and by our colleagues at other institutions.

2 The Syllabus as Planning Tool

Within most college or university courses the syllabus serves as the principal tool for course planning. Stark (2000, p. 413) defines the course syllabus as an academic plan ". . . purposefully constructed to facilitate student learning". According to Parkes and Harris (2012), the course syllabus has three major purposes: (1) as a contract between instructor and student; (2) as a permanent record of what took place in a classroom; and (3) as a learning tool. Syllabi can be highly diverse in terms of content, organization and length. As unique documents, they reflect an instructor's attitudes, beliefs and feelings about teaching, course subject matter, appropriate methods of student evaluation, and other instructional elements. At a minimum, syllabi offer contact information, a description of course objectives, and an overview of grading standards. In addition, most identify required reading materials and include a basic term schedule or calendar. As suggested by Slattery and Carlson (2005), a well-constructed syllabus enables students to see how individual course elements fit within the overall pattern of a course and its objectives.

In additional to their use by students and instructors, syllabi have value outside the classroom. For example, they may be used by faculty involved in the planning and revision of other academic programs and by individuals external to an institution responsible for program review or accreditation. Syllabi may also be used by academic advisors assisting students in the selection of courses (Pastorino 1999) or by university officials in decisions concerning the transfer of academic credit among institutions.

3 Design Considerations for GIS Courses

In part because of its "hands-on" nature, the design and planning of GIS courses is nearly always a challenge. Along with teaching, instructors may be responsible for maintaining and troubleshooting GIS hardware and software and in some institutions, the training and supervision of teaching assistants. Additional challenges can be introduced by periodic changes in software functionality that require revision to exercises or other teaching materials and by unknown factors such as equipment failures, software glitches and network problems. As suggested by Foote (2012), GIS instructors must also deal with the sequencing of course topics since more advanced content builds on successful mastery of basic concepts.

A longstanding issue in GIS curriculum design is balancing theoretical elements of GIS with operational skills (Montagu 2001). This distinction has been represented as a continuum with education (conceptual or theoretical knowledge and problem solving skills) at one extreme and training (skills necessary to complete specific tasks) on the other. Courses that ignore conceptual dimensions of GIS may offer insufficient breadth to adequately prepare students for real-world problem solving while those with a minimal practical component leave students with few skills and little practical experience using GIS. Unfortunately, the emphasis placed on training in some courses can be reinforced by the way entry-level GIS positions are advertised in government and industry. While employers say they want well-rounded graduates, their job announcements frequently emphasize skills utilizing specific GIS software (Wikle 2010).

4 Exploring GIS Course Syllabi

As noted by Fagin and Wikle (2010), college and university GIS instruction has experienced dramatic change over the last 30 years. Emerging from an interdisciplinary niche at a few research universities, GIS is taught at hundreds of four-year and comprehensive universities and a rapidly expanding number of community colleges and K-12 schools. The breadth of academic disciplines that participate in GIS instruction has also become more diverse through specialized courses such as "GIS in Emergency Management" and "GIS Applications in Real Estate." Whereas instructional resources were once extremely limited, GIS instructors can choose from an increasing range of textbooks and other teaching materials including tutorials that offer scenario-based exercises with sample datasets. Academic programs in GIS that utilize individual courses have also become more diverse with the growing number of standalone minors, certificates, and degrees (Wikle and Finchum 2003). The proliferation of both courses and programs has been a factor in efforts to identify specific knowledge, skills and competencies important to GIS practitioners that began with the NCGIA's Core Curriculum in GIS in the late 1980s.[1] More recently the *Geographic Information Science Body of Knowledge* (BoK) offers a well-documented and detailed outline of GIS subjects and topics useful for measuring student outcomes against explicit benchmarks (DiBiase et al. 2006).[2]

Despite the availability of new teaching materials and curriculum guides such as the BoK, GIS course planning often remains *ad hoc* and driven by individual instructors' learning objectives rather than standardized approaches adopted across disciplines, institutional types, and course levels. To investigate further, we explore GIS course planning and content through a comparison of syllabi used in teaching GIS at US colleges and universities. Our principal research objective is to evaluate the extent to which courses exhibit standardization or independence in structure and content. Beyond a look at GIS topics, an exploration of course syllabi provides an opportunity to evaluate course planning issues such as student evaluation methods, course resources, and the extent to which course topics vary by institution type, academic level, and discipline.

5 Methods

Our investigation was initiated using an Internet-based keyword search to identify GIS educators at community colleges, four-year colleges and universities, and comprehensive/research universities within the US. An e-mail was subsequently sent to 600 instructors requesting a copy of syllabi they use for teaching college or university GIS courses. A total of 320 syllabi were received. Although the majority of respondents sent a single syllabus, a few respondents shared information for more than one course or for the same course offered in a different academic term. After eliminating duplicates and courses not focused explicitly on GIS (e.g. courses using GIS software but emphasizing cartographic design), a final sample was developed that contained 312 syllabi.

Our sample facilitated the creation of a database for coding syllabi by institution type (community college, four-year, comprehensive/research), academic level (undergraduate, graduate, or combined undergraduate/graduate), and the academic unit or discipline through which the course was offered. Six disciplinary categories were used for grouping syllabi: geography (GEOG), geology/earth sciences (GEOL), agriculture/forestry (AGFOR), planning (PLAN), engineering (ENG), and computer science (CS). For each syllabus, we also recorded if a prerequisite was required, the type and weight assigned to methods for evaluating student performance such as exams, exercises, papers, projects and class participation/attendance, and learning resources listed such as textbooks and software packages.

Since course instructors use many different terms to describe similar content, it was necessary to condense subject matter and topics found on syllabi into a manageable list for analysis and comparison. A master inventory of subject matter compiled from all syllabi was consolidated into 17 thematic categories (Table 1) loosely based on major topics outlined in the *GIS&T Body of Knowledge* (BoK) (DiBiase et al. 2006). For example, terms such as "spatial data representation" and "spatial data structures" were assigned to a rubric called "data models." Once all topical content was cross-walked to one of the 17 categories we cross-tabulated major subject matter areas by institution type, course level and academic discipline to facilitate comparisons.

6 Findings

Descriptive statistics provide a starting point for evaluating GIS course planning using the syllabi database. Almost two-thirds (62%) of syllabi in the sample represent courses offered under a geography prefix. The next largest group included courses under agriculture or for-

Table 1 Subject areas used in the analysis

Course Topic	Course Topic
Basic Analytic Operations (Vector)	Scripting/Model Builder
Data Models	Geostatistics
Data Creation/Acquisition/Editing	Network Analysis
Georeferncing Systems	Query Operations and Query Language
Cartography/Graphic Representation Techniques	Special Topics
Basic Analytic Operations (Raster)	Metadata, Standards, and Infrastructure
Database Management Systems	Spatial Statistics
Properties (Attributes)	Topology
Remote Sensing/Image Processing	

estry prefixes (10%) followed by planning (8%), geology/earth science (6%) and computer science (3%). Just over three-quarters (76%) of syllabi represent courses offered at comprehensive or research universities compared to 16% at four-year colleges and universities and 8% at community colleges. In terms of academic level, 61% were undergraduate courses, 15% were graduate courses and 23% combined undergraduate and graduate courses. The academic level for approximately 1% of syllabi could not be determined. Just over a one-third (38%) of the courses listed a course prerequisite.

A comparison of course titles revealed a relatively high level of consistency in wording used to represent courses. The most common course name was "Introduction to Geographic Information Systems" (16%), including variants (e.g. Introduction to GIS, Introduction to Geographical Information Systems), followed by "Geographic Information Systems" or variants thereof (10%) and "Advanced Geographic Information Systems" (6%). In comparing wording used in titles, 42% contained the words "Geographic Information Systems" while just 9% used "Geographic Information Science" and 2% "Geospatial."

A total of 94 different textbooks and workbooks were listed on syllabi with 239 of the 312 syllabi (76%) identifying at least one required textbook. An additional 75 courses listed at least two books and 15 courses listed three or more required textbooks. Bolstad's *GIS Fundamentals* was the most commonly used textbook, with 41 syllabi (13%) listing it as a required course text. Other commonly used textbooks include Price's *Mastering ArcGIS* (9%), Chang's *Introduction to Geographic Information Systems* (8%), Lo and Yeung's *Concepts and Techniques in Geographic Information Systems* (8%), Ormsby et al.'s *Getting to Know ArcGIS Desktop* (7%), and Gorr and Kurland's *GIS Tutorial 1: Basic Workbook* (5%) (Table 2). Diversity in the number of textbooks ranged from 15 in community colleges to 32 in four-year institutions and 74 in comprehensive universities.

A total of 10 different software packages were listed with 230 syllabi either explicitly listing a package or implicitly suggesting which software was used (e.g. through use of software specific textbooks or exercises). Nine courses listed at least two software packages, three listed three different software packages, and one indicated the use of four different software packages. Esri's ArcGIS, listed on 222 (71%) of course syllabi, was by far the most commonly used software. The second most popular package was Clark Labs' IDRISI listed on seven syllabi followed by Intergraph's ERDAS Imagine (four syllabi), and Intergraph's GeoMedia (two syllabi). A few other software packages were each included on just one syllabus.

Table 2 The top 10 GIS textbooks

Textbook	Number	Percent Using
Bolstad: *GIS Fundamentals*	41	13
Price: *Mastering ArcGIS*	28	9
Chang: *Introduction to Geographic Information Systems*	25	8
Lo/Yeung: *Concepts and Techniques of Geographic Information Systems*	24	8
Ormsby et al: *Getting to Know ArcGIS Desktop*	23	7
Gorr and Kurland: *GIS Tutorial 1*	17	5
Allen: *Getting to Know ArcGIS*	12	4
Mitchell: *The ESRI Guide to GIS Analysis*	12	4
DeMers: *Fundamentals of Geographic Information Systems*	12	4
Longley et al: *Geographic Information Systems and Science*	9	3
Others	128	41

6.1 Evaluation Methods Used on Syllabi

An important objective in exploring syllabi was comparing methods used in evaluating student performance. The analysis revealed a high dependence on hands-on exercises and other practical activities that expose students to GIS functions and problem solving. A total of 302 syllabi (98%) utilize hands-on GIS exercises as an evaluation method. The second most commonly used evaluation method was tests/quizzes, used on more than three quarters of courses. Final exams were listed on less than half (42%) of courses in the sample. Two-thirds (66%) of courses required students to demonstrate proficiency by completing a term project. Although accounting for a small percentage of a student's grade, many courses included credit for class participation or attendance (40% of courses). Writing assignments, such as term papers, were among the least common method for evaluating student performance, used in just 15% of the evaluated courses.

A comparison of syllabi across institution type, course level and discipline revealed some noteworthy differences. For example, tests and quizzes are used more often in community colleges compared to either four-year institutions or comprehensive universities. Likewise, tests and quizzes were favored in undergraduate compared to graduate programs (Table 3). Chi-square analysis showed significant differences among institution type ($p = 0.03$) and course level ($p < 0.00$) in the use of quizzes and exams as an evaluation method. Similar results were uncovered for the more frequent use of a final exam as an evaluation method in community colleges ($p = 0.08$) and undergraduate courses in general ($p = 0.0007$). The pattern for final projects and papers was very different. Assignments involving papers and projects were more common at four-year and comprehensive universities and more likely to be assigned in graduate as opposed to undergraduate courses. Comparing evaluation methods across disciplines was somewhat difficult, though, given the small number of syllabi in some disciplinary categories. Nonetheless, we found that final projects were used in about two-thirds of courses across the six disciplinary categories, while writing assignments were relatively uncommon (Table 4).

Another goal was to identify the relative weight of student evaluation methods in determining the final grade assigned. In comparing relative weights assigned to evaluation criteria

Table 3 Percent of syllabi using student evaluation method by institution type and level

Evaluation Method	CC	4Y	COMP	Undergrad	Graduate	Combined
Exercises	100	100	95.78	97.38	93.48	97.22
Tests/Quizzes	95.83	82.35	73.84	82.20	52.17	79.17
Paper	4.17	21.57	14.77	13.61	23.91	13.89
Class Participation	29.17	39.22	41.77	38.74	45.65	38.89
Final Exam	66.67	50.98	37.55	48.17	17.39	41.67
Final Project	50	68.63	67.51	62.30	73.91	70.83

Table 4 Percent of syllabi utilizing student evaluation method by discipline

Evaluation Method	GEOG	GEOL	AGFOR	PLAN	ENG	CS
Exercises	96.91	100	96.77	96	83.33	100
Tests/Quizzes	80.41	94.44	83.87	60	50	88.89
Paper	12.89	0	6.45	28	0	0
Class Participation	32.47	61.11	51.61	56	66.67	22.22
Final Exam	46.39	44.44	41.94	28	0	66.67
Final Project	68.04	66.67	58.06	60	66.67	66.67

Table 5 Grading weight assigned to evaluation methods by institution type and level

Evaluation Method	CC	4Y	COMP	Undergrad	Graduate	Combined
Exercises	45.25	37.03	38.91	38.10	41.67	40.18
Tests/Quizzes	36.79	32.76	28.97	32.96	18.24	30.63
Final Project	7.41	17.25	19.36	16.68	24.17	17.97

across institution type we only found a significant different ($p = 0.0067$) for the weight of final projects in determining course grades with four-year and comprehensive universities placing a greater emphasis on this evaluation method (on average 17% and 19% of final grades, respectively) (Table 5). In comparison, community colleges tended to place less emphasis on this evaluation criterion (on average, 7% of the final grade). When comparing relative weights assigned to evaluation criteria across course level, though, we found significant differences in weights assigned to both tests ($p = 0.0002$) and final projects ($p = 0.037$). On average, graduate classes placed less weight on tests than undergraduate and combined courses (18% of final grades, compared to 33% for undergraduate courses and 31% for combined courses) and more weight on final projects (24% of the final grade compared to 17% for undergraduate courses and 18% for combined courses). Due to the relatively small number of syllabi in some disciplines comparatively speaking, we opted to exclude discipline as a factor in comparing weight assigned to evaluation methods.

Table 6 Chi-square comparison of course topics by academic level

Course Topic	p-value
Basic Analytic Operations (Raster)	0.7877
Basic Analytic Operations (Vector)	0.0038**
Cartography/Graphic Representation Techniques	0.0000**
Data Creation/Acquisition/Editing	0.0000**
Data Models	0.0000**
Database Management Systems	0.2975
Georeferncing Systems	0.0000**
Geostatistics	0.0177*
Metadata, standards, and infrastructure	0.3617
Network Analysis	0.0481*
Properties (Attributes)	0.0001**
Query Operations and Query Language	0.0039**
Remote Sensing/Image Processing	0.1774
Scripting/Model Builder	0.3204
Spatial Statistics	0.0854
Topology	0.2744

*significant at the 0.05 level
**significant at the 0.01 level

6.2 Analysis of Course Content

The final component of our evaluation was an exploration and comparison of course topics. Content analysis of syllabi helped uncover the frequency at which 17 topic categories appeared in courses by institutional type, course level, and discipline. Of the 312 syllabi reviewed 50 (16%) provided no explicit list of topics covered over an academic term. Of the remaining 262 syllabi, courses covered an average of six of the 17 topical categories, with 27 syllabi (10% of the sample) listing 10 or more topics and eight syllabi (3% of the sample) listing just one topic. Topics included on at least 50% of syllabi were vector analytic operations (63%), data models (61%), data creation/acquisition/editing (59%), georeferencing systems (56%), cartography/graphic representation techniques (52%), and raster analytic operations (51%). Chi square analysis was also useful for showing differences when we compared courses by academic level. Syllabi were divided into categories corresponding to undergraduate introductory courses, more advanced (non-introductory) courses, and graduate courses (Table 6). When compared across levels, significant differences were found in topic coverage for basic analytic operations (vector) ($p = 0.003$), cartography/graphic representation techniques (($p = 0.000$), data creation/acquisition/editing ($p = 0.000$), data models ($p = 0.000$), georeferencing systems ($p = 0.000$), geostatistics ($p = 0.017$), network analysis ($p = 0.481$), properties ($p = 0.000$) and query operations ($p = 0.003$).

Across institution types the only significant difference in content corresponded to metadata/standards/infrastructure ($p = 0.001$), where it was included more frequently on community college syllabi compared with syllabi corresponding to four-year or comprehensive universities. Finally, topics varied little across discipline with the exception of raster operations ($p = 0.009$), network analysis ($p = 0.019$) and remote sensing/image processing ($p = 0.015$)

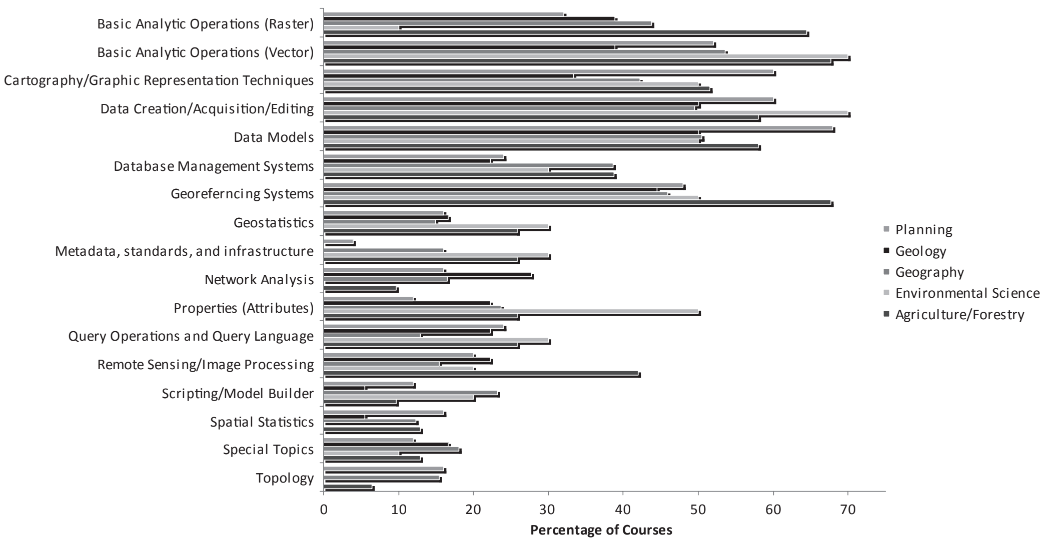

Figure 1 Course topics by discipline

(Figure 1). Engineering and agriculture/forestry courses were more likely to cover raster operations than other disciplines (83% and 65% of engineering and agricultural courses, respectively), while engineering courses (67% of engineering courses) were more likely to cover data acquisition, and agricultural/forestry courses (42% thereof) were more likely to cover remote sensing.

7 Discussion

Our analysis of the GIS course syllabi demonstrated the breadth of GIS course offerings at various institutions, within different academic departments, and across academic levels. While we discovered some commonalities between the content of courses across institutional types, disciplines, and academic levels, we also uncovered disparities. We attribute the latter to specialization in both department specific and upper-level courses. Among findings that accentuate the similarities in courses are the high percentage of courses with practical, hands-on components and topical focuses on key theoretical elements. Conversely, the sheer number of textbooks used by the various courses (over 90, including a number of software specific workbooks, with no textbook being used more by 13% of the evaluated courses) and differences in evaluation criteria (with the exception of the near universal importance placed on hands-on activities) demonstrate the challenges in uniformity among the evaluated GIS courses.

Another finding was that two-thirds of four-year institutions and comprehensive universities assign projects compared to just half of community colleges. It is noteworthy that while GIS instruction is often focused on conceptual foundations and problem solving skills using GIS software, research has demonstrated the importance of general workplace skills in defining an employee's value within a professional setting (Noll and Wilkins 2002; Thomas 2008). GIS courses and programs that emphasize realistic projects may help students strengthen these "soft skills" that include teamwork, creativity, communication (oral and written), and time management. In addition, hands-on exercises and projects give students opportunities to experience uncertainty associated with "real world" scenarios. Along with conceptual and practical skills, projects introduce students to legal, social, ethical, and managerial issues encountered in the workplace (Crampton 1995; Unwin 1997).

The comparison of topics listed on syllabi also revealed some noteworthy findings, most notably differences in foci on basic GIS skills vs. analytical functions. These differences were mostly accentuated between course levels, but also across academic disciplines and institution types. For example, undergraduate courses are more likely to list basic GIS topics and skills such as cartography/graphic representation techniques, data creation/acquisition/editing, and referencing systems compared with graduate level courses that were more likely to include topics such as geostatistics, scripting/model builder and spatial statistics. Similarly, certain disciplines, such as agriculture/forestry and engineering, focused to a greater extent on raster-based GIS operations than other disciplines. These disparities are understandable given the overall objectives of courses at different institutions or academic levels and across disciplines. Nonetheless, they present challenges for the development of a cohesive, transferable GIS curriculum that satisfies students' needs, individual instructors' learning objectives, and potential employers' skillset and knowledge requirements.

It should be noted that inclusion or exclusion of a topic may not imply that a topic was covered. For instance, while one instructor may expressly note that s/he covers metadata or other standards, another may present the topic within class discussion focused on data creation and acquisition without expressly mentioning it on the syllabus. Similarly, time constraints or other issues may lead an instructor to modify topics covered during the course of a semester. Moreover, in our attempt to crosswalk topical content to our standardized list, the meaning of syllabi terms may have been misunderstood or misinterpreted in a few cases. Such limitations must be recognized in using syllabi as tools for evaluating course content.

Although useful for identifying patterns in course design and content, our analysis falls short in one important way. While it may be possible to observe overall trends, our findings cannot begin to address the complexity underlying the design and implementation of a multi-course, multi-instructor GIS curriculum. Indeed, the process of defining specific learning outcomes and selecting course content and activities is influenced by a diverse set of institution-specific factors ranging from faculty expertise to program objectives, infrastructure, and student capabilities. Rather than suggesting a one-size-fits-all curriculum, we believe that GIS planning should begin with an inclusive process for defining learning outcomes across all courses within an institution. The GIS&T BoK provides a common reference useful to faculty committees for identifying topics and activities that enable introductory courses to provide a foundation for more advanced coursework.

7.1 Outcomes Assessment and Course Planning

Prager (2012) argues in favor of designing GIS&T curricula to achieve a desired set of learning outcomes. Although our analysis focused on the syllabus as a tool for course planning, course and program design and revision must also be informed through systematic feedback. Along with identifying gaps or deficiencies that serve as barriers to achieving explicit standards, outcomes assessment has become an important method for documenting value added by programs during a time period when higher education has experienced pressure to be more efficient and accountable. At the course level outcomes assessment involves defining markers for the mastery of predefined knowledge, skills or competencies. Assessment data is then used within the course planning process for addressing gaps between stated learning outcomes and measured student achievement. Learning outcomes within GIS courses can be measured in several ways. For example, conceptual information and critical thinking can be evaluated by inspecting written answers to test questions across all students within a course (Carr 2011). Higher level problem solving can be evaluated through an examination of specific tasks on exercises using rubrics that define student mastery of skills on individual or group assignments. Under most circumstances student names are removed from exams, papers, projects and other materials before each "artifact" (i.e. a written response to a test question) is evaluated independently by two or three faculty members.

8 Conclusions

The expansion of GIS within higher education has created opportunities and benefits within a growing number of academic disciplines and application areas. New courses address increasingly specialized student interests while also strengthening professional course tracks that serve as cumulative and integrative components of larger academic programs. However, while society benefits from new GIS application areas, unbridled course proliferation creates challenges. If not coordinated across campuses, specialized and discipline-specific GIS courses can result in subject matter duplication and confusion about prerequisites, course sequencing and other issues. A challenge for GIS instructors will be to look beyond the courses they teach. By identifying gaps and reducing duplication, planning and coordination offers possibilities for improving instruction and strengthening the preparation of GIS professionals.

Notes

1 As noted by Kemp (1995) the Royal Institute of Chartered Surveyors developed a sample syllabus at about the same time as the NCGIA.
2 The BoK was developed through the University Consortium for Geographic Information Science and published in collaboration with the Association of American Geographers.

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