Some Observations Regarding Geocomputational Teaching through Interdisciplinary Teams

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ABSTRACT

Geocomputation is an inherently interdisciplinary topic, combining both geospatial information science (GISc) and computer science (CS). It could be taught by individuals with strong backgrounds in both areas, but it is argued that such individuals are rare and academia is poorly positioned to produce a future generation of such dual-skilled individuals. Interdisciplinary team teaching is presented as an alternative. Hurdles to developing such team-taught classes are identified, and possible ways to overcome them are presented. Finally, a way of restructuring academia to be more supportive of such interdisciplinary team projects is presented.

CCS CONCEPTS

• Social and professional topics • Professional topics • Computing education • Computing and education programs • Information science education

KEYWORDS

Education, Interdisciplinarity, Geospatial information science (GISc)

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1 Introduction

At U.S. universities, geocomputational teaching is most commonly performed by practitioners of Geospatial Information Science (GISc) who have become well versed in the practices (and hopefully the concepts) of Computer Science (CS). The success of this approach is dependent upon the CS skills of the instructor – whose training in this area is very likely to be significantly less rigorous that that of a true computer scientist. While some instructors have overcome this handicap and have become excellent geocomputational teachers, many more struggle with CS foundational ideas. The result is their teaching often focuses on the nuances of a particular programming environment – e.g., how to get ArcPy and Python to accomplish a particular task – rather than foundational CS concepts like data models and algorithm development and evaluation. This is problematic; programming environments change constantly, and students instructed in only the ins-and-outs of a particular programming environment may soon find their skills outdated. On the other hand, students instructed in underlying concepts and ideas can apply these ideas to any environment that they may encounter.

One obvious way to address this problem is to find instructors equally well qualified in both GISc and CS. Unfortunately, it is equally obvious that there are not enough of these dual-skill instructors to go around. Furthermore, it seems unlikely that U.S. universities will be able to produce a new generation of dual-skilled instructors anytime soon. At present, acquiring skills in both GISc and CS at U.S. universities basically requires students to pursue a double major. It is sometimes suggested that a double major is not required because GISc students can acquire the necessary CS skills by "taking a few CS classes," but this is not practical. The CS classes a GISc student would need typically have lengthy lists of prerequisites (making it difficult to fit all the necessary courses into the GISc curriculum) and are often restricted to CS majors. Given that both the number of individuals wanting to pursue double majors is quite small to begin with and that the economics of staying in college for the additional semester (or more typically the additional academic year) required to complete a double major have become quite daunting, it seems unlikely that double majors are going to solve the shortage of dual skilled geocomputational instructors anytime soon.

An alternative to relying on dual-skilled instructors is team teaching interdisciplinary geocomputational class with both GISc

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and CS instructors. Experience has shown that this approach can work extremely well, but interdisciplinary team teaching within U.S. universities can be problematic. University administrative structures, as well as faculty (and administrator) reward systems, often serve to discourage interdisciplinary teaching. The remainder of this essay will identify problem areas, propose work arounds to circumvent these areas, and (perhaps wishfully) suggest changes that could encourage interdisciplinary teaching in the future.

2 University Administrative Structures and Interdisciplinarity

From the perspective of administrative theory, modern universities are simple hierarchical organizations with (typically) four administrative levels. Confusingly, these levels (and the titles of the leaders of each level) go by different names at different institutions. Despite the different nomenclatures, these levels and their functions remain quite consistent across institutions. For the sake of clarity, I will refer to the four levels as the department (typically lead by a chairperson), the college (lead by a dean), the university's total academic enterprise (lead by a provost), and the university as a whole (lead by a president).

A convincing argument can be made that four is at least one too many administrative levels for a modern university, and further arguments can be made as to which level(s) should be eliminated. Those arguments are not germane to the current discussion. The question here is how does the existing four-level administrative structure help or hinder interdisciplinary teaching; specifically, teaching of geocomputational courses.

The most common category of interdisciplinary teaching seen in U.S. universities involves collaborations between two or more disciplines represented by different departments within a single college. Interestingly, these interdisciplinary efforts rarely develop in the manner envisioned by administrative theory – under that theory, possible synergies between two or more smaller administrative units (in this case, departments) should be recognized and efforts to implement interdisciplinary teaching should be initiated by the leaders of the next larger administrative unit (in this case, the college). That rarely happens in academia. The more common mechanisms are (1) individual faculty members from two or more departments within the same college, who meet and interact on a regular basis at college-level events, recognize and initiate interdisciplinary efforts on their own, or (2) the chairs of two or more departments, who once again meet and interact with one another regularly at college leadership meetings and other venues, recognize opportunities for collaborations and initiate interdisciplinary efforts between their departments.

Using these two mechanisms, within-college interdisciplinary efforts do occur, but they are relatively rare, and they typically occur at very small scales – for example, a class may incorporate "guest lecturers" from other disciplines, or in more ambitious cases, a certain portion of the course may be taught by a faculty member from another discipline. While these sorts of collaborations are frequently positive and helpful, they are basically separate, segregated discussions of two related disciplines that just happen to take place in a single course. They fall short of the truly integrated, multidisciplinary approach called for in many areas, including geocomputation. What is needed are courses designed to intertwine GISc and CS concepts and ideas. Courses should highlight how successful practitioners of geocomputation are able to look at issues from both a GISc and a CS perspective, understand how GISc theories and ideas will influence how CS theories and ideas are applied to that issue, as well as the reverse – understand how CS theories and ideas influence how GISc theories and ideas are applied to the issue. Asking students to develop this level of integrated thinking by exposing them to two disciplines separately is not particularly realistic.

For geocomputation, the situation is even more difficult, because the GISc and CS departments are typically not located within the same college. Under administrative theory, this situation should be handled by the lowest administrative level that encompasses both colleges – the provost's office – recognizing the opportunity for interdisciplinarity and taking steps to initiate that activity. This virtually never happens. First, the provost is probably unaware of the opportunity for interdisciplinarity – recognizing such opportunities requires a deep level of understanding of at least one of the disciplines involved and at least a solid appreciation of the other discipline(s) involved – and given that a typical university has departments representing dozens if not hundreds of disciplines, it is not realistic to expect the provost to have solid understandings of any more than a tiny handful of them. Second, in academia any effort by an administrator to "tell a faculty member" what or how to teach runs the risk of raising a messy and usually counterproductive dispute centered on academic freedom. As a result, most provosts are very reluctant to do anything that might lead them down this road – including initiating interdisciplinary efforts.

In addition, the unofficial mechanisms that can initiate interdisciplinary teaching found within single colleges – informal meetings among faculty and/or depart chairs – are much less effective between colleges. University colleges tend to be fairly well "siloed," even to the point that it is rare for multiple colleges to share office space – on most campuses, each college has it own building(s) or at least its own floors (or wings) in shared buildings. Social activities where faculty can meet and interact focus almost exclusively on the department or college level; faculty from different colleges have very little opportunity to meet. Given this, it is unsurprising that faculty from different colleges rarely come together to organize interdisciplinary teaching; they simply lack any effective mechanism to interact with one another in a setting that lends itself to developing such efforts.

3 How University Resource Allocation and Reward Systems Hinder Interdisciplinary Efforts

How universities allocate resources and reward faculty (as well as administrative units) poses additional problems to interdisciplinary teaching. Leaving aside the perennial debate over the relative weights given to teaching versus research, at some level all universities have to evaluate teaching, provide resources for the university's teaching efforts, and in some fashion reward outstanding teaching efforts and modify or perhaps discontinue unsuccessful efforts. The resources being distributed are usually faculty time (what and how many courses is a faculty member going to be asked to teach in order to meet their teaching workload requirements), graduate teaching assistant positions, non-tenure track faculty hires, and in the longer term, future tenure track faculty hires. At the individual faculty level, the rewards being discussed are usually annual evaluation ratings, which translate into annual salary increases. At the departmental (and perhaps college) levels, additional rewards involved are typically increased budgetary allocations (and possibly increased allocations of manpower), and perhaps even increased administrative autonomy.

Universities struggle mightily with how to evaluate teaching. The debate and opinions in this area are endless, but most people would agree that evaluating teaching involves at least three areas – the *quantity* of teaching (how many courses are taught, how many students are in each of these courses, and how much effort goes into teaching each class), the *quality* of teaching (are students learning the material presented in the course), and the *impact* of teaching (how much do students benefit, either during the rest of their tenure at the university or during their professional careers after they leave the university, from the teaching). Unfortunately, both the quality and especially the impact of teaching are very difficult to measure, so most teaching evaluation efforts tend to focus on quantity. Team taught geocomputational classes suffer in this area. Such classes tend to have small to modest enrollments, which is a strike against them when they are assessed for teaching quantity. Further, since they are team taught, the "credit" for the teaching effort is distributed among multiple faculty members, which hurts each faculty member in terms of reaching their individual teaching workload requirements.

Most universities at least pay lip service to evaluating teaching quality, usually through student surveys and occasionally with teaching peer review. The efficacy of both of these techniques is debatable, but this debate is not relevant to the current discussion. Team taught geocomputational courses may do very well or very poorly in these measurements, just like any other course. Individual instructors vary in the quality of their teaching, and some instructors who do well with certain courses struggle with others. Instructors participating in team taught geocomputation classes are no exception.

Where team taught geocomputational class should shine is in the impact area, because such classes give students the ability to approach issues from multiple perspectives. This should make students better academic and real-world problem solvers, which is an outstanding benefit found in few classes. However, very few universities make any sort of concerted effort to measure teaching impact, so this benefit of team taught geocomputation courses usually goes unnoticed.

Given that teaching evaluations – focused on quantity and to a lesser extent quality of teaching – go into both resource allocation and reward decisions for both individual faculty and for the departments/colleges they represent, their impacts are quite significant. They are also incomplete measures of teaching, and their failings disproportionately impact team taught interdisciplinary classes like geocomputation. This makes team taught interdisciplinary classes unattractive to both individual faculty and departments/colleges. Given this, it is hardly surprising that such courses are rare in today's academia.

4 How to Foster Team Taught Interdisciplinary Courses Within Academia as it is Currently Structured

Given the obstacles arrayed against team-taught geocomputation courses, how can such courses be successful in contemporary academia? While there is no single silver bullet that can overcome all of the hurdles facing such classes, a number of things can help:

- *Courses must be conceived and instigated by faculty*. In previous portions of this document, I have mentioned the possibilities of courses being created through the actions of department heads, deans, or others, and while such things do occur, the overwhelming majority of new classes are instigated by small groups of faculty. Being that GISc and CS faculty are unlikely to meet socially at university functions (since they are in deferent colleges), the onus is on the faculty themselves to seek out their colleagues from other departments and explore the possibilities.

- *The course must have support not only from the faculty teaching it, but from the faculties in the GISc and CS departments*. Faculty support makes administrative support much more likely. If a class with little support also fares poorly under the previously-discussed teaching evaluation system, it becomes an easy target for elimination. Conversely, if the faculty support a class, administrators are much more likely to find ways to work around mediocre teaching evaluations. As the old adage says, there is power in numbers, and courses supported by entire departmental faculties are much more likely to enjoy administrative support than courses advocated by only their instructors.

This begs the question of exactly how to garner such faculty support. In my experience, most GISc faculties do not require much convincing; faculty teaching subsequent courses see the benefits of having students with strong geocomputation skills in those courses. CS faculties can be more difficult to convince. Typically, CS departments are struggling to keep up with demand for their teaching; there are a plethora of students seeking CS degrees and many universities require "Intro to CS" courses as part of their core curriculums. The burden of teaching such classes falls on CS faculties. This high demand for teaching masks the benefits instructors may experience from having a relatively small proportion of their students having gained geocomputational skills. Finally, in my experience, CS as a discipline places much more emphasize on grantsmanship and less on teaching as compared to GISc. Together, all of these experiences make CS faculties understandably reluctant to take on additional teaching responsibilities.

The way to overcome such reluctance is to demonstrate that a geocomputation class can benefit CS students. Like all good faculty members, the vast majority of CS faculty want to provide their students with a high quality education, and if they see a geocomputation class as contributing to that education, they will support it. The issues faced in geocomputation (e.g., data mining, information security, processing performance when working with extremely large datasets, parallelization, opportunities in computer graphics/data visualization limited only by the imaginations of the students and instructors, etc.) provide wonderful platforms upon which broad CS issues can be taught. When CS faculty see this, they will support such classes.

- *The course must become a required component of at least one degree program*. This is largely an extension of the previous point. When resources are tight, elective courses are easier targets for elimination than required courses, and in other times, it is easier to maintain courses that may not perform well under the flawed teaching evaluations systems in place at most universities when those courses are a required component in one or more curricula.

- *The instructors must work with their department chairs, who must work with their deans, who must reach out to the provost to ensure that the special nature of courses such as a team taught geocomputation class is recognized and addressed in resource allocation and reward decisions*. Perpetually fighting a defensive battle to justify team taught interdisciplinary courses that do not perform well under the metrics most universities use to evaluate teaching is a fool's game. If program heads, deans and the provost support team taught interdisciplinary classes, it is in their power to find alternative ways to evaluate these courses and their instructors. For example, faculty can survey (formally or informally) graduates regarding the impact the class has had on their careers; if the class is living up to its expectations, it should do well in that area. This information can be provided to department chairs, deans and possible even the provost. Supportive university administrators can use this sort of data to justify giving positive evaluations to courses such as geocomputation that do not perform as well under the conventional teaching evaluation metrics used in other courses.

5 How to Restructure Academia so it Supports Interdisciplinarity

The fundamental structural problem found in academia today is that universities are undeniably "bottom up" organizations but they are administered in a "top down" fashion. Academic freedom gives individual faculty members almost unlimited control over their teaching efforts and the academy's ubiquitous emphases on faculty developing their own research programs gives faculty almost unlimited freedom in that area as well. Coupled this with the job security granted through tenure, and it is clear that faculty members have almost complete control over their activities; they are essentially independent contractors. They all share the university's overarching goals of teaching and research, but they do not work in prescribed areas to accomplish specific goals established by university administrators. Furthermore, even the one teaching-related decision that does not fall to individual faculty members – the design of the overall curricula required to earn degrees – is not decided upon by higher administration. Instead, it falls to the combined decision making of the faculty of individual departments – and departments form the *lowest* level of the university's administrative hierarchy. All of this focus on individual faculty and low-level administrative units clearly demonstrates that universities operate through the collective decisions made by individuals and small groups of faculty; despite what higher administrators may think, they really do not run the university.

However, university administrators do control resource allocation throughout the university, and they control the evaluation processes that are used to determine future resource allocations (including annual salary increases). There is a legitimate debate to be had about the obvious conflicts of interest in controlling both allocations and the mechanism that drives future allocations, but that is not the point vis-à-vis team taught interdisciplinary courses. The issue here is the degree of alignment of between the goals and aims of the faculty and those of the administration. When both sets of goals and aims align, resources flow into the areas supported by the faculty, and the university operates smoothly. Problems arise when the goals and aims of the faculty and the administration do not align. These problems could be eliminated by restructuring university administrative structures to reflect the *de facto* bottom up nature of university operations. This sort of restructuring is the most profound change needed in contemporary U.S. universities.

Perhaps understandably, university administrators have constructed resource allocation and performance evaluation systems that function best when universities are fully "siloed." If to the extent possible, each department is responsible for only its own set of course and degree offerings, and handles all of the university's research in a certain academic area, the department can be evaluated using simple metrics and it can be rewarded or censured based on those metrics. If departments are intertwined and highly collaborative, the evaluation and resource distribution processes become much more complex.

But complexity in this area is unavoidable. Whether the university is a liberal arts institution where the concern is providing students with a broad, interdisciplinary background that spans many fields or a public university facing the public's demands to prepare graduates for employment in the real world, where jobs seldom if ever are restricted to individual academic disciplines, the demand for interdisciplinary, team-taught experiential classes is only going to grow. University administration systems, and even university accreditation organizations, are going to have to be redesigned to encourage interdisciplinarity rather than merely tolerate it.

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