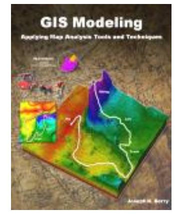
Beyond Mapping IV

Topic 6 – *Education Outside the Traditional Lines (Further Reading)*



GIS Modeling book

Lumpers and Splitters Propel GIS — *describes the two camps of GIS (GeoExploration and GeoScience) (December 2007)*

Melding the Minds of the "-ists" and "-ologists" — *elaborates on the two basic mindsets driving the geotechnology community (July 2009)*

Questioning GIS in Higher Education — *describes thoughts and notes from a panel discussion on "GIS in Higher Education" (June 2012)*

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Lumpers and Splitters Propel GIS

(GeoWorld, December 2007)

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Earlier discussions have focused on the numerical nature of GIS data (GeoWorld Sep-Nov, 2007; *Topic 7* in the online *Beyond Mapping III compilation at* http://www.innovativegis.com/basis/MapAnalysis). The discussions challenged the traditional assumption that all data are "normally" distributed suggesting that most spatial data are skewed and that the *Median* and *Quartile Range* often are better descriptive statistics than the *Mean* and *Standard Deviation*.

Such heresy was followed by an assertion that any central tendency statistic tends to overly generalize and often conceal inherent spatial patterns and relationships within nearly all field collected data. In most applications, *Surface Modeling* techniques, such as density analysis and spatial interpolation, can be applied to derive the spatial distribution of a set of point-sampled data.

Figure 1 outlines the major points of the earlier discussion. The left side of the figure depicts *Desktop Mapping's* approach that reduces a set of field data to a single representative value that is assumed to be everywhere the same within each polygon (Discrete Spatial Object). Each parcel is "painted" with an appropriate color indicating the typical value—with darker green indicating a slightly lower average value derived from numerous samples falling within the polygon.

Map Analysis's approach, on the other hand, establishes a spatial gradient based on the relative positions and values of the point-sampled data (Continuous Spatial Distribution). A color ramp is used to display the continuum of estimated values throughout each parcel—light green (low) to red (high). Note that the continuous representation identifies a cluster of extremely high values in the upper center portion of the combined parcels that is concealed by the discrete thematic mapping of the averages.

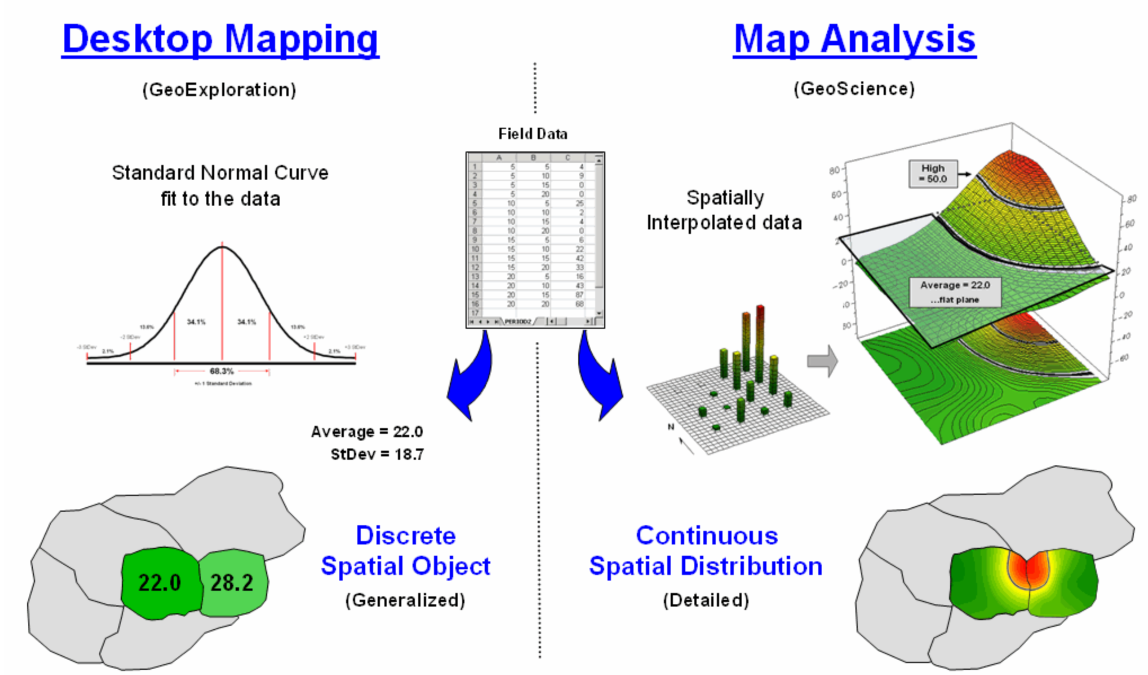

Figure 1. A data set can be characterized both discretely and continuously to derive different perspectives of spatial patterns and relationships.

OK, so much for review …what about the big picture? The discussion points to today's convergent trajectory of two GIS camps— *GeoExploration* and *GeoScience*. Traditional computer companies like Google, Microsoft and Yahoo are entering the waters of geotechnology at the GeoExploration shallow end. Conversely, GIS vendors with deep keels in GeoScience are capitalizing on computer science advances for improved performance, interoperability and visualization.

An important lesson learned by the GeoScience camp is that data has to be integrated with a solution and not left as an afterthought for users to cobble together. Another lesson has been that user interfaces need to be intuitive, uncluttered and consistent across the industry. Additionally, the abstract 2D pastel map is giving way to 3D visualization and virtual reality renderings— a bit of influence from our CAD cousins and the video game industry.

But what are the take-aways for traditional computer science vendors? First and foremost is an active awareness of the breadth of geotechnology, both in terms of its technical requirements and its business potential. Under the current yardstick of "eyeball contacts," GeoExploration tools have been wildly successful.

But at the core, have recent technological advancements really changed mapping? …or has the wave of GeoExploration tools just changed mapping's expression and access? …has the GIS evolution topped (or bottomed) out? …what about the future?

Current revolutionary steps in analytics and concepts are underway like the energized paddling beneath a seemingly serene swan. As a broad-brush framework for discussion of where we are heading, recall from your academic days the Philosopher's Progression of Understanding shown in figure 2. It suggests that are differences between the spatial *Data/Information* describing geographic phenomena and the *Knowledge/Wisdom* needed for prescribing management action that solve complex spatial problems.

Philosopher's Progression of Understanding—

- ✓ **Data** (all facts)
- ✓ **Information** (facts within a context)

  …**GeoExploration** *emphasizes tools for data access and visualization (general user)*

Mapping focus

Data/Structure and Analysis focus

- ✓ **Knowledge** (interrelationships among relevant facts)
- ✓ **Wisdom** (actionable knowledge)

  …**GeoScience** *emphasizes tools for spatial reasoning and understanding of spatial patterns and relationships (application specialist)*

Figure 2. The two broad camps of geotechnology occupy different portions of the philosopher's progression of understanding.

Most GeoExploration applications simply assemble spatial data into graphic form. While it might be a knock-your-socks-off graphic, the distillation of the data to information is left to visceral viewing and human interpretation and judgment (emphasizing Data and Information).

For example, a mash-up of a set of virtual pins representing crimes in a city can be poked into a Google Earth display. Interpretation and assessment of the general pattern, however, is left for the brain to construe. But there is a multitude of analytics that can be brought into play that translates the spatial data into information, knowledge and wisdom needed for decision-making. Geo-query can segment by the type of crime; density analysis can isolate unusually high and low pockets of crime; coincident statistics can search for correlation with other data layers; effective distance can determine proximity to key features; spatial data mining can derive prediction models.

While the leap from mapping to map analysis might be well known to those in GeoScience, it represents a bold new frontier to the GeoExploration camp. It suggests future development of solutions that stimulate spatial reasoning through "thinking with maps" (Information and Knowledge) rather than just visualizing data— a significant movement beyond mapping.

In part, the differences between the GeoExploration and GeoScience camps parallel society's age-old dichotomy of problem perception—lumpers and splitters. A "lumper" takes a broad view assuming that details of a problem are not as important as overall trends ...a picture is worth a thousand words (holistic). A "splitter" takes a detailed view of the interplay among problem elements ...a model links thousands of pieces (atomistic).

So how does all this playout in geotechnology's future? The two camps are symbiotic and can't survive without each other; sort of like Ralph and Alice Kramden in The Honeymooners. GeoExploration fuels the fire of mass acceptance, and in large part finances technology development through billions of mapping clicks (General User; access and visualization). GeoScience lubricantes the wheels of advancement by developing new data structures, analytical tools and applications (Application Specialist; spatial reasoning and understanding).

It's important to note that neither camp is stationary and that they are continually evolving as we move beyond traditional mapping. A large portion of the mystique and influence of application specialists just a few years ago are now commonplace on the desks (and handheld devices) of the general public. Similarly, the flat, pastel colored maps of just a few years ago have given away to interactive 3D displays. While there will always be the lumpers and splitters differences in perspective, their contributions to the stone soup of geotechnology are equally valuable—actually invaluable.

Melding the Minds of the "-ists" and "-ologists"

(GeoWorld, July 2009)

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I recently attended the GIS in Higher Education Summit for Colorado Universities that wrestled with challenges and opportunities facing academic programs in light of the rapid growth of the geographic information industry and its plethora of commercial and government agency expressions. Geotechnology's "mega-technology status" alongside the giants of Nanotechnology and Biotechnology seems to be both a blessing and a curse. The Summit's take-away for me was that, while the field is poised for exponential growth, our current narrow footing is a bit unstable for such a giant leap.

Duane Marble in a thoughtful article (*Defining the Components of the Geospatial Workforce—Who Are We?;* ArcNews, Winter 2005/2006) suggests that—

> *"Presently, far too many academic programs concentrate on imparting only basic skills in the manipulation of existing GIS software to the near exclusion of problem identification and solving; mastery of analytic geospatial tools; and critical topics in the fields of computer science, mathematics and statistics, and information technology."*

This dichotomy of "tools" versus "science" is reminisce of the "*-ists* and *-ologists*" Wars of the 1990's. While not on the same level as the Peloponnesian War that reshaped Ancient Greece, the two conflicts have some parallels. The pragmatic and dogged Spartans (an oligarchy) soundly trounced the intellectual and aristocratic Athenians (a democracy). However in the process, the economic toll was staggering, poverty widespread, cultures devastated and civil war became a common occurrence throughout the Greek world that never recovered its grandeur.

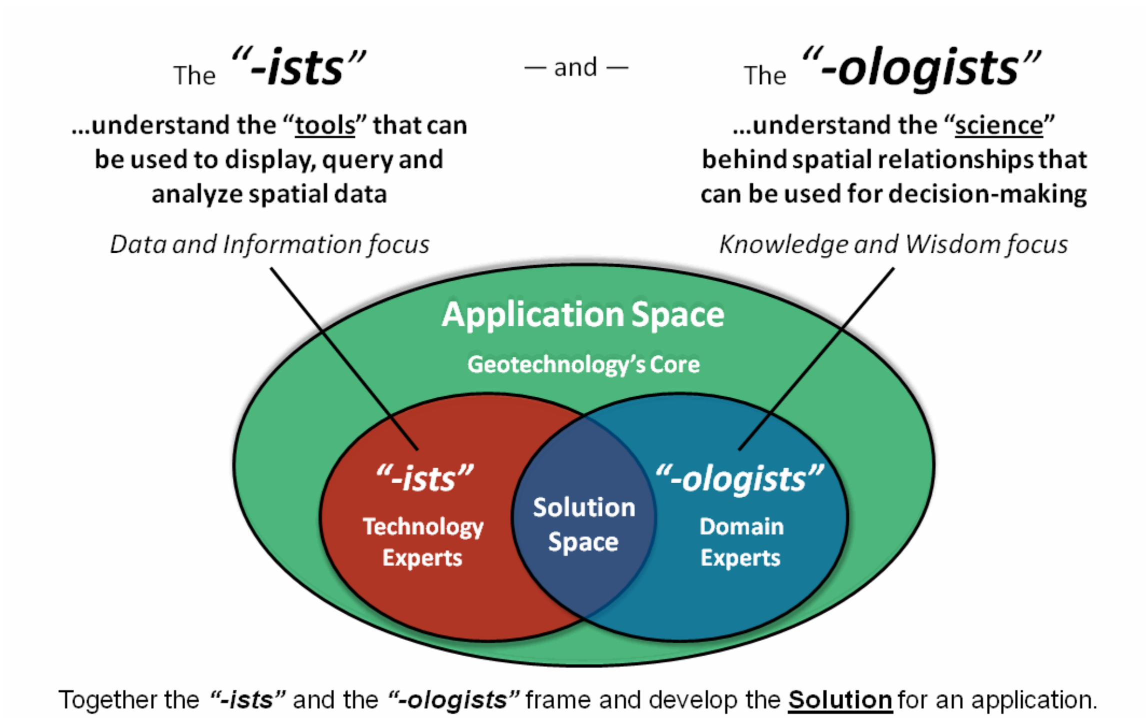

Figure 1. A civilized and gracious tension exists between the of-the-tool and of-the-application groups.

Figure 1 portrays a similar, yet more civilized and gracious tension noted during the Education Summit. The "*-ists*" in the group pragmatically focused on programs emphasizing a GIS specialist's command of the tools needed to display, query and process spatial data (Data and Information focus). The "*-ologists*," on the other hand, had a broader vision of engaging users (e.g., ecologists, sociologists, hydrologists, epidemiologists, etc.) who understand the science behind the spatial relationships that support decision-making (Knowledge and Wisdom focus).

My first encounter with the "-*ists*" and "-*ologists*" conflict involved the U.S. Forest Service's Project 615 in the early 1990's (615 looked like GIS on the line-printers of the day). The nearly billion dollar procurement for geographic information technology was (and likely still is) the largest sole-source acquisitions of computer technology outside of the military. The technical specifications were as detailed as they were extensive and identified a comprehensive set of analytical capabilities involving innovative and participatory decision-making practices. The goal was a new way of doing business in support of their "New Forestry" philosophy using ecological processes of natural forests as a model to guide the design of managed forests—an "-*ologists*" perspective justifying the huge investment and need for an entirely new approach to maps and mapping.

However, the initial implementation of the system was primarily under the control of forest mensurationists—an "*ists*" perspective emphasizing data collection, inventory, query and display. The result was sort of like a Ferrari idling to and from a super market of map products.

Geotechnology's critical and unifying component is the application space where the rubber meets the road that demands a melding of the minds of technology <u>and</u> domain experts for viable solutions. While mapped data is the foundation of a solution, it is rarely sufficient unto itself. Yet our paper-map legacy suggests that "map products" are the focus and spatial databases are king—"build it and they (applications) will come."

Making the leap demanded by mega-technology status suggests more than a narrow stance of efficient warehousing of accurate data and easy access to information. It suggests "spatial reasoning" that combines an understanding of both the tool and the relevant science within the context of an application.

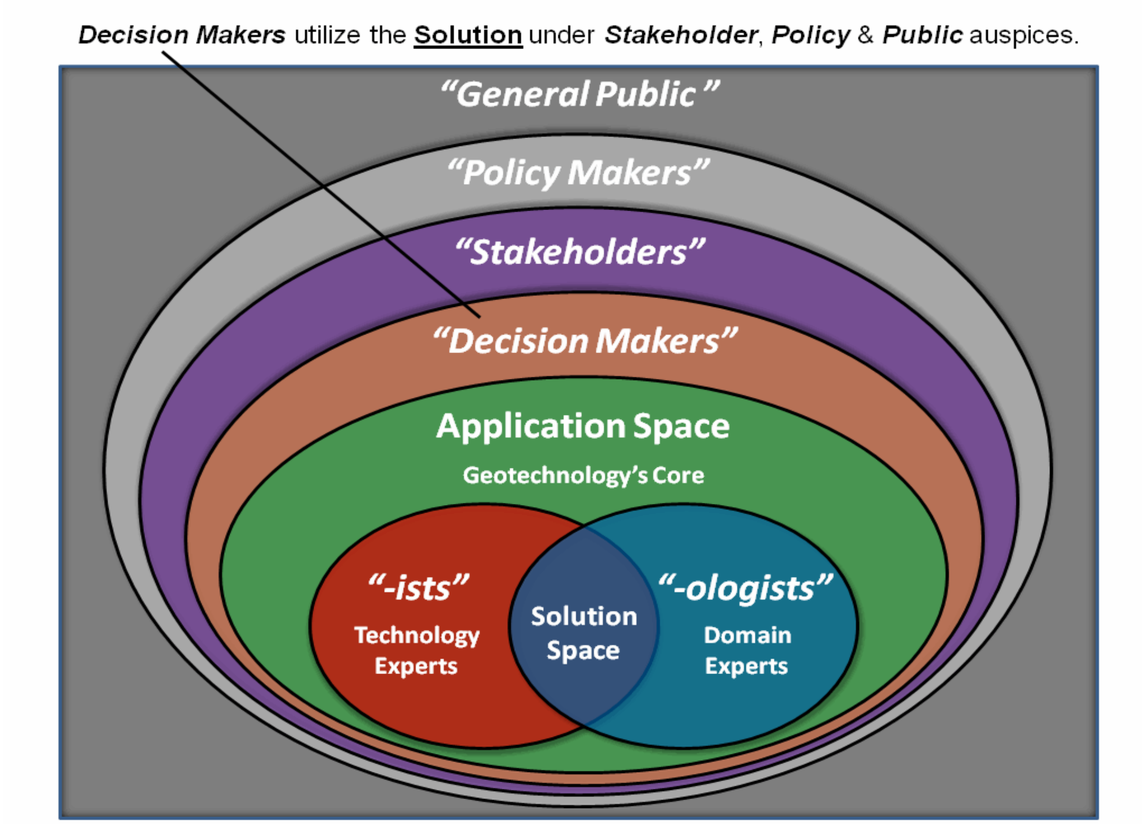

Figure 2. Geotechnology applications involve series of interacting levels of people, polices and paradigms.

Like a Russian nesting doll, spatial applications involve a series of interacting levels of people, polices and paradigms (figure 2). *Decision-makers* utilize a spatial solution derived by the "*-ists* and *-ologists*" within the guidance of *Stakeholders* (imparting value judgments), *Policy Makers* (codifying consensus) and the *General Public* (recipients of actions). An educated society needs to understand spatial technology commensurate with the level of their interaction—to not do so puts Geotechnology in "black box" status and severely undermines its potential utility and effectiveness.

An academic analogy that comes to mind is statistics. While its inception is rooted in 15th century mathematics, it wasn't until early in the 20th century that the discipline broadened its scope and societal impact. Today it is difficult to find disciplines on campus that do not develop a basic literacy in statistics. This level of intellectual diffusion was not accomplished by funneling most of the student body through a series of one-size-fits-all courses in the Statistics Department. Rather it is accomplished through a dandelion seeding approach where statistics is enveloped into existing disciplinary classes and/or specially tailored courses (e.g., Introduction to Statistics for Foresters, Engineers, Agriculturists, Business, Basket Weaving, etc.).

This doesn't mean that deep-keeled Geotechnology curricula are pushed aside. On the contrary, like a Statistics Department, there is a need for in-depth courses that produce the theorists, innovators and specialists who grow the technology's capabilities and databases. However it does suggest a less didactic approach in which all who touch GIS must "start at the beginning and when you get to the end...stop" (The Cheshire Cat).

It suggests breadth over depth for many of tomorrow's GIS *"-ologists*" who might be more "of the application" than the traditional "of the tool" persuasion— sort of like an outrigger canoe with Geotechnology as the lateral support float. Also it suggests a heretic thought that a "disciplinary silos" approach which directly speaks to a discipline's applications might be the best way to broadly disseminate the underlying concepts of spatial reasoning.

While academic silos are generally inappropriate for database design and development (the "-*ists*" world), they might be the best mechanism for introducing and fully engaging potential users (the "-*ologists*" world). In large part it can be argued that the outreach to other disciplines is our foremost academic challenge in repositioning Geotechnology for the 21st Century.

Questioning GIS in Higher Education

(GeoWorld, June 2012)

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Recently I had the opportunity to sit on a panel concerned with "GIS in Higher Education: Simultaneously Trivializing and Complicating GIS" (see author note 1). In about an hour of interactive discussion we only addressed a couple of the planed questions. Below are thoughts and notes from the ones we discussed and initial thoughts on those we didn't get to.

[Note: during the break prior to the panel, I sketched the "technical tool" versus "analytical tool" trajectory on the whiteboard (figure 1)]. The use of GIS as a "technical tool" has skyrocketed, while its use as an "analytical tool" has relatively stalled over the past decade.

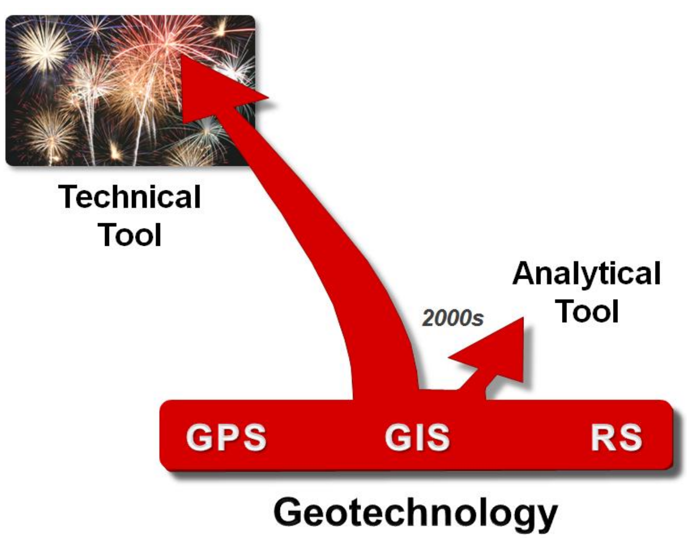

Figure 1. During the past decade GIS as a "technical tool" has skyrocketed, while its use as an "analytical tool" has relatively stalled.

Question: Is there an <u>inherent responsibility</u> for the GIS community in higher education to further general awareness and understanding of geotechnology (RS, GIS, GPS) across campus? If so, <u>in what ways</u> can we provide opportunities for non-GIS faculty and students to learn about GIS capabilities as a "technology tool" and as an "analysis tool" considering interdisciplinary education constraints and considerations (e.g., budget, organization, time, promotion/career considerations, etc.)?

In the current euphoria of GIS as a "technical tool," the marketplace is defining not only what GIS is, but its future. To some degree, higher education in GIS on many campuses seems to have abdicated a primary leadership role and tend to have taken a "vocational role" focusing on training GIS-specialists.

To most folks on campus, geotechnology is simply a set of highly useful apps on their smart phone or a 3D fly-by anywhere in the world— in a sense <u>trivializing GIS</u>. To a smaller contingent on campus, it is career path that requires mastery of the mechanics, procedures and buttons of extremely complex commercial software— in a sense <u>complicating GIS</u>.

Any new or rapidly evolving technology has an inherent responsibility to further general awareness of the full potential of the technology. The technical tool's mapping, display and navigation capabilities seem to be easily learned through vender promotion and peer pride "look at what this can do" instruction.

However the radical nature of the "analytical tool" perspective drastically changes how we perceive and infuse spatial information and reasoning into science, policy formation and decision-making— in essence, how we can "think with maps" for solving complex spatial problems. To achieve our billing as one of the three mega-technologies of the 21^{st} century (Bio-, Nano- and Geotechnology) we need to 1) insure that spatial reasoning skills are taught K12 through higher education, 2) instill the idea that modern digital maps are "numbers first, pictures later" and 3) these organized sets of numbers support quantitative analysis.

I am increasingly struck by the thought that we are miss-communicating GIS's potential, particularly with the science communities on campus who ought to be excited about infusing spatial considerations into their research and teaching. The result is that innovation and creativity in spatial problem solving are being held hostage to 1) a trivial mindset of maps as pictures, 2) an unsettling feeling that GIS software is too complex, and 3) a persistent legacy of a non-spatial mathematics that presupposes spatial data can be collapsed to a single central-tendency value that ignores any spatial variability inherent in the data.

The most critical step in providing opportunities that further general awareness and understanding across campus is to recognize the inherent responsibility of non-GIS student education, as well as traditional GIS specialists. Specific actions might include—

- Encourage seminars demonstrating applications,
- Establish a networking organization encompassing all interested disciplines,
- Teach a class or lab for a department outside of your own,
- Organize or team-teach a discipline-oriented workshop with a domain expert,

- Write proposals for non-GIS teaching, research and outreach,
- Solicit VP-level administers' support for integrated efforts, and
- Consider adopting a *Spatial*STEM approach that translates grid-based map analysis operations into a mathematical/statistical framework that serves as the communal language of science, technology, engineering and mathematics disciplines (see author note 2).

OK, that's my Pollyanna perspective …what's the chance that an enlarged view of GIS education will ever take root on your campus? …what would it take?

Question: What are the similarities and differences between GIS and non-GIS students (e.g., background, interests, time, career aspirations) and what similarities and differences are there in structuring course content and "hands-on" experiences (e.g., formal class, workshops, seminars)?

My experience is that non-GIS students are less interested in the mechanics of GIS and more interested in how GIS might be applied in their field to solve problems. For the past few years I have had considerable proportions of students outside of Geography/GIS in my graduate course in GIS Modeling at the University of Denver (see author note 3) with more outside students than inside this past term, as well as two qualified undergrads. These students know little about traditional GIS concepts (geodes, coordinates, projections, data structures, cartography, etc.) but in most cases a lot about quantitative methods for analyzing data.

I use an easy-to-learn grid-based software package (MapCalc Learner, see author note 4) in the course that students load onto their personal computers along with the databases used in the weekly homework assignments. The 3-hour class meeting is consumed with lecture and discussion (no formal lab sessions). The students work in 2-3 person teams on their own and are expected to complete the homework assignment as a professional report (format, spelling, grammar, composition are graded) with discussion and appropriate screen grabs of their results—more problem-solving than lab exercise.

I believe several "characteristics" of non-GIS students can be identified—
- Interested in applying GIS to solve problems in their field,
- Rarely to mildly interested in becoming GIS-specialists,
- Want to know the basic concepts, procedures, considerations and limitations of the technology,
- Focused on the utility of GIS to them (minimally interested in RS or GPS),
- Concerned about the practical aspects of GIS (e.g., software, data availability) , and
- Generally interested in the future directions of GIS.

I believe some fundamental "characteristics" in structuring an educational offering for non-GIS students (course, short course, workshop, guest lecture/lab or seminar) to consider are—
- Tailoring the presentation to the audience's interests, disciplinary background and current spatial problems is critical (GIS for GIS sake is unacceptable),
- Instructor "hands-on demonstrations" (or student hands-on exercises) are extremely valuable,
- Animated slides that sequence logical steps in developing a concept is preferable,

- Ample time/opportunity for discussion is important (Socratic questions as lead-in to topics are effective), and
- Links to online further readings/references are useful.

OK, that's my scar-tissue-based advice …what has been your experience(s) in presenting GIS to non-GIS folks? …what words of advice can you share?

Question: Given the advance and convergence of Citizen Science/Volunteered Geographic Information, mobile and easy-to-use geo-technologies, the open data movement, and cloud-based GIS, <u>is everyone a geographer</u>? Is <u>everyone able to easily ramp into a GIS career</u>?
- GIS as an interactive "technical tool" for map viewing, navigation and geo-query is for everyone (potentially billions of users; negligible skills required),
- Map making today primarily involves choosing a template and following a wizard's guidance from the cloud so just about anyone can be a map maker (millions; minimal skills),
- GIS as an "analytical tool" is for many individuals as they augment their domain expertise with spatial reasoning and problem-solving skills (millions; considerable skills), and
- GIS as a career is not for everyone (hundreds of thousands; considerable skills).

Question: How will <u>cloud computing and interactive applications impact GIS education</u> both from a GIS-specialist and a GIS-user perspective?
- For the GIS specialist they need a working knowledge of structuring online databases and interactive services/solutions in the cloud, and
- For the GIS user they will be free from flagship software demands and will be able to utilize very large data sets and services from the get-go, and
- Lat/Lon grid-based referencing will become a universal key for joining currently disparate data sets in the cloud.

Question: What does <u>the GIS education community need to do</u> in the next 1 to 3 years to ensure that spatial analysis, geographic inquiry, and GIS are supported, taught, and <u>used throughout the educational system</u>?
- Teach the teachers,
- Help construct tailored introductory lectures/labs for existing courses in other disciplines, and
- Develop/promote/offer courses for non-GIS students (ideally team-teach with domain expert).

Question: What <u>types and levels of computer knowledge/expertise and quantitative methods will be required</u> for developing successful GIS applications and solutions?
- We need to develop in our GIS students a better understanding of grid-based spatial stat/math operations and quantitative analysis methods,
- Instill skills in general-purpose, high-level programming languages, such as Python, for integrating systems and programs with GIS, and
- Instill skills that are needed for the production and maintenance of websites (web design and digital media studies).

Question: What factors are most limiting to the continued development of GIS education on your campus (student interest, colleague backing, workload, promotion/tenure process, administration support, space, budget, etc.)?

- Promotion and tenure doesn't fully recognize interdisciplinary efforts,
- Budgets for interdisciplinary courses and teaching are not readily available on most campuses, and
- Departmental workload does not provide time for efforts outside of the department.

The bottom line is that the GIS academic community has an intellectual and noble responsibility to educate non-GIS students in the full capabilities of geotechnology and how it is changing our paradigm of what maps are and how they can be used from a historical perspective of "Where is What" to a modern expression of "Why, So What and What If" within problem solving contexts. The rub is that there is minimal incentive, encouragement or support in turning the academic tanker— at this point a few charitable GIS'ing zealot professors are needed.

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Author's Notes: *1) GIS in Higher Education Symposium, Metro State College, Department of Geography, Denver, Colorado; April 6, 2012. 2) See **www.innovativegis.com/basis/Papers/Other/SpatialSTEM/SpatialSTEM_case.pdf**. 3) You can review all of the GIS Modeling course materials to include lecture PowerPoints, exercises, exams and MapCalc Learner software used at **www.innovativegis.com/basis/Courses/GMcourse12/**. 4) For more information on freely distributed MapCalc Learner, see **www.innovativegis.com/basis/**, select Software items.*

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