



Educating the Spatial Thinker

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David Bodenhamer established The Polis Center in 1989 as a multidisciplinary research unit focused on the innovative use of advanced spatial technologies in community-based and scholarly problems. The self-funded center has a staff of 25 FTE and has generated more than \$65 million in grants and contracts since its founding. Bodenhamer also helped to create the Virtual Center for Spatial Humanities—a collaboration among West Virginia University, Florida State University, and IUPUI—to promote the use of spatial theory and spatial technologies in the humanities. He has developed international partnerships in Europe and Asia to advance this rapidly growing field. The author or editor of ten books, Bodenhamer is co-general editor of the Indiana University Press Series in the Spatial Humanities and co-editor of *The International Journal of Humanities and Arts Computing*.

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Bodenhamer, Abstract:

Deep Maps, Deep Contingencies: The Promise of Spatial Humanities

New technologies such as Geographic Information Systems (GIS) have facilitated the (re)discovery of space for humanists. Yet until recently GIS has had only limited ability to move us beyond a map of geographical space into a richer, more evocative concepts of place based on history and memory. Over the past few years, GIScientists have made advances in spatial multi-media, in GIS-enabled web services, geo-visualization, cyber geography, and virtual reality that provide capabilities far exceeding the abilities of GIS on its own. This presentation will explore how the convergence of technologies—including but not limited to GIS—has led to the development of a new multi-dimensional and multi-disciplinary approach known as spatial humanities. This convergence of technologies promises to revolutionize the role of place in the digital humanities by allowing us to move far beyond the static map, to shift from two dimensions to multidimensional representations, to develop interactive systems, and to explore space and place dynamically—in effect, to create virtual worlds embodying what we know about space and place.

Characterized by the “deep map” that enables an exploration of multiple perspectives and deep contingencies, the spatial humanities does not ask humanists to force their disciplines into a narrow or predefined technical framework but instead bends spatial technologies toward the needs of humanists. It is an approach that goes beyond the map and allows humanists to explore linkages of space and time that often are unavailable both in traditional textual forms and in technologies such as GIS. As such, spatial humanities has special significance, not only for the scholar, but also for the archivist, museum curator, educator, and librarian who work with humanities materials.

Michael Goodchild

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Michael Goodchild has served as Director of the National Center for Geographic Information and Analysis (NCGIA); Associate Director of the Alexandria Digital Library Project; and Director of the Center for Spatially Integrated Social Science. Goodchild's research publications, including more than 400 scientific papers and a dozen authored and edited books, have laid a foundation for geographic information science and spatial analysis, extended the development of geo-libraries, contributed to understanding uncertainty in geographic data, and advanced capabilities in location-allocation modeling.

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Mary Hegarty

Ph.D., Carnegie Mellon University
Professor, Department of Psychological & Brain Sciences
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Mary Hegarty's research is on spatial thinking in complex activities such as comprehension, reasoning and problem solving. In research on mechanical reasoning and interpretation of graphics, she uses eye-fixation data to trace the processes involved in understanding visual-spatial displays (diagrams, graphs, and maps), and making inferences from these displays. A unique characteristic of her research is that she studies spatial thinking from the perspective of individual differences as well as employing more commonly used experimental methods. In her work on individual differences, she studies large-scale spatial abilities involved in navigation and learning the layout of environments, as well as smaller-scale spatial abilities involved in mental rotation and perspective taking. Her current research projects include understanding the roles of internal and external visualizations in reasoning about physical systems including molecules, machines, and meteorological phenomena and the use of visualization versus analytic problem solving strategies in scientific problem solving.

Hegarty is a fellow of the American Psychological Society, a former Spencer Postdoctoral Fellow, and is the past chair of the Cognitive Science Society. She is Associate Editor of *TopiCS in Cognitive Science* and is on the editorial board of *Journal of Experimental Psychology: Learning, Memory and Cognition*, *Journal of Educational Psychology*, *Learning and Individual Differences*, and *Spatial Cognition and Computation*. Her current research is funded by the National Science Foundation.

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Krzysztof Janowicz

Ph.D., University of Muenster
Assistant Professor for Geographic Information Science
Department of Geography, University of California, Santa Barbara

Krzysztof Janowicz is running the STKO Lab, investigating the role of space and time for knowledge organization. Krzysztof is a Faculty Research Affiliate of the Center for Information Technology and Society as well as the Cognitive Science Program. He is the community leader of the 52° North Initiative for Geospatial Open Source Software semantics community and one of the two Editors-in-Chief of the *Semantic Web Journal*.

Janowicz, Abstract:

Big Geo-Data

The volume of geo-data is increasing at a higher rate than our capacities for long-term archiving. New data is added at a velocity, surpassing our ability to consume it. Even more, instead of a manageable number of data providers and formats, data is published by a myriad of human users, software agents, and technical sensors in a variety of different multi-media formats. These three are characteristic for Big Data, which is most likely going to revolutionize how we lay out GIS projects. While Big Data introduces new challenges, we should not be afraid and do not have to drown in information. Recently, IBM argued that data is the new natural resource. For scientists and GIS practitioners this means that data becomes available at higher spatial, temporal, and thematic resolution. This offers exciting opportunities and will enable us to answer complex social and scientific questions that span over domain boundaries and cannot be answered from within one scientific domain alone. However, Big Data is not better data and especially not more usable data. If geo-data is everywhere, which dataset is suitable and compatible for the task at hand? This talk highlights how space and time can aid knowledge organization and offers thoughts on how we can realize a more intelligent interchange of geo-data.

Kim Kastens

Ph.D., Scripps Institute of Oceanography, University of California, San Diego

Lamont Research Professor

Adjunct Professor of Earth & Environmental Sciences, Lamont-Doherty Earth Observatory
Columbia University

Kim Kastens' training and early career were in marine geology, focusing on the geological evolution of the Mediterranean region, and the structure and tectonics of transform faults. Over the past twenty years, Kastens has shifted her focus towards improving the public's understanding of the Earth and environment, through training of environmental journalists, professional development of teachers, innovative use of information technology, and science of learning research. Her educational efforts have included the developing the *Where are We?* software to help children learn to read maps, developing Data Puzzles to foster use of authentic geoscience data in high schools, and designing a series of professional development workshops to enhance the spatial thinking of high school Earth Science teachers and students. Her research on learning projects have investigated how children use maps while navigating, how climate forecast maps and bathymetric maps are understood by their target audiences, how high school Earth Science students learn from physical models, and how people visualize a three-dimensional geological structure from the limited information available from outcrops. She recently lead a multidisciplinary effort to create a "Synthesis of Research on Thinking & Learning in the Geosciences," soon to be published as a Special Publication of the Geological Society of America.

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Kastens, Abstract:

Educating Spatially-adept Earth Science Teachers and Students

In their quest to explain the workings of our intricate and ever-changing planet, Earth Scientists make use of a wide range of spatial concepts, spatial skills, and spatial representations. Helping students understand these concepts, master the skills, and achieve even basic literacy with the representations is a major challenge for Earth Science educators.

At the high school level, the best-researched and most-populated Earth Science curriculum places strong emphasis on extracting information from spatial representations, including maps, cross-sections, simple block diagrams, and solar system diagrams. Mental animation, perspective-taking, and representational correspondence (comparing, contrasting, and combining information from different spatial representations) are the most commonly tested spatial skills, but the skill on which students perform worst is describing or explaining spatial phenomena in their own words. Promising instructional interventions include teaching with dynamic physical models, perspective taking games and puzzles, data-first sequencing of instruction on selected topics, and having students reconstruct temporal sequence of geological events by deconstructing spatial relationships.

At the college and pre-professional level, a major current thrust of both research and curriculum development is trying to help students visualize and reason about three-dimensional forms and the interior of 3-D volumes. Oceanographers use this skill when they envision how water masses move through the ocean, as do structural geologists when they combine information about the attitude of a rock layer at scattered outcrops to envision the geological structure (e.g. fold, fault, or basin). Progressing from thinking about 1- and 2-D spatial phenomena to 3- and 4-D thinking is the most distinctive intellectual accomplishment marking the transition from high school to undergraduate Earth science education. Promising instructional interventions include exercises of gradually-increasing difficulty requiring visual penetrative ability, and combining field-based instruction with computer-rendered data visualizations of the field area.

A final important challenge is educating faculty about the range of spatial abilities to be expected among their students. A geoscience professor's own spatial ability—as someone who has excelled in a spatially-demanding profession—is likely to be a poor proxy for the spatial ability of the typical student. It can be a real “aha moment” for an instructor to realize that a student is simply not seeing what the instructor is seeing even though they are looking at the same data set or landscape or diagram.

John P. Wilson

Ph.D. University of Toronto
Professor, Spatial Sciences and Sociology
Dana and David Dornsife College of Letters
Arts and Sciences, University of Southern California (USC)

John P. Wilson directs the Spatial Sciences Institute as well as the Geographic Information Science & Technology Graduate Programs, GIS Research Laboratory, and Geospatial Services Unit that is part of the Southern California Environmental Health Sciences Center. He also holds adjunct appointments as Professor in the School of Architecture and in the Viterbi School of Engineering's Departments of Computer Science and Civil & Environmental Engineering. He founded the journal *Transactions in GIS* (Wiley-Blackwell) in 1996 and has served as Editor-in-Chief since its inception, is a past-president of the University Consortium of Geographic Information Science (2006–2007), and an active participant in the UNIGIS International Network, a worldwide consortium of 12+ institutions that collaborate on the development and delivery of online geographic information science academic programs. Wilson's research is focused on the modeling of environmental systems and he makes extensive use of GIS software tools, fieldwork, spatial analysis techniques, and computer models. He has published numerous books and articles on these topics, including two edited volumes *Terrain Analysis: Principles and Applications* (John Wiley and Sons, 2000) and the *Handbook of Geographic Information Science* (Blackwell Publishers, 2007).

Wilson, Abstract:

How Can We Reshape GIS Education to Serve Future Needs?

This field of geographic information science has grown enormously in the past few decades against a backdrop of rapid technological change and the deployment of geospatial solutions across many branches of government and the private and not-for-profit sectors. There has been a tremendous increase in our computational resources and Cloud Computing coupled with the Web and mobile devices now afford us the capacity to access these resources from almost anywhere. There has also been a tremendous growth in the number and variety of proprietary and open-source software solutions and there is now a much larger geospatial enterprise which supports many more applications and various institutional and technological efforts to build and distribute local, national, continental and global datasets.

All of these developments have resulted in a much larger demand for GIS education. There are now many examples of both residential and online educational programs that span multiple levels and serve hundreds of students per year. Notable examples include the University of Salzburg, Nanjing Normal University, Kingston University, Penn State, UCSB, and USC. It is also the case that the world and our students are changing. Michael DeMers (2009, p. iii) wrote in the preface to the fourth edition of his introductory GIS textbook that it was aimed at "students who are comfortable with e-mail and text messaging, digital file formats (mp3, mp4, jpeg), computer games and visualizations, and a host of other technologies that did not exist 10 years ago."

The tremendous gains afforded by these technological advances shift the attention of educators to the various ways in which they might establish and nurture their communities of GIS-savvy scholars because these individuals will likely bring a much greater diversity of interests, skills, and experiences than students did in the past and there will be a need to build a series of varied and effective pathways to support these different learning outcomes and styles. One possible path forward would be to invoke and use a geospatial framework where the overarching goal is to teach various kinds of students about spatial methods using geographic data.