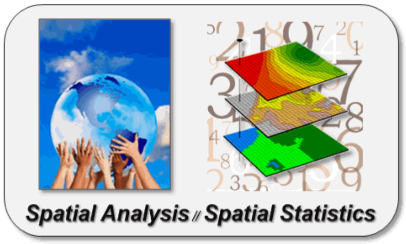
Making a Case for *Spatial*STEM – *Infusing Spatial Analysis and Statistics into Science, Technology, Engineering and Math Education at the College Level*



A workshop developing the underlying theory, practice and application of spatial data analysis and reasoning skills for college-level instructors in science, technology, engineering and math programs.

Presented by **Joseph K. Berry**

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Background

STEM is an acronym that stands for Science, Technology, Engineering, and Mathematics that identifies an educational approach designed to transform instruction by more seamlessly integrating the fields into regular curricula. In addition, it attempts to alter the typical instructor-centered classroom by encouraging an educational environment driven by problem-solving, discovery, exploratory learning, and actively engaging students in finding solutions.

Spatial Analysis and Statistics form a relatively new set of tools for quantitative analysis that cuts across a multitude of disciplines and applications. At its foundation is the perspective that "*maps are numbers first, pictures later*" and that there is a comprehensive "map-ematics" extending traditional mathematics and statistics as a means to better understand spatial patterns and relationships. These fundamental analysis tools build upon the STEM foundation in a manner analogous to statistics and matrix algebra as extensions to traditional mathematics at the turn of the last century.

For example, the calculation of slope and aspect in terrain analysis is actually a spatial extension of the mathematical derivative with numerous applications outside of traditional mapping, such as calculating the slope of a barometric surface to derive a map of wind speed (high winds where pressure is rapidly changing), while its aspect map identifies wind direction. Similarly, calculating the slope of a cost surface to derive a marginal cost surface identifying where costs are rapidly changing; its aspect identifies the direction of maximum change at every map location.

While there have been great strides in implementing STEM-based education in K-12 classrooms, its adoption in higher education has been less successful. The cross-cutting nature of *Spatial*STEM provides a common foundation in mathematics and statistics for analyzing spatial data that can help bridge the disciplinary silos and stimulate interdisciplinary interaction.

Background Reading:

– Making a Case for SpatialSTEM: Spatial Considerations in Science, Technology, Engineering and Mathematics Education — *white paper describing a framework for grid-based map analysis and modeling concepts and procedures as direct spatial extensions of traditional mathematics and statistics*
http://www.innovativegis.com/basis/Papers/Other/SpatialSTEM/SpatialSTEM_case.pdf
– SpatialSTEM: Extending Traditional Mathematics and Statistics to Grid-based Map Analysis and Modeling — *white paper describing an innovative approach for teaching map analysis and modeling fundamentals within a mathematical/statistical context*
http://www.innovativegis.com/basis/Papers/Other/SpatialSTEM/SpatialSTEM_extendedcase.pdf

Workshop Goal and Objectives

This workshop provides a fresh perspective in interdisciplinary instruction at the college level by combining the philosophy and approach of *STEM* with the spatial reasoning and analytical power of *Map Analysis and Modeling*. Upon completion of the workshop participants will develop a basic—

1) understanding of the nature of spatial data and its underlying concepts,
2) working knowledge of grid-based map analysis capabilities and procedures, and a
3) spatial reasoning case study of their own design using one of the prepared datasets (optional).

The workshop is intended for instructors from across campus wanting to introduce spatial reasoning and modeling concepts to their students through hands-on exercises and engaged case study. The sessions are presented in the vernacular of the STEM community using examples building on the common language of math/stat. Spatial reasoning principles and procedures, such as logical flowcharting, 3D data visualization and animated map display, are demonstrated through several cross-cutting "mini-case studies." Participants receive a copy of the instructor's book *Map Analysis: Understanding Spatial Relationships and Understanding*, extensive set of links to online readings, PowerPoint slide sets, MapCalc Learner software, databases and example application models that they can "tweak" for use in their classes. All materials are royalty free and can be edited and freely disseminated.

Workshop Organization and Logistics

The workshop involves two 2-hour sessions on fundamental concepts, procedures and considerations in grid-based Map Analysis and Modeling through hands-on practice. An optional third 2-hour session provides an opportunity for participants to develop their own lecture/lab materials customized for their teaching situation.

The workshop is not a didactic training course in GIS principles, procedures and software techniques for geospatial specialists. Nor is it a dog-and-pony slideshow/lecture describing GIS applications. Participants will be actively engaged in numerous hands-on exercises and in developing materials for their own lecture and lab sessions on applying spatial reasoning skills and map analysis procedures to their own field. Participants are encouraged to bring a PC-compatible portable computer with CD-ROM and USB port.

Workshop Schedule:

Overview Seminar (50 minutes). This presentation is open to all and will have materials describing the workshop but not focus on the workshop— rather, this overview of map analysis and modeling should be of general interest to all students, faculty, staff and community involved quantitative analysis. The presentation thesis is that there is a mathematical structure for teaching map analysis that provides a common foothold in understanding the concepts, procedures and considerations that resonate with both non-GIS and GIS communities.	
Session 1 (2 hours). Modern digital maps are "numbers first, pictures later." In map-*ematical* processing, these data can be conceptualized as a set of "floating maps" with a common registration that enables the computer to "look" down and across the stack of map layers to spear or coral sets of numbers for processing. *Spatial Analysis* involves quantitative analysis of the "spatial context" of mapped data, such as add, subtract, multiply, divide, exponentiation, root, log, cosine, differentiate and even integrate maps. In addition, the spatial coincidence and juxtaposition of values among and within map layers create new mathematical operations, such as effective distance, optimal path routing, visual exposure density and landscape diversity, shape and pattern.	
(.5 hour)	**Maps as Data** — Discrete map objects vs. continuous geographic space — Grid data types, structures and display — *Spatial*STEM classes of analytical techniques
(1.5 hour)	**Analyzing Spatial Context** *(Spatial Analysis)* — **Basic GridMath & Map Algebra** *(+ - * /)* — **Advanced GridMath** *(Math, Trig, Logical Functions)* — **Map Calculus** *(Spatial Derivative, Spatial Integral)* — **Map Geometry** *(Euclidian Proximity, Narrowness, Effective Proximity)* — **Plane Geometry Connectivity** *(Optimal Path, Optimal Path Density)* — **Solid Geometry Connectivity** *(Viewshed, Visual Exposure)* — **Unique Map Analytics** *(Contiguity, Size/Shape/Integrity, Masking, Profile)*
Session 2 (2 hours). *Spatial Statistics* involves quantitative analysis of the "numerical context" of mapped data, such as characterizing the geographic distribution, relative comparisons, map similarity or correlation within and among data layers. Spatial Analysis and Spatial Statistics form a map-*ematics* that uses sequential processing of analytical operators to develop complex map analyses and models. Its approach is similar to traditional mathematics except the variables are entire sets of geo-registered mapped data.	
(1.5 hour)	**Analyzing Numeric Context** *(Spatial Statistics)* — **Basic Descriptive Statistics** *(Min, Max, Median, Mean, StDev, etc.)* — **Basic Classification** *(Reclassify, Contouring, Normalization)* — **Map Comparison** *(Joint Coincidence, Statistical Tests)* — **Unique Map Statistics** *(Roving Window and Regional Summaries)* — **Surface Modeling** *(Density Analysis, Spatial Interpolation)* — **Advanced Classification** *(Map Similarity, Maximum Likelihood, Clustering)* — **Predictive Statistics** *(Map Correlation/Regression, Data Mining Engines)*
(.5 hour)	**Spatial Modeling** — Modeling structure, processing hierarchy and analysis levels *(Suitability Model example)* — Calibrating and weighting model criteria — Simulating alternative scenarios and perspectives
Optional Session 3 (2 hours).	
(2 hours)	**Independent Lecture/Lab Material Development** — Participants work with the instructor to "tweak" workshop materials for use in their classes

About the Instructor

***Joseph K. Berry** is a leading consultant and educator in the application of Geographic Information Systems (GIS) technology. He is the author of the popular books Beyond Mapping, Spatial Reasoning and Map Analysis, author of the Beyond Mapping column for GeoWorld magazine for over twenty years, and written over two hundred papers on the theory and application of map analysis and modeling techniques. Since 1976, he has presented college courses and professional workshops on geospatial technology to thousands of individuals from a wide variety of disciplines. He holds a B.S. degree in forestry from the University of California, Berkeley, a M.S. in business management and a PhD emphasizing remote sensing and land use planning from Colorado State University.*