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Commentary

Spatial thinking and scientific urban planning

The revolution in digital geospatial (also termed spatial information) technology has created a new wave of enthusiasm for 'scientific' urban planning—the third in the 100-year history of modern urban planning. Since the beginning of the last century urban planners have alternately embraced rational planning, rigorous scientific methods, and exploitation of technology, only to reject scientific city planning when the application of the technology and the theory of the day failed to produce the overly optimistic results advocates had promised. Geospatial technology for urban planning including allied visual and 3-D modelling technologies holds far greater promise than earlier waves of technology. However, to maximize the returns of this historic opportunity, planning students and planning practitioners need a realistic and practical framework to appreciate the strengths and weaknesses of both spatial information and associated technologies. This commentary will place current developments in geospatial technology and spatial thinking in a historical planning context, will outline both realistic possibilities and limitations of geospatial technologies, and will suggest a practical approach to spatial thinking education for urban planners ranging from baseline spatial literacy to specialized knowledge experts.

The vision of scientific city planning—wave 1: the city scientific movement (1909 – 30)

The audience at a plenary session of the fifth US National Conference on City Planning (held 1913 in Boston) responded enthusiastically to George B Ford's assertion that "city planning is rapidly becoming as definite a science as pure engineering" (Ford, 1913, page 551). Ford continued to champion the 'city scientific' or 'city practical' movement until his death in 1930. The first wave of modern city planning was an idealistic movement, optimistic that planning could ameliorate the dreadful conditions in industrial cities of the time. Leading planners believed in scientific city planning, but support soon waned. Cities simply lacked the money and staff capacity to gather necessary data. Available technology was incapable of handling the data analysis that scientific city planning required. Ford and other city scientific planners failed to develop the theory and operational skills to perform the types of quantitative analysis that would produce useful results. Efforts at scientific city planning championed by the earliest professional planners failed to meet expectations (Boyer, 1983; Scott, 1995). From the 1920s to the 1940s, planning academics and practitioners shifted their focus from the 'city scientific' planning approach to the art of planning 'garden cities', preparing 'city beautiful' designs, planning metropolitan regions, and neighbourhood unit design. The goals of first-generation 'city scientific' planners were admirable: to replace uninformed, politicized, often corrupt, city decision making with rational, quantitative data analysis and objective, value-neutral, scientific decision making. However, the city scientific planners' belief that optimum planning decisions could be obtained by analyzing city physical features using the technology and methodology of the time proved hopelessly naïve.

Had the first-wave city scientific planners acknowledged the complexity of city systems (and relations among them) and couched their agenda in terms of helping decision makers to make more informed decisions rather than claiming that 'best' solutions could be derived scientifically, they may have been more effective. Had Ford and his followers developed a realistic curriculum to teach city planners applied social science methods and management skills, that would have been an important supplement to the planning education of the time, which consisted almost entirely of architectural design at the city scale (Hall, 2002).

Wave 2—the systems revolution (1965 – 73)

A second wave of enthusiasm for scientific solutions to urban problems—the 'systems' approach—arose in the mid-1960s. During this period 'systems analysts' broke problems into component systems and used statistical packages and operations research techniques on mainframe computers to analyze and improve the systems. Some visionary academic urban planners, regional scientists, and traffic engineers began to use mainframe computers and the systems approach to analyze, forecast, and model urban systems (Hall, 2002; Taylor, 1999). Advocates of the systems approach in urban planning argued that individual city systems—such as a traffic system—could be modelled in the same way that auto industry analysts modelled systems for producing and distributing a car. With a sufficiently robust model, enough data about land use, demography, and commuting patterns, and the time and money for model calibration, transportation analysts believed that by using the systems it would be possible to, for example, forecast future traffic flows precisely enough such that they could specify the 'best' location for a given motorway/highway (Breheny and Hooper, 1985).

As with the earlier 'city scientific' movement, claims for systems analysis and large models again proved overstated and disenchantment with systems planning set in (Meyerson and Banfield, 1964). In a 1973 'requiem' for large-scale urban models, Douglass Lee concluded that none of the goals for large-scale urban models developed in the 1960s and early 1970s had in fact been achieved (Lee, 1973). Lee's fundamental critique revolved around the inability of large-scale models to accurately model complex urban systems. The ultimate problem, Lee argued, was a combination of a lack of adequate theory and the sheer complexity of cities. Disillusioned with the limitations of large-scale urban models and preoccupied with other issues, many university departments of urban planning deemphasized systems planning and large-scale modelling in the 1970s and 1980s and shifted their attention to a variety of other qualitative and normative approaches (Hall, 2002).

Wave 3—the digital spatial information revolution (1990 – present)

We are in the midst of a third wave of enthusiasm for scientific city planning. The current wave is driven by new possibilities engendered by the use of georeferenced data and geospatial technologies both to analyze and to plan cities. It is grounded in the new field of GIScience (Longley et al, 2005), which is a core component of what Dibiase et al (2006) have termed 'GIScience and Technology' (GIS&T), which incorporates GIScience, geospatial technology, and their applications. Geospatial technology encompasses a subset of those information technologies that manipulate georeferenced data and includes GIS as well as elements of remote sensing, mobile computing, computer assisted design, visualization, and other allied technologies (Dibiase et al, 2006). Also critical to wave 3 is theory about virtual reality system design, cellular automata models, and complexity (Batty, 2005; Longley and Batty, 2003). What can these new geospatial technologies and the increasing emphasis on 'spatial thinking' really do to improve the practice of urban planning? What can we learn from the past boom – bust cycles of enthusiasm for scientific urban planning to craft a realistic and potentially long-lived use of these technologies? How should planning students be educated about spatial thinking and geospatial technology? It is perhaps helpful to distinguish geospatial technology concepts and operations in relation to their level of difficulty. Paradoxically, spatial thinking and geospatial technology operations are becoming both more accessible and more complex at the same time, calling for their use in urban planning along a continuum.

A three-tier approach to UK spatial planning education for planners

Urban planning education seeks to equip students with theoretical concepts and practical skills to perform roles related to land use, transportation, and environmental planning and other spatial planning concepts (RTPI, 2004). A postgraduate (masters) degree in urban planning is increasingly common as the exit professional degree for city planners, though some planners end their initial planning education with an undergraduate degree in urban planning or a related discipline such as geography. A small number of students who intend to teach at university level or do specialized research go on to obtain PhDs in urban planning. A tiered approach to spatial planning education would recognize and address the different needs of these different groups of students.

Level 1: generalist spatial thinking education

Generalist urban planners should be spatially literate. All planners should understand core spatial concepts relevant to urban planning and should possess rudimentary GIS skills. Understanding core spatial thinking concepts, what the key geospatial technologies are, and how they can be applied to solving urban problems should be a required part of the initial planning education of undergraduate and graduate urban planning students and continuing education (CPD) for practicing planners. Spatially literate generalist planners should understand the importance of scale, map projections, and good cartographic design. They should understand thematic mapping concepts such as differences between mapping absolute values and ratios. They should be familiar with geographical concepts such as the modifiable area unit problem (MAUP), spatial manifestations of the ecological fallacy, and how choropleth maps generalize data and conceal complexity. Graduates with this level of exposure to spatial thinking would not be equipped to do much analysis or technical work with GIS, but would nevertheless be informed consumers of spatial information and be sufficiently aware to avoid making common errors. For example, planners often use indices of multiple deprivation which are produced, particularly in the UK, on an intermittent basis but each time use a different methodology and set of data. It is therefore not possible to measure change over time using these indices, but this often happens in practice owing to a lack of understanding by users of such techniques.

Current trends in technology mean that formerly technically demanding GIS operations have been increasingly automated with user-friendly menu-driven graphical user interfaces. The ease of performing very basic GIS operations has also been aided by the development of what has become known as Web 2.0, in particular the development of user-generated multimedia content (Anderson, 2007). The prominence of web-based mapping programmes and virtual globes (Rakshit and Ogneva-Himmelberger, 2008; Tuttle et al, 2008) now allows the generalist user to perform basic GIS operations on spatial data, such as change scale, find features, zoom, pan, turn map layers on and off, perform attribute and spatial queries, and produce usable custom maps, with much of the very basic functionality of a GIS. Further, this technology allows users to capture their own empirical spatial data and create cartographically acceptable maps and visual representations of reality, what Goodchild (2007; 2008) has termed 'volunteered geographical information' (VGI). Here users are in effect building their own spatial databases on the web from the bottom up, as exemplified in initiatives such as OpenStreetMap (rather than the more usual top-down approach as represented by national mapping agencies). As a consequence, two-dimensional and three-dimensional urban imagery accessible to unskilled users is proliferating on the web. In short, according to Goodchild (2007, page 213), technological developments have led to the 'democratization of GIS', although others would disagree (Elwood, 2006).

Level 2: core professional spatial thinking education
For intermediate users, spatial thinking and the application of geospatial technologies to urban planning merits a required full course or the equivalent time devoted to this material in modules (most likely within methods and analysis courses). Commercial out-of-the-box GIS can teach fundamental software-independent spatial thinking skills that will make urban planners better consumers of planning-related spatial information. They incorporate point-and-click interfaces and icons that make it possible for beginning students to perform many useful spatial analysis operations that would have required a high level of specialized skill a few years ago. Undergraduate and postgraduate planning students can master a useful starter set of operations in these GIS in one or more module(s) or a single course.

Recent studies identify and describe core spatial thinking concepts (National Research Council, 2005) and GIS&T education curriculum design (Dibiase et al, 2006), which allow progression beyond level-1 concepts. A twelve-week course with a one-hour lecture and a two-hour practical each week should provide a solid foundation in this material equivalent to the substantive content of existing introductory GIS&T textbooks or books designed specifically to teach GIS to urban planners. A number of writers have proposed useful competency-based spatial thinking models for practitioners (DiBiase et al, 2006; Gaudet et al, 2003; LeGates, 2009a; 2009b). A competency-based model for UK planning education proposed by LeGates (2009b) identifies desirable spatial thinking competencies for planners in six areas—cognitive foundations, technical competency, competency in cartography, spatial analysis, and interpersonal relations, and understanding the relationship of GIS to other software—and spells out competencies appropriate for planners at different academic levels and with different specializations.

Level 3: specialized spatial thinking education
A small number of specialized urban planners will devote most or all of their time to using spatial information technology to produce analyses and maps, teach spatial planning courses, or work to develop spatial planning. For sophisticated users, advanced spatial analysis is intellectually demanding (de Smith et al, 2007). In addition, creating virtual reality representations that allow viewers to walk or fly through three-dimensional urban landscapes or creating web 'mashups' that bring real time data from multiple sources together, require programming skills. Conceptualizing and programming cellular automata models to show interaction effects between urban variables over long periods of time (Batty, 2005; Longley and Batty, 2003) are also difficult. A single introductory spatial thinking course or the equivalent is therefore not enough for these students. Students completing their initial planning education who intend to undertake spatial analysis in planning themselves should have completed a number of spatial thinking courses and have some expertise in applying the material to planning. Large planning programmes at universities that have the staff/faculty and student depth to mount multiple courses may be able to offer their students a sequence of beginning, intermediate, and advanced spatial analysis courses taught by faculty within the planning department itself. For example, in the UK, The University of Manchester requires an introductory 'spatial thinking' course, builds modules applying spatial analysis into practical courses, and offers more advanced spatial analysis courses in the analysis and monitoring of spatial planning policy and outcomes (LeGates, 2009a). In the US the Massachusetts Institute of Technology, Rutgers, the University of Akron, and the University of Illinois Urbana-Champagne offer multicourse specialized tracks in spatial analysis for urban planners (LeGates, 2006). Postgraduate planning programmes with spatial planning specializations can choose to admit students with substantial

backgrounds in spatial thinking, such as those graduating from GIScience, geomatics, or geography degrees and then require, encourage, or permit them to pursue additional courses in GIScience, geomatics, and/or geography, as well as specialized and integrative spatial planning courses.

Conclusion

Geospatial technologies represent a fundamental change in our ability to plan cities. However, overblown claims and unrealizable projects to exploit these technologies still run the risk of disillusioning people, as occurred in the historic waves of enthusiasm for scientific planning. Planning is both a normative and a political process, both an art *and* a science. Science can produce better decision making, but science per se cannot solve planning problems. GIS is therefore not a panacea to the planning process, but neither is it a static technology incapable of development. A recent (December 2008) specialist meeting was held in Santa Barbara (California) to explore the connection between GIS&T and the 'design sciences' (including planning), in order to push GIS forward. From this, Goodchild (2009) identified several key questions*: To what extent are the fundamental spatial concepts that lie behind GIS relevant in design? To what extent can the fundamental spatial concepts of design be addressed with GIS? Is it possible to devise a curriculum designed to develop spatial thinking in both GIS and design?* In relation to the first two questions, Couclelis (2008; 2009a; 2009b) has suggested that, although many core spatial concepts and much spatial thinking are similar, there is scope to augment 'analytic' GIS to reflect the normative 'design sciences' interest with 'purpose' and 'function', as encapsulated in the 'spatial plan'. This hints at a future characterized by fruitful collaboration between GIS&T professionals and design scientists, such as planners and architects, towards both an improved geospatial technology which is even better suited to planning cities and improved spatial thinking in both GIS&T and planning.

In relation to the third question, we would argue that, as a baseline, all urban planners should be spatially literate. Generalist planners should master a core set of spatial thinking skills and a starter set of spatial analysis operations. More specialist planning students should be able to do advanced work bridging planning and GIS&T sufficiently to qualify them to do or teach spatial analysis or engage in research that will advance the field. Imbuing planning students and practitioners with a respect for geospatial technologies and a realistic understanding of the strengths and limitations of these technologies is important. Cities are too complex and planning decisions too normative for planners to provide scientifically 'best' solutions. But a realistic incorporation of spatial thinking concepts along with the use of geospatial technology such as GIS into urban planning education and practice will produce better spatial planning.

Richard LeGates, Urban Studies and Planning, San Francisco State University
Nicholas J Tate, Department of Geography, University of Leicester
Richard Kingston, School of Environment and Development, University of Manchester

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