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Analysing Heritage Landscapes with Historical GIS: contributions from problem-based inquiry and constructivist pedagogy

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ABSTRACT *This article examines a practical classroom experience using GIS technologies to analyse aspects of a local heritage landscape. An inventory of historic buildings comprising architectural and construction details was revised in the field and then analysed using GIS software. Elements of the geographies of these buildings were displayed using thematic mapping and students used these maps to develop explanatory hypotheses and to suggest policy options for future management of the heritage landscape. Practically, the project demonstrated the contribution GIS can make to historical geography methods, engaged students in an externally supported research partnership working with real-world data, and suggested directions for local public policy formation. Pedagogically, the project demonstrated that historical GIS can be used effectively to shape problem-based inquiry and constructivist learning.*

KEYWORDS Historical GIS, heritage buildings, student research, constructivist pedagogy

Introduction

In an era of declining research budgets, increased pressure to educate students in the use of more sophisticated analytical techniques and public calls to introduce students to the policy environments of the world outside the university, instructors must adopt creative ways to teach historical geography. Further, historical geography now faces the need to train students not just in the use of traditional archive sources but also in the numerous computer methods that are transforming analytical aspects of the sub-discipline. This article reports on a project designed: (1) to demonstrate the application of computerised geographic information systems (GIS) and digital databases to issues in historical geography; (2) to engage real-world historical data with all their richness, complexities, omissions and ambiguities; and (3) to bring students into contact with the heritage

management needs of the local municipal planning environment. In doing so, this project incorporated undergraduate students into a funded research programme, giving them experiences with research design, data quality control and product. The key argument of this article is that GIS technologies lend themselves to incorporation into problem-based inquiry and can contribute significantly to constructivist pedagogy within historical geography and heritage landscape management.

GIS as a Learning Tool for Geography

This article addresses three related issues in the GIS and geographic pedagogy literature: first, teaching GIS and other forms of computer-mediated learning; second, the presently under-developed discussion of the application of GIS technologies to teaching historical geography; and third, connections to the substantial literature on problem-based inquiry and constructivist pedagogy.

Much of the early literature on computer-mediated learning in geography was dominated by highly specialised discussions that concentrated on the technical aspects of computer-mediated resources (including the teaching of statistical methods, physical geography, remote sensing and exploring the uses of the Worldwide web) but had far less to say about broader geographic pedagogy (Shepherd, 1985; Rees, 1987; Flowerdew & Lovett, 1992; Bishop *et al.*, 1993; Bishop *et al.*, 1995; Newnham *et al.*, 1998). While recent discussion has moved beyond the mechanics of specific computer methods to engage theoretical and practical pedagogical issues involving the integration of computer-mediated learning into the classroom (Kemp *et al.*, 1992; Walsh, 1992; DiBiase, 1996; Foote, 1997; Krygier *et al.*, 1997; Summerby-Murray & Ollerhead, 1997), there remains considerable scope for the evaluation of computer-mediated methods as pedagogical tools.

A significant debate confronting educators in geography in this discussion is the extent to which the introduction of GIS into curricula constitutes training in a particular skill or contributes to broader themes of geographic education. As GIS entered the core curriculum of geography programmes through the 1990s, this debate became increasingly sophisticated. For example, a special 'Open Forum' section of *The Professional Geographer* in 1993 revisited Dobson's 1983 article on automated geography with contributors critiquing the nature of technical training and the impact of GIS in furthering what was seen to be a strongly empiricist agenda (Dobson, 1983, 1993; Armstrong, 1993; Cromley, 1993; Goodchild, 1993; Marble & Peuquet, 1993; Monmonier, 1993; Pickles, 1993; Posey, 1993; Shepherd, 1993). The contributions of Pickles and Shepherd to this forum, with their questioning of the nature of scientific knowledge rendered in a GIS, provided a conceptual foundation for the later suggestion of three perspectives, ranging in a continuum from 'GIS as tool', through 'GIS as tool-making' to 'GIS as science' (Wright *et al.*, 1997a; see also Goodchild, 1985; Pickles's 1997 response to Wright *et al.*, 1997a; and a subsequent reply by Wright *et al.*, 1997b). The present study situates GIS within the latter perspective and provides a practical example of how GIS functions within a scientific research design that considers fundamental issues surrounding geographic information such as scale, abstraction, boundaries, data quality, assessment of uncertainty and modes of display and representation (Kemp *et al.*, 1992, p. 183; Wright *et al.*, 1997a). The emphasis in this approach is not on the use of GIS technologies as a mechanistic tool or on the technicalities of software design, innovation and modification but rather on the scientific inquiry processes by which

geographic phenomena are measured, generalised, analysed and represented and how these processes are sharpened through the use of GIS technologies.

The second issue to consider in the GIS and geography pedagogy literature is the slow adoption of GIS technologies into mainstream historical geography, despite calls for those working with historical data to “take advantage of the analytical potential of cartography” (Foote, 1992, p. 121) and the sophisticated database querying and mapping available for historical spatial analysis within a GIS. In large part this reflects the difficulties of constructing suitable historical databases and digital boundary files and in geo-referencing historical statistical information. Some exceptions within historical geography include theoretical work considering the potential role for GIS in measuring the time dimension and its impact on the nature of geographic inquiry (Peuquet, 1994; Harvey, 1997), the use of mapping capabilities of GIS software to assess scalar distortion in historical cartography (Locke & Wyckoff, 1993) and the analysis of detailed historical databases, particularly at national and sub-national scales as in the case of the Great Britain Historical GIS (Miller & Modell, 1988; Southall & Gregory, 2000). However, there is little exploration of the pedagogy of GIS within historical geography and only a few examples of the application of GIS to heritage landscape management (Taylor, 1994; Paine & Taylor, 1995).

In addressing this deficiency, the present study applies GIS technologies to an analysis of historical buildings and students are forced to grapple with the difficulties of real-world database construction where historical sources are frequently imperfect, incomplete and unreliable. Research on historic buildings, generally, can draw on a wealth of existing data contained in municipal tax records, building construction and inspection records and fire insurance reporting. These systematic historical records can be supplemented with specialty surveys, of the sort reported in this article, contextualised through archival work in business papers and family histories, and connected to contemporary property development processes (Wyatt, 1997). In this way, GIS technologies complement more traditional historical geography methods.

The third context for this study is found in the way in which the use of real historical data and practical GIS technologies situates this project clearly within a problem-based constructivist pedagogy. Numerous authors have pointed to the need to integrate practical and theoretical elements of GIS into geographic education and to go beyond simply understanding the intricacies of proprietary software (e.g. Foote, 1997). While some of this discussion has concentrated on the practical difficulties of financing laboratory space and appropriate technical support or even what DiBiase (1996) refers to as the split personality of GIS education divided between technical skill and general concepts (Walsh, 1992; DiBiase, 1996; Audet & Paris, 1997), the strongest outcomes occur when GIS is matched with problem-based inquiry or what Sui (1995, p. 581) refers to as “real, substantive issues facing modern society” (Hill, 1994; Klein, 1995; Bradbeer, 1996). Whether it be the siting of sanitary landfills (White & Simms, 1993) or analysis of business directories to chart regional variations in company names (Alderman & Good, 1996), the most successful examples of integrating GIS into curricula come when students are enabled “to understand the unique properties of geographic information” and develop “critical appreciation of the social context and implications of its production and use” (DiBiase, 1996, p. 66). Further, such pedagogy encourages students to become contributors to the development of community policy (Buckingham-Hatfield, 1995).

Central to a problem-based inquiry is a constructivist approach to the creation of knowledge (Yell and Scheurman (1998) summarise useful resources). Constructing the nature of inquiry, either cognitively or socially, goes well beyond a behaviourist

processing of information and instead encourages students to deal with the realities of data quality, the varying and contingent problems that need to be solved in the course of research, and the need for interaction and dialogue within the research process (Scheurman, 1998). Scheurman suggests that learning processes can be characterised as those that deal with the processing and replication of objective knowledge or those that arise within the experiencing and constructing of a subjective knowledge. Loosely, these divisions correspond with what Kolb (1984) has described as passive and active learning types (Brown, 1999). Despite earlier concerns that an empiricist tendency within GIS education would lend itself to a behaviourist information transfer of objective knowledge as a dominant pedagogy (Shepherd, 1993), Sui (1995) argues that GIS offers strong connections to geography's methodologically diverse intellectual core. It is a small step to argue, as this article does, that GIS can serve a constructivist pedagogy within this intellectual core by developing student research experience and highlighting the constructed nature of research problems and policy outcomes.

GIS and the Analysis of Historic Buildings in Sackville, New Brunswick

Project Background: defining the problems

This project has its origins in an earlier study that sought to identify large-scale heritage landscapes in and around Sackville, a small town (population 6000) in New Brunswick, Canada (Summerby-Murray, 1999). The present project focuses at a much finer spatial scale by using a GIS to integrate individual property information, civic address information and a field-based revision of the Sackville section of the Canada Inventory of Historic Buildings (CIHB) carried out initially in 1973 by the Parks Service of Environment Canada. The GIS was then used to map thematic analysis of designated historic building architecture and geographies of construction patterns between 1770 and 1914. The project was developed as the major research experience for a one-semester third-year undergraduate historical geography course. The lecture, seminar and laboratory components of the course allowed the practical aspects of the study to be supplemented with conceptual discussion of heritage landscapes and their socially constructed and contested nature, concentrating particularly on the commodification of historic landscapes for heritage tourism purposes and questions of historical accuracy, authenticity and exclusion (Johnson, 1996; Graham *et al.*, 2000). With funding from internal university research grants, a GIS technician was hired from the local municipal planning authority and agreements to gain access to data were negotiated with the planning authority, the municipality and a provincial government department.

The project was explained to students as having a variety of 'problems' that they had to solve as small groups: an outdated architectural database requiring revision; a field identification problem; technical problems relating to the incorporation of the revised database and appropriate digital boundary files into the GIS; querying and display issues within the mapping analysis; problems of interpreting maps in terms of resultant geographic patterns; and developing recommendations which would offer future direction for local policy initiatives in historic building protection, development restrictions, heritage tourism and public education. This policy aspect was particularly significant in that the project was conceived as a partnership between students and agencies external to the university mentioned above. The partnership stopped short of a binding contractual agreement but the realisation that they were involved in a piece of work of direct relevance to these external institutions was a motivating force for students. Further, this

TABLE I. Learning objectives, research design and pedagogical outcomes.

Primary learning objectives	Research problems	Research design to overcome problems	Type of learning activity (after Kolb, 1984, & Brown, 1999)	Type of learning activity (after Scheurman, 1988)	Type of knowledge (after Scheurman, 1988)
1. Demonstrate application of GIS in historical geography	1. Disconnected databases	1. Identify relevant databases	Passive	Process and replicate	Objective
		2. Develop method of connecting historical spatial data	Passive	Process and replicate	Objective
		3. Train students in GIS	Active	Process and replicate	Objective
		4. GIS analysis and mapping	Active	Experience and construct	Constructed
		5. Evaluate method	Active	Experience and construct	Constructed, subjective
2. Engage real world data	1. Data inaccuracy and identification issues	1. Group fieldwork	Active	Experience and construct	Constructed
		2. Group discussion, speculation and problem solving	Active	Experience and construct	Constructed
	2. Abstraction, representation, and display	3. Data entry	Passive	Process and replicate	Objective
		4. Data quality control	Active		Objective
		5. Developing research themes	Active	Experience and construct	Constructed
		6. GIS analysis and mapping	Active	Experience and construct	Constructed
		7. Research paper	Active	Experience and construct	Constructed
		8. Critique method and suggest alternative resources	Active	Experience and construct	Constructed
3. Develop policy outcomes	1. Policy as a social construction	1. Research paper and policy recommendations	Active	Experience and construct	Constructed

sort of partner relationship was recognised as beneficial by those allocating research funds within the university. The various project problems, an outline of the research design, and the pedagogical goals of the project are summarised in Table I.

Connecting Research Problems, GIS and Learning Objectives

The primary learning objectives of the study noted in Table I were translated into a project design that focused on a series of problems. Some of these problems were solved

by the course instructor and technician while others were the result of group learning processes. After outlining how a research design was developed to overcome these problems, the remainder of this article turns to an assessment of the types of learning involved and the contribution of GIS.

The first problem of the project was simply that the databases identified as being of most relevance to the project lacked a common connection. The proposed solution was to use a GIS and some common reference data to join the databases. The property identification number (PID) from the municipal tax assessment records was determined to be the most practical means of linking the civic address, property information and CIHB databases. This method relied on field-checking each property to ensure an accurate match. Data entry of the PID numbers was carried out by the instructor and technician, rendering this part of the project largely passive in terms of student learning. More active learning occurred during the training of students in the mechanics of ArcView® GIS, although the processes concentrated on replicating techniques of table joining rather than analysis.

The second set of problems revolved around data accuracy and spatial identification within the three project databases. This was the most difficult, time-consuming and productive aspect of the project as it was here that students were challenged to consider that any GIS is only as good as the database to which it is applied. Further, developing a usable database was not simply a laboratory exercise but involved group work to assess the built environment in the field and raise hypotheses to confirm accurate identification of buildings. While the property information database (containing tax assessments, ownership information, mortgage information, and other geo-referenced data) was accurate as of December 1997 and was largely unproblematic, the 1973 CIHB and 1998 civic address databases contained numerous errors and inconsistencies that were a key part of the learning process in this problem-based exercise and highlighted the way in which knowledge about heritage is a constructed product.

The CIHB database was developed from a series of architectural surveys carried out in the early 1970s for a selection of residential, institutional, commercial, industrial and other buildings constructed before 1914 and designated historically significant largely on the basis of age. While a sophisticated critique of the accuracy of the architectural data was beyond the scope of this study, it was clear that the CIHB suffered from a building identification problem that rendered it largely inaccessible to researchers and policy makers. Table II displays the categories of information available for each building listed in the CIHB. Further, it was suggested at the outset of the project that the CIHB reflected implicit assumptions about the designation 'historic' and thus could be used to raise questions about the values associated with the heritage landscape. Using GIS was suggested as one means of questioning these assumptions and bringing them into a discussion of local heritage planning policy.

The civic address database listed information on 1998 property owners, 1998 street addresses and any earlier street numbering and addressing. Developed for the introduction of an emergency 911 telephone system, in most cases the 1998 street addresses did not match with the 1973 addresses of buildings listed in the CIHB and field checking of each database entry was required. The class was divided into groups of two to four students who remained together for the subsequent analysis and constituted an important part of the informal learning environment in both the field and the laboratory, as suggested by DiBiase (1996, p. 64) and Bradbeer (1996, p. 14). Each group was assigned approximately 60 buildings listed in the CIHB and provided with 'old' civic addresses (and suggested 'new' addresses if possible), black-and-white photographs of the build-

TABLE II. Summary of information available for each building from 1998 update to 1973 Canadian Inventory of Historic Buildings database for Sackville ($n = 329$).

(a) Identification data

- Property ID #*
- Last revision date*
- 998 civic address*
- 998 geocode*
- 973 geocode
- 973 civic address
- Town location

(b) Building type and uses

- Years of construction or demolition (known and estimated)*
- Names of architect(s), builders(s), contractors(s) & engineers(s)
- Uses: present, original & associated (e.g. residential, industrial)*
- Present state: abandoned, occupied, vacant*
- Present site: original, moved, unknown*

(c) Architectural details

- Structure and plan: mass (single detached, row), plan view, number of wings, dimensions in metres, number of storeys, number of bays on façade
 - Basement construction: above ground, partial, full below ground, materials
 - Exterior façade wall: materials—earth, wood, stone, brick, composite materials, concrete, metal, glass, same as other exterior walls
 - Wall construction, e.g. horizontal log, mortise and tenon, nailed frame
 - Decoration, e.g. plain, arcading, columns, buttress, quoins, tie rods, half-timber, crenellation, date stone
 - Roof: type, surface material, eaves trim, verges, towers, steeples and domes, dormers, chimney style and location
 - Windows: location, shape, trim, sill type, number of sashes, opening mechanism, pane arrangement
 - Main entrance: location, shape, trim, number of door leaves, panels per leaf, main stair location and direction, porch type, materials, height and special features
 - Alterations or additions to style
 - Property features: fences, gates, garden feature, water feature, other
 - Recognized historic or archaeological site
-

Note: * Information revised or added in 1998.

ings in 1973, data recording sheets to update address information and add comments on obvious architectural features, use or occupancy, and disposable cameras to capture a new photographic record (these subsequently provided the basis for a digital image bank). The fieldwork component was vital to the project, not simply because the database could not be revised accurately in any other way but also because it reinforced the spatial significance of the data and the manner in which data are abstracted and represented in tabular and graphic form. The field component also gave students some sense of ownership over the revised database, something that is next to impossible with pre-packaged tutorial exercises.

In practical terms, the field-based data collection component produced a series of unanticipated problems beyond the research design, which had to be solved by students in the field. Dealing with inconsistent (non-sequential and multiple) civic addresses proved difficult. In some cases, buildings had held five different addresses since the 1970s. Some buildings were identified by popular name rather than number and in at least one case such a name was transferred to another building on the opposite side of a street from that listed in the earlier survey. Only by careful field observation were students able to piece together some of these connections, which were then verified by

documentary and archival sources. Reproduction of photographs taken in the 1973 survey was poor and hampered easy identification of buildings, particularly when buildings of similar style were located in close proximity, as is the case on many Sackville streets. What were initially thought to be distinctive architectural features were found to be reproduced on many buildings, confusing the identification process but opening up new questions about geographic patterns for later analysis. Further, the 1973 photographs were taken in mid-summer and foliage often obscured parts of buildings. Students identified a similar problem with their own 1998 photographs taken in mid-January: parts of buildings were obscured by snowdrifts, although the lack of foliage allowed easier viewing of building architecture. Perhaps the most frustrating field identification problem came from the removal and destruction of buildings listed on the 1973 inventory. In an area of new commercial development, for example, a total of 11 historic houses had been removed. While some were destroyed, others were relocated to other parts of the town or outside the municipal area. For example, one house was moved 100 metres to another site, displacing another historic house which itself was then moved to yet another property. The only obvious links here were the family name of the owners and some limited architectural detail from poor photographs, providing students with first-hand evidence that research often resembles detective work. The identification problem was of such magnitude that by the end of the class field component of the project, only 45 per cent of buildings on the 1973 database had been identified with complete certainty. Later work (using homeowner interviews, tax records, and subsequent fieldwork) brought this rate to 61 per cent, still leaving a substantial portion of the 1973 inventory unusable.

To develop strategies for solving these various identification problems, the instructor worked with each group in the field, helping to identify useful clues such as evidence of earlier civic numbers, obvious building alterations and other 'local knowledge' of ownership patterns. In this way, students were encouraged to use the surrounding landscape as a resource, suggesting other buildings or features that would help identify the building in question, talking to building owners if available, writing speculations and reasoning in the field, and developing a list of further information they felt would be necessary to ensure a positive identification of the building. Each group reported their successes, difficulties and speculations back to the class at the weekly briefing session, although this proved less effective than informal discussions that occurred in the computer laboratory. Encouraging students to see the common difficulties in their field experience was hampered in part by the relative independence of each group and the flexibility given them to carry out the field component. Organising a two- or three-day intensive field component with ongoing debriefing was impossible because of student timetables and the end result was a wide variability in the quality of fieldwork.

Overall, the field component both contributed to increasing students' practical understanding of data collection and provided them with a more informed view on the limits of the GIS database and its subsequent interpretation. A key gain for students was a demonstration that empirical research in historical geography is multi-faceted: the GIS would not give them the answers automatically, fieldwork can produce both confirming and contradictory evidence, traditional documentary sources still play an important role, and solid deductive reasoning skills lie at the basis of research. To these should be added the practical environmental difficulties of doing fieldwork in cold climates when the weather is at its most inclement: low temperatures making film brittle in cameras, frozen and inoperable ball-point pens, cold fingers and indecipherable writing, photographs streaked with horizontal snow and sleet, rain-soaked data sheets despite all plastic

protection and drenched, hypothermic students being rescued from the field on Saturday mornings in the instructor's car. All of these were part of an active learning process that involved experience and experiment and a heightened sense that both the mechanisms of enquiry and the nature of data produced were constructed projects.

Returning to the laboratory, students updated the geo-referenced entries in the CIHB database. These entries were reviewed by the instructor and GIS technician in a multiple-source checking procedure involving the early photographs and current tax assessment data listing ownership and other details. This quality control process also involved acting on many of the students' recommendations for the use of other sources. With each entry verified, students were required to submit their labelled 1998 photographs. These were mounted on a new data sheet (Figure 1) and further property identification information was added. The datasheets were scanned as graphics images in preparation for inclusion on a CD-ROM and the property identification numbers were entered into the main architectural database to provide a link to the attribute table of the property-based digital boundary files of the area. This largely mechanical element of the project involved few problems for students. Most were already familiar with basic spreadsheet operations and some already had considerable experience working with scanned computer images.

Using ArcView[®] GIS to link the updated CIHB database to other property databases and developing subsequent thematic queries brought students face to face with a further research problem arising from the use of real-world data, the second of the primary learning objectives of the project: issues of abstraction, representation and display in the use of geographic information (Kemp *et al.*, 1992). Within minutes, each group was able to display cartographically the results of quite sophisticated queries of the revised CIHB database. The initial class assignment called for each group to produce one map demonstrating an aspect of the spatial patterns of historical buildings that might illustrate some of the conceptual elements of heritage landscape management discussed in the lecture and seminar component of the course. This map was then to provide the basis for each group's policy recommendations. It quickly became obvious that the instructor's single-map requirement had under-estimated both the speed and complexity of the GIS analysis and the abilities of students to explore new permutations of the querying and display aspects of the software. Many groups chose instead to produce a series of maps to reinforce the conceptual point of their analysis, focusing on particular building periods, architectural elements and sociopolitical geographies.

The final learning objective of the project was to develop a set of recommendations that policy makers (local heritage planners, land-use regulators, developers, and/or the public and commercial tourism industry) would find useful and to assess these in the light of such heritage policies being socially constructed and contingent. Because much of the heritage management literature covered in the course had focused on issues of authenticity and social exclusion in the derivation of heritage landscapes, it was no surprise that student groups produced interpretations of the GIS cartography based on such themes as 'élite construction', 'absence of the labouring landscape' and 'industrial buildings and built heritage'. Scholars such as Horne (1993, p. 376) have referred to this élite bias within historic building inventories as the 'under-representation problem', pointing to the dominance of residential and institutional buildings that represent high culture, wealth and economic and political power.

Using these concepts, students developed research papers that drew on their empirical experience from the GIS analysis, describing their methodology and analysing geographic patterns. The resulting recommendations in the student papers ranged from

