Opening up GIS Training and Education – Building an IIGLU

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Summary:
The increasing availability of free data and software, along with the recognition of the power of Geographical Information Systems as an integrator of data from diverse sources and in varying formats has led to an uptake in the use of GIS by non-expert users. However, GIS remain complicated to use. GIS tutorials generally involve following step-by-step instructions to accomplish a specific task, whereas GIS books often focus on concepts with no link to software packages. IIGLU has been built to bring these together, presenting concepts as a simplified tutorial with links to instructions for multiple GIS packages.

KEYWORDS: open education, inter-disciplinary GIS, end users, open data, spatial concepts

1. Introduction

Traditionally, geographical information was produced by official or commercial data providers (Goodchild in Schuurman 2009). However, more recent advances in positioning, web mapping, mobile communications and Web 2.0 (Goodchild 2007, Haklay et al. 2008, Elwood 2009) led to increasing availability of data (Budhathoki et al. 2008) much of which is free (Coleman et al. 2009). Official datasets are being released (e.g. the Ordnance Survey's 'Open Data'[1]); academics are being encouraged to share research data (EPSRC 2011).

This increase in data is coupled with a reduction in expertise of the users of this data (i.e. users of Geographical Information Systems, GIS). Formerly, users were GIS experts with training in spatial data management and an understanding of GIS concepts such as error. However, the availability of free GIS software (e.g. Google Earth Builder, Quantum GIS[2]) and access to University-wide licenses for software such as ESRI's ArcGIS[3] encourages non-specialist users to make use of GIS.

Such free data and free software is encouraging, and will allow non-specialist users to take advantage of the ability of GIS to act as an integrator of data from diverse sources and in different formats. Indeed, with a rising trend in inter-disciplinary research (Britsh Library 2010) this is going to be more important. However, GIS are hard to use (Davides and Medyckyj-Scott). While training material does exist (e.g. ESRI's *Virtual Campus*), software-specific learning can result in mechanistic operation without an understanding of underlying concepts. Concepts can be learned from books (e.g. Longley et al. 2011) but these do not generally provide links as to how to accomplish tasks in specific software packages. In both cases, the needs of users outside the discipline of GIS specialists are generally not well catered for.

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[1] http://www.ordnancesurvey.co.uk/oswebsite/products/os-opendata.html
[2] http://www.qgis.org/
[3] http://www.esriuk.com/industries/subindustry.asp?indID=21&SubID=104

This paper describes the development of IIGLU (Interactive, Integrated, Geographic Learning and Understanding) – a framework created to overcome these issues.

2. The IIGLU Framework

IIGLU is an online framework, consisting of three components designed to take users through a discipline-specific path towards GIS understanding and use. The first part of the framework consists of an online series of **decision flow diagrams** to help users to identify specific scenarios based on their own level of expertise and discipline. Figure 1 shows one of the starting diagrams. Users are asked to choose whether they wish to learn about GIS through discipline-specific information, and if so given a choice of disciplines where tutorials have been created. Users wishing to gain an understanding of general GIS concepts can click the option to the right.

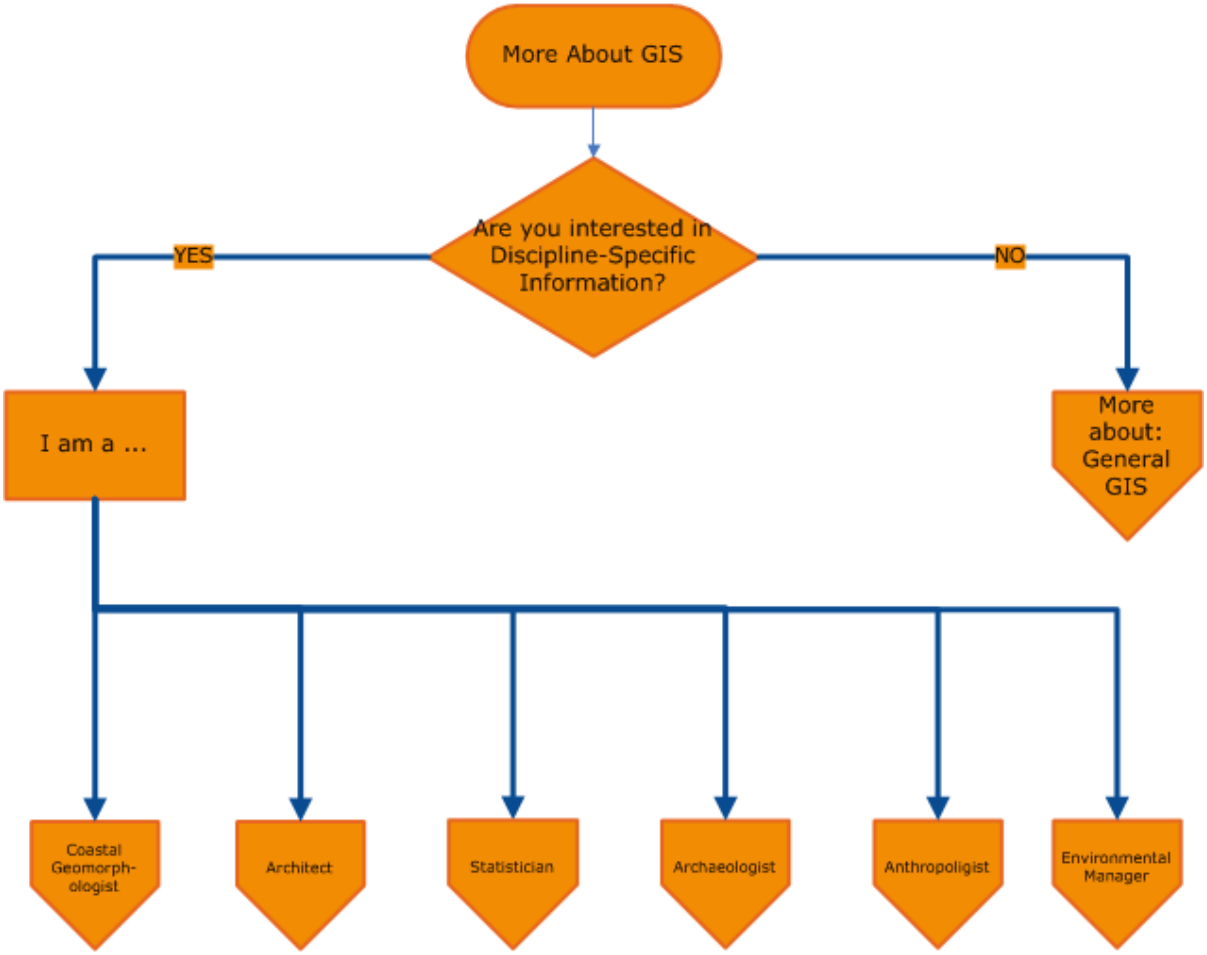

Figure 1 - Example IIGLU Flow Diagram

The flow diagrams link to **scenarios** where the user interacts with maps, videos and other teaching material. Information is presented in small chunks (tutorials, which are broken into smaller steps) and the software is designed to ensure maximum usability. In contrast to traditional tutorials, users are not required to follow step-by-step procedures ('open this file', 'zoom to this location') – instead they simply click on 'next' or 'previous' buttons and can focus on concepts rather than on an instructions list.

Figure 2 shows Step 1 of a scenario designed to introduce beginners to the concepts of data quality and why it is important to understand their data before using it inside the GIS. The student reads the text in the grey panel, performs the requested activities on the map and then clicks '*Next*' to move to the next step of the tutorial.

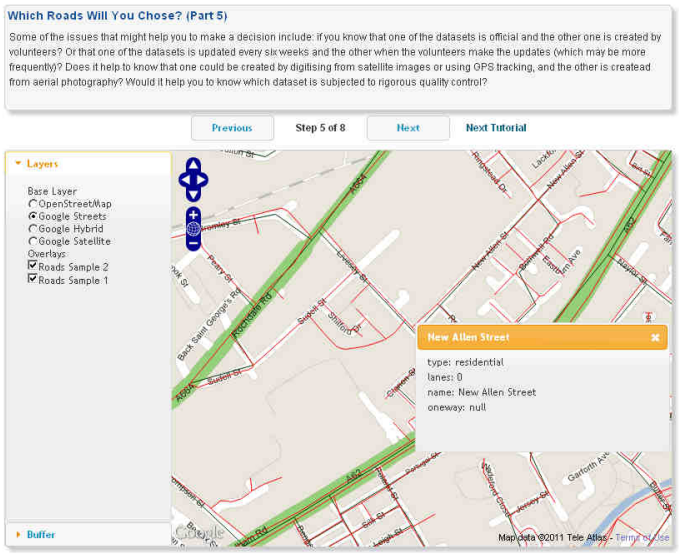

Figure 2 - IIGLU Web Mapping Scenario Step

Along with the text in the grey panel, scenario material can consist of the map (as shown in Figure 1) with both base-map layers provided (OSM, Google Streets, Hybrid and Satellite), as well as the ability to include teacher provided vector layers. For each step, different base maps and/or vector layers can be switched on. Users can zoom in and out and pan, switch layers on and off and find out information about the map data (by hovering over data with the mouse). Buffering functionality can also be added to a map-based scenario element, to demonstrate basic spatial analysis functionality.

A second type of interaction is provided through the form of a video link, where a You Tube video can be embedded into the scenario. This allows IIGLU to take advantage of a wide range of available material presenting GIS concepts (Figure 3).

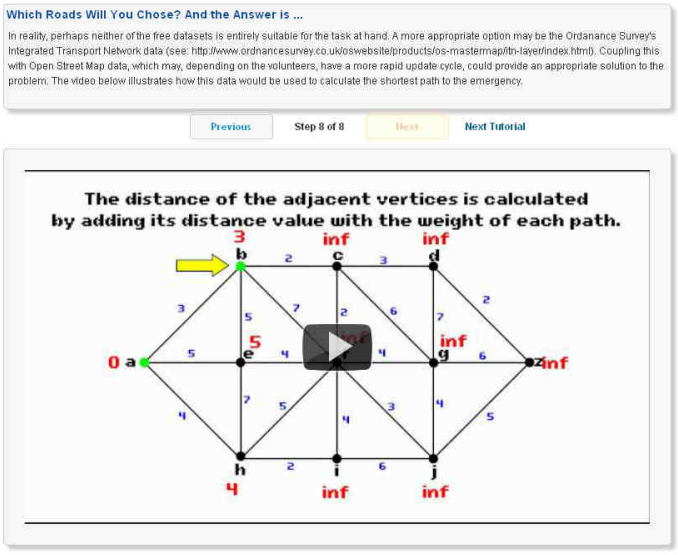

Figure 3 - IIGLU Video Scenario Step

Additionally, links can be made to HTML text (or links to other HTML or online material) can be used

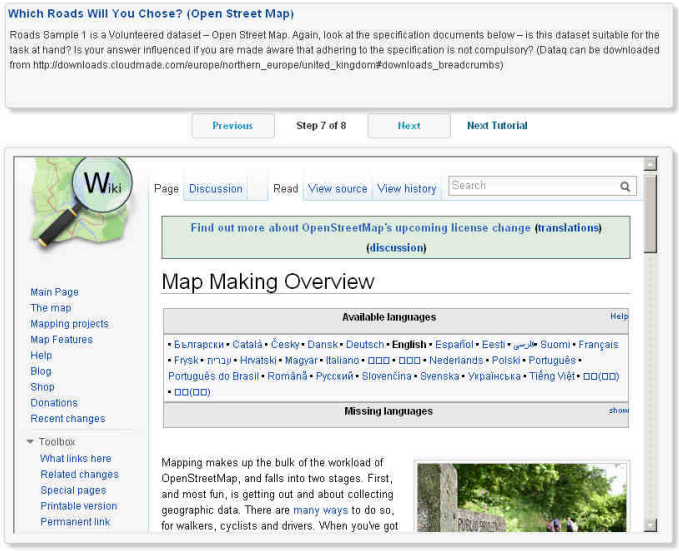

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Figure 4). This option in particular gives the scenario developer great flexibility in terms of the type of material presented – it could be simple images, additional text, a document (e.g. PDF) or more interactive HTML material. Links to entire web pages can also be made and these are embedded inside the IIGLU page.

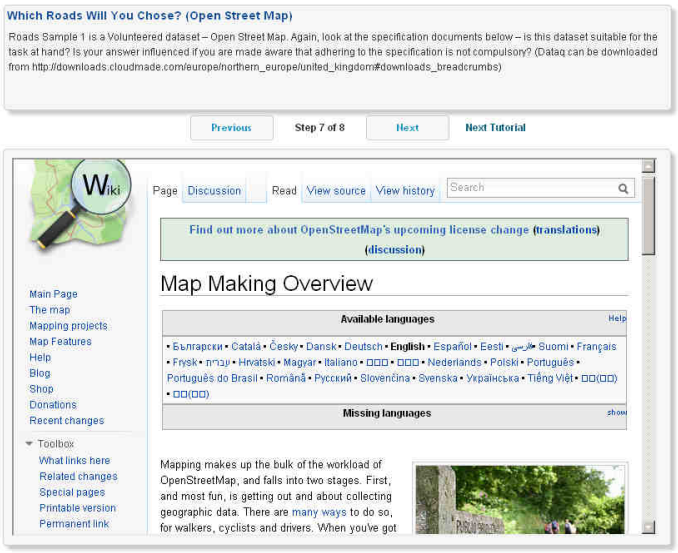

Figure 4 - IIGLU HTML Scenario Step

The scenarios and the flow diagrams link to the third component of the framework, the **IIGLU wiki** which gives instructions on how to perform a specific task in a named GIS, with appropriate links to further training material. For example, users may wish to know how to create a map from a file containing comma separated values. They are first asked to check if the file has coordinate values in a column, and if so directed to the process for the specific GIS of their choice. It is important to note that the Wiki does not re-create data import instructions from scratch, but rather links to resources provided by the specific software vendor. However, the Wiki does highlight differences in terminology used by the different vendors (are they *layers* or *themes*, is it a *choropleth* or *thematic* map?). Both students and teachers can contribute to the Wiki, which is a central resource to bridge the gap between

concept and software, and also provides lists of sources of data and GIS packages and links to further tutorials.

3. IIGLU Technology

The technologies underpinning IIGLU take advantage of the free, open source trends that drive the need for IIGLU itself. IIGLU is built using the GeoDjango[4] framework on the server-side, and a client-side making use of JavaScript, JQuery[5], HTML and CSS technologies, along with a PostGIS[6] database which is used to store both scenario content and spatial datasets. Web mapping is enabled via the OpenLayers[7] framework.

GeoDjango is a framework designed to facilitate the building of GIS-based web applications, and to enable the use of spatial data on the web. It is based on the Django framework, a Python based web app development framework that was originally designed to handle fast-moving news websites. Django offers an object-relational mapping capability making the web app code database agnostic, a Model-View-Controller paradigm for the structured development of web apps, as well as an integrated template language for the creation of html outputs, resulting in a clear separation between data, code and outputs.

The OpenLayers framework is an open source JavaScript library used to provide web mapping services, integrating data from Open Street Map and Google Maps, as well as from the IIGLU database to offer a range of options to scenario developers. JQuery provides a pre-prepared library of JavaScript functions that enable handling of events, animation and AJAX calls.

Utilising the PostGIS database in conjunction with GeoDjango provides both an appropriate method for data storage & management, as well as the power to perform spatial data operations on the data. This offers an opportunity to provide more extensive functionality to scenario developers – concepts such as area measurement, point-in-polygon and so forth could be offered as tools and selected depending on the different disciplinary scenarios.

The IIGLU Wiki uses MediaWiki[8] software, which was originally created to drive WikiPedia, and which is an extensively used open and customisable wiki framework. The editing tools inside the Wiki may also already be familiar to scenario creators and students, and extensive tutorial material is available if required. Microsoft's Visio tools are used for flow diagram creation, offering direct embedding of HTML links into the flow diagram elements, as well as easy export to HTML pages for uploading onto the IIGLU website.\

4. Using IIGLU

Two user roles exist in IIGLU – *teachers and GIS experts*, who create material, and *students* who use material specific to their discipline.

4.1 Teachers and GIS Experts

Teachers use IIGLU to create new flow diagrams and scenarios for different contexts and disciplines. The flexibility of IIGLU means that teachers can include existing text-based

[4] https://docs.djangoproject.com/en/dev/ref/contrib/gis/
[5] http://jquery.com/
[6] http://postgis.refractions.net/
[7] http://openlayers.org/
[8] http://www.mediawiki.org/wiki/MediaWiki

material (as an HTML or PDF page), or videos of classroom sessions (*lecture casts*) as well as creating their own GIS exercises using the web-based mapping tools. They can upload required datasets in KML format, thus adding layers to the map as required by their scenario.

Importantly, discipline-specific IIGLU scenario creation can be done in conjunction with specialists, with interviews leading to a case study. This involves the GIS expert gaining an understanding of the other discipline, identifying typical data used and tasks that could be performed in a GIS. Once the tasks are identified, these are then mapped to concepts in GIS, and a scenario developed combining the concepts with discipline specific context. As shown in Figure 5, the scenarios themselves are developed as a series of small tutorial steps. Each step is recorded as a '*state*' which can be reused. States can also be re-ordered if required.

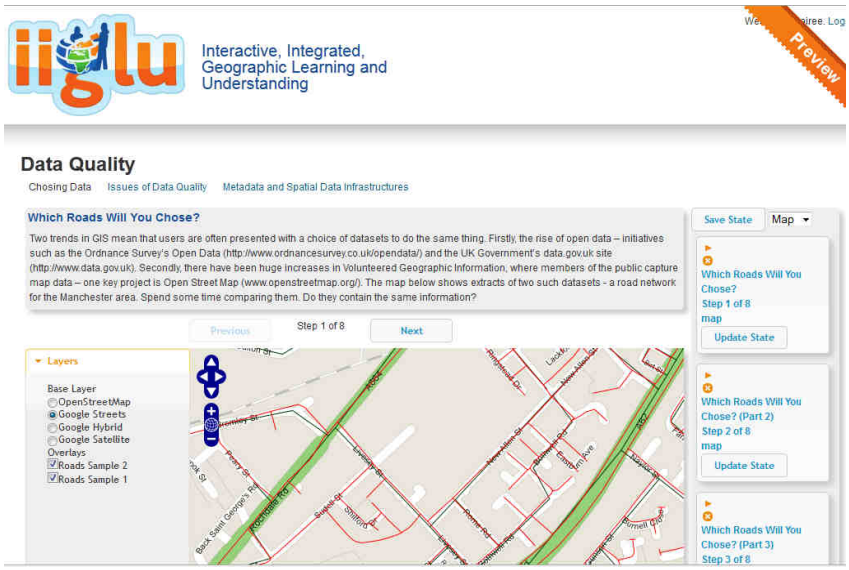

Figure 5 - IIGLU Scenario Steps – Teacher Perspective

4.2 Students, Academics and Researchers wishing to know more about GIS

Students, Academics and Researchers wishing to familiarise themselves with GIS first work through the decision flow diagrams to find an appropriate entry point to the teaching tools. They can then work through scenarios at their own pace, moving backwards and forwards as required. Finally, they can make use of the information in the Wiki to apply the concepts learned. Depending on the entry point, only a very basic level of internet knowledge is assumed, with a core assumption being that the student is not familiar with GIS in any form (although some may have used Google Maps or similar).

5. User testing

As an integral part of this project, the evaluation of the system will be conducted using a case-control user test, including students from the Digital Humanities MSc from the Anthropology department at UCL, with no prior GIS knowledge. Students will be divided into 2 groups. The first group will be given a step-by-step exercise to complete using a proprietary software package (for example ArcGIS), while the second group will make use of IIGLU first before doing the step-by-step GIS exercise. Both groups will afterwards be questioned about their understanding of the spatial processes they just engaged with. Comparing results between groups should highlight significant differences in understanding

of spatial concepts, between users who first used IIGLU and others who just used a GIS package.

6. Outcomes and Further Work

To date (November 2011) two full scenarios have been developed – *Water Catchments* and *Data Quality*. These clearly demonstrate the end-to-end value of the IIGLU framework, and highlight the rich material that can be developed when mixing the methods used for teaching concepts rather than basing tutorials only on map or data activities. IIGLU is currently in Alpha development, with testing (both usability and functionality) due in 2012. It is planned to open the tool up to the wider teaching community to develop a set of discipline-specific scenarios for use by academics and researchers.

Current functionality could also be extended to provide a wider range of map-related options for scenario developers including the ability to demonstrate shortest path calculations, choropleth mapping, area and length measurement as well as other options such as point-in-polygon functions. In all cases, however, the requirement for such functionality will be based on discipline-specific needs determined by meetings with potential end users. The potential to add functionality such as the ability to link directly to external datasets, such as those provided via Open Geospatial Consortium's Web Map Service and Web Feature Service standards, will also be evaluated.

Another possible avenue for further research and development is the potential tracking of student progress through the different scenario steps. IIGLU could record, and compare student state with a predefined teaching state to recognize and for example determine if the student has reached the correct position on the map, at the correct zoom level and with the correct layers and info boxes switched on or off, to automatically progress to the next state. This comparison to 'correct' values, along with an added ability to ask questions of the student and validate their answers, will help to ensure that student understanding of a particular concept is reached and that they are not simply clicking through the tutorials.

IIGLU has been developed specifically to help non-specialists from other disciplines learn GIS concepts using material and data that was already familiar to them. Given the increasing open data and open software currently available, IIGLU provides the open education required to make sure GIS is used by as wide an audience as possible. Users will develop a fuller understanding of the potential of GIS software and data, and this in turn will ensure that such tools are applied appropriately and with scientifically valid outcomes.

7. Acknowledgements

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8. Biography

Dr Patrick Weber is a Teaching Fellow at the Department of Civil, Environmental and Geomatic Engineering at University College London. He recently completed his Engineering Doctorate in Spatial Decision Support Systems, where he developed an interest in the application of usability design practices for the implementation of GIS projects. Dr Patrick Weber also has research interests in the evaluation of VGI projects adoption and interaction with the general public.

Claire Ellul is a Lecturer in Geographical Information Science at University College London. Her research interests include 3D GIS, Spatial Data Infrastructures and data management in multi-disciplinary research projects and the use of GIS technology in Extreme Citizen Science.

Dr Catherine (Kate) Jones is a lecturer in Human Geography in the department of Geography at the University of Portsmouth with 8 years expertise in delivering GIS projects, analysis and mapping solutions for variety of public sector bodies: local councils, London Metropolitan Police and NHS Primary Care Trusts. Having been awarded her MSc in GIS in 2003 she completed her PhD in 2008 and worked as a post-doc on an interdisciplinary academic research project (2007-2009) - all at UCL. She is an expert within the field of cartography, usability analysis and useful and useable GIS for enabling and developing spatial capabilities for non-domain experts.