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Geo-Ed

Using open-ended geographic information system assessments to allow students to construct relevant geographies given the internationalisation of tertiary education in New Zealand

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Abstract: The geospatial skills shortage in New Zealand requires the development of more undergraduate geographic information system (GIS) courses. However, the internationalisation of New Zealand's tertiary education system has resulted in an increasingly diverse tertiary student population, which makes it challenging to teach GIS in a way that maximises relevance to all tertiary students. One approach to this challenge is to make use of the recent proliferation of openly available GIS data, and to internationalise GIS curricula by using open-ended assessments that provide students with the opportunity to learn GIS by constructing their own geographies of relevance.

Key words: context, geographic information system, geospatial, learning, open data, teaching.

Teaching GIS with relevant geographies

There is currently a geospatial skills shortage in New Zealand, and there is a need for tertiary education to develop undergraduate courses to teach geospatial technology such as geographic information system (GIS) software (de Róiste 2014). Developing GIS courses can be challenging as there are a variety of approaches to GIS education that balance a duality of teaching about GIS or with GIS (Sui 1995), which equates to perceptions of GIS as either a tool or a science (Wright *et al*. 1997). But as both technical skills and scientific analysis are considered important by GIS employers and educators (Wikle & Fagin 2015), core GIS competencies to be taught should include both technical knowledge and skills and the ability to think scientifically about geographical issues (Schulze *et al*. 2013). While there is clear evidence of the most important topics to teach about GIS as a tool (Wikle & Fagin 2014), how best to teach GIS as part of geographical science is a more difficult for an instructor to determine. But what is critical is that GIS be taught in a context that has relevance to the student, which should be quite possible given GIS can relate to all kinds of geographies (Sui 1995).

In some geography courses, it is the geography itself that is the learning objective.

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However, for GIS courses, the learning objectives are technical skills and analytical knowledge. Therefore, the geography being used to teach GIS should be foundational knowledge that the student already possesses on which to build GIS knowledge and skills. The geography is being used simply to set the context for the student in order that the GIS learning objectives have relevance. In this setting, the geography should be as relevant as possible to the student so that the geography becomes a bridge between the student and the GIS learning objectives, rather than presenting an additional barrier that must also be overcome.

To illustrate, while teaching GIS computer laboratories based solely on US data, I have observed that the technical GIS learning objectives were sometimes being diverted due to a student's unfamiliarity with US geography. I suspect that this was frustrating for students, as they were no longer learning GIS, but instead were first having to learn US geography, which was understandably perceived by some students as having no relevance to them.

To examine this issue of learning GIS with relevant geographies, I included two specific questions within a voluntary and anonymous end of course evaluation for an introductory GIS course. This single cohort consisted of 35 New Zealand-based undergraduate students from whom 22 responses were provided. When asked 'Do you think having lab exercises using GIS data for locations you are familiar with would help you learn GIS?', the responses suggest that many students would benefit from learning GIS using relevant geographies:

- 'Bringing a bit more context to things around us would definitely make it more interesting and would pull me in to understand things better.'
- 'It would not matter much for me, but it might make things more interesting.'
- 'Using GIS data for locations students are familiar with would definitely help learn faster how to use a GIS.'
- 'Yes definitely . . . often the US examples would tell you to find this or locate that and just expect [you] to know where said place or location is.'
- 'Yes! It took a while to navigate US maps.'

However, while there appears to be a preference for learning with data from more familiar locations, when the students were asked 'From what locations would you like to use GIS data?' there was less clear picture of what those locations should be:

- 'New Zealand or maybe Australia.'
- 'New Zealand would be better than UK or USA . . . but I must admit, I learned a bit about the US.'
- 'Makes no real difference.'
- 'Not quite sure.'
- 'New Zealand examples. Or well known historical areas.'
- 'Ultimately, it might make no difference as you should be able to work with [a] variety of data both familiar and unfamiliar.'

While New Zealand is highlighted as a location of interest by some of the students, it is possible that geographical relevance is not necessarily achieved simply by teaching solely with New Zealand geographies. The anonymity of the course evaluation precludes identifying the nationalities of the students making comments, but it is possible that the lack of a clear geographic preference might be a result of the geographical diversity of the students. Of the 35 students invited to participate, 40% were New Zealand citizens, 20% were foreign-born residents, and 40% were international students. This created a cohort of students representing a global community with representatives from all inhabited continents. Such geographical diversity within a New Zealand tertiary classroom will not be unusual given the internationalisation of tertiary education in New Zealand.

The internationalisation of New Zealand tertiary education

Reforms to New Zealand's education policy from the mid-1980s encouraged the development of education as a form of export commodity. There has been enormous growth in the number of international students since 2000, and tertiary education exports are now a significant contributor to the national economy (Martens & Starke 2008). Recent growth in international students has been driven by students from Asia, in particular China and India, but there are international tertiary students in New Zealand from countries throughout the world (Fig. 1).

The internationalisation of New Zealand tertiary education also results from immigrant students who, although resident in New Zealand, may have different cultural values and perceptions to education that need to be recognised and accommodated (Jiang 2010). As with international students, the growth in resident immigrant students is driven mainly by arrivals from Asia, particularly from China, India and South Korea. However, there are also a large number of immigrant students from countries such as the UK, South Africa, Australia, Fiji, Tonga and Samoa (Fig. 2).

This evidence of the internationalisation of New Zealand tertiary education, both in terms of international but also domestic students, represents a process that is global in its extent and that shows clear patterns of growth. This has implications for designing GIS courses to meet

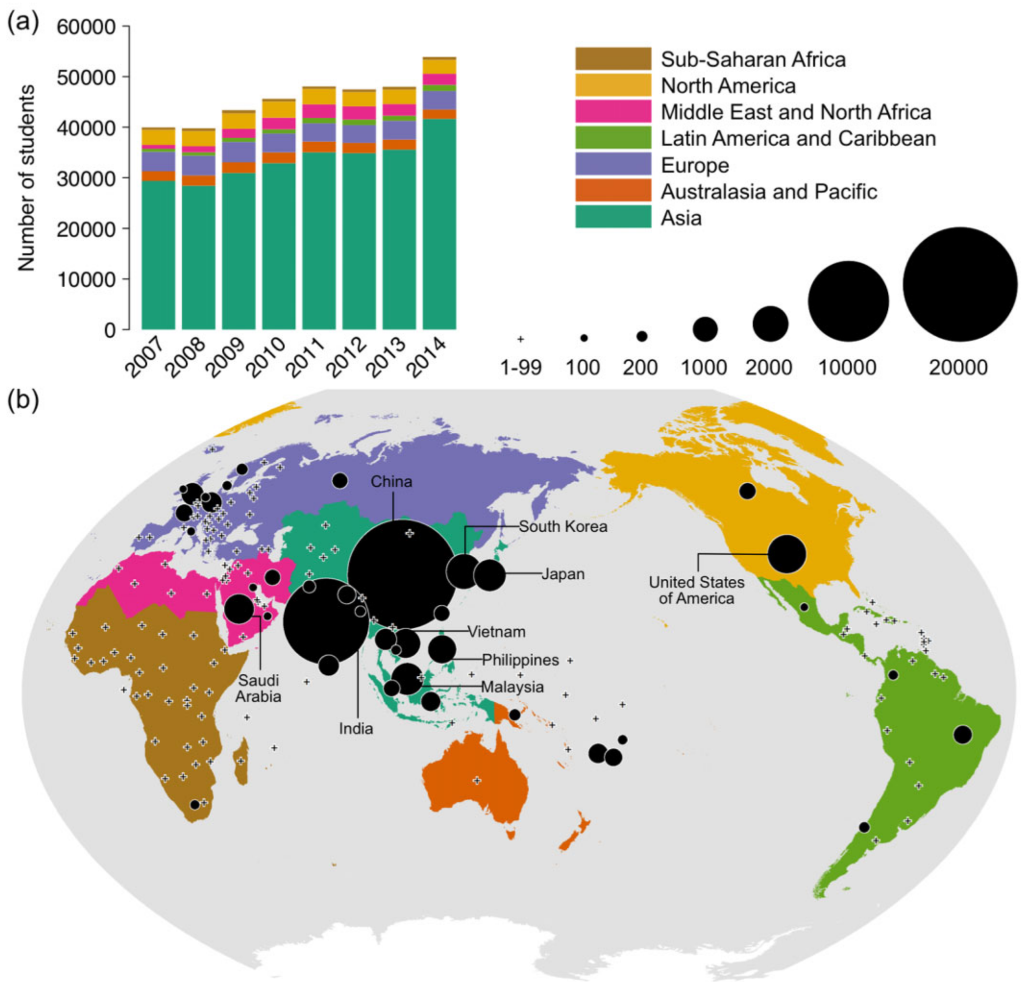

Figure 1 The numbers and origins of international tertiary students within New Zealand from 2007 to 2014. (a) The total number of students per year broken down by geographical region. (b) The number of students in 2014 from individual countries. Data are from Education Counts (http://www.educationcounts.govt.nz) and consist of counts of students without Australian or New Zealand citizenship or permanent residence status that are enrolled with a tertiary education provider, with the origin of students specified by country of citizenship.

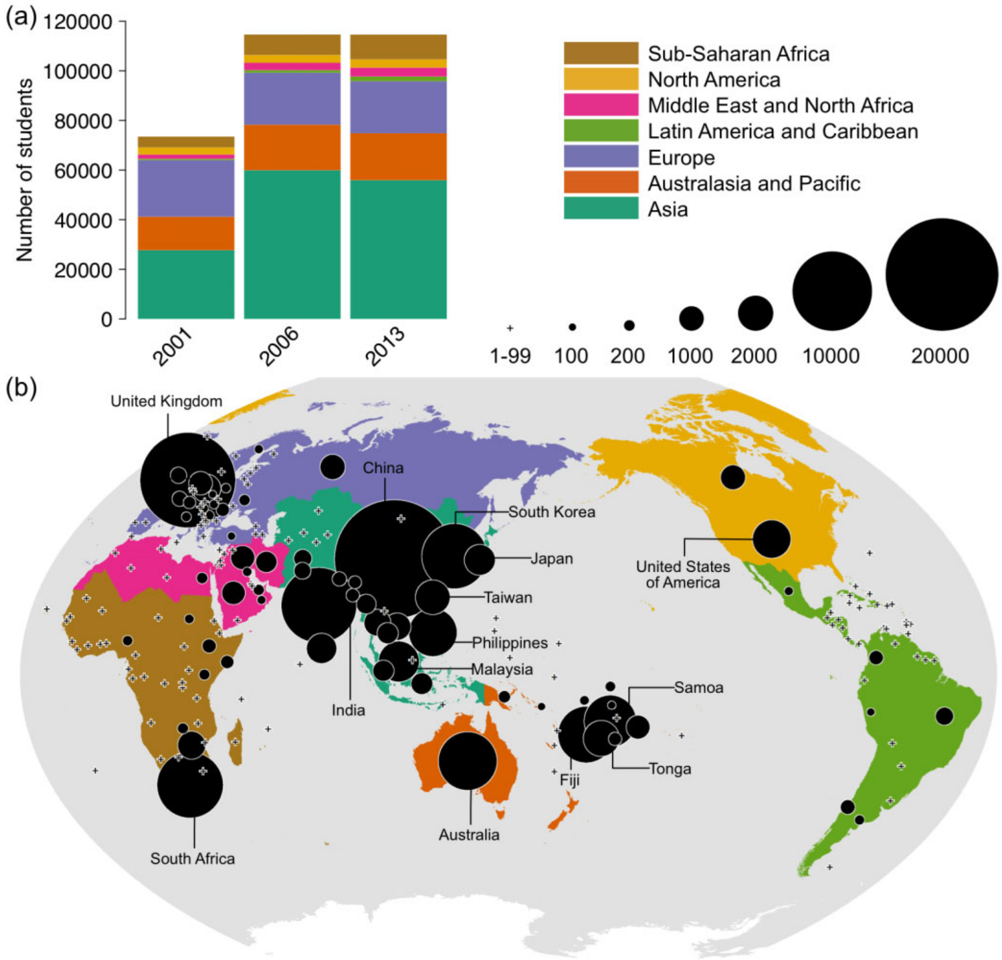

Figure 2 The numbers and origins of overseas-born tertiary students within New Zealand in 2001, 2007 and 2013. (a) The total number of students per year broken down by geographical region. (b) The number of students in 2013 from individual countries. Data are from Statistics New Zealand (http://www.stats.govt.nz/) and consist of census counts of people aged 18 and over who are engaged in studying and were not born in New Zealand, with the origin of students specified by country of birth.

the geospatial skills shortage in New Zealand, as while teaching technical aspects of GIS could be taught in an aspatial manner, ideally the teaching of more scientific GIS analytical thinking should be done in the context of a geographical issue that is perceived as relevant by the student. One approach to this situation would be to internationalise the curriculum (Haigh 2002). This will enable students to learn GIS with geographies that are as relevant as possible to their cultural context, and do not create barriers to learning by relying on prior knowledge of localised geographies that may be perceived as irrelevant. An internationalised curriculum also provides opportunities for all students to develop global thinking, which is a commonly desired graduate attribute that prepares students to work in an increasingly international and multicultural world (Haigh 2002).

Internationalising GIS curricula with open-ended assessments

So how should GIS curricula be internationalised? Initial learning activities such as lectures that introduce 'the what' and computer laboratory exercises that demonstrate 'the how' are I think necessary learning activities that require a structured approach in order to provide scaffolding on which students can construct their own learning. Therefore, I would suggest that internationalisation is probably best achieved through an assessment in which students take 'the what' and 'the how' and apply it to a more relevant geography to understand 'the why', thereby creating a learning process akin to the absorb, do and connect learning model of Horton (2012). Additionally, this process of transferring what is demonstrated in one geographical context, and applying it in another more relevant geographical context, is exactly this process that will have to be repeated by students when they have to learn new GIS skills and knowledge beyond the course; so, this type of assessment actually supports long-term learning (Boud & Falchikov 2006).

Given the geographical diversity of tertiary students in New Zealand (Figs 1,2), internationalisation of GIS curricula cannot be achieved through closed assessments that dictate the geography to which GIS skills and knowledge can be applied. Instead, the assessment needs to be open-ended to allow students to choose a relevant geography. Open-ended assessments that pose a question but require the students to choose their own approach or data encourage students to develop creative research skills and are more diagnostic of a student's abilities (Unwin 1980). The degree of openness can vary depending on factors such as the level at which the course is taught and perhaps the complexity of the GIS task. However, in all cases, open-ended assessments are a form of problem-based learning, which has been advocated as an effective approach to teaching GIS by engaging deeper levels of thinking and hence learning (Drennon 2005; Kinniburgh 2010; Read 2010).

One of the advantages of teaching GIS is that the same principles and techniques can be readily applied to data for any geographical topic and place. Therefore, it would be quite straightforward for a GIS learning objective to form the basis of an open-ended assessment that allows students to contextualise the learning objective with a relevant geography. For example, consider an open-ended assessment based on creating a kernel density map (Fig. 3a). The required input data simply needs to consist of point data with an associated magnitude value, and therefore could quite easily be applied in the context of a variety of geographical issues (Fig. 3b). Students can then choose a place of interest for which they can create a relevant geography (Fig. 3c). By constructing geographies of relevance, students are then better able to appreciate the GIS skills and knowledge that are being assessed. It will also be much easier for students to critically evaluate the results of the GIS analysis if they are familiar and interested in the geography they have created.

Of course GIS data for the same geographical region may well be interpreted differently depending on students' individual cultural characteristics such as ethnicity, gender and age. But open-ended assessments are quite capable of accommodating such a diversity of interpretations as long as the intended learning outcome and assessment task are constructively aligned (Biggs 2014). Therefore, the assessment criteria should not relate to the geography that the student has created to contextualise the GIS process, as this is simply a means of providing context for the student to aid their comprehension of the learning outcome. The assessment criteria should simply focus on the student's ability to apply and interpret the GIS technique, regardless of the geography with which this was done.

Perhaps the major obstacle to implementing such an open-ended approach is access to sufficient GIS data to support a variety of geographical topics and places. But this is becoming much less of an issue with the growth of open GIS data that is legally, financially and technically open and accessible to all (Sui 2014). There are now a wide variety of open GIS data that can be freely accessed and that can be readily adapted for use in GIS teaching (Table 1). Use of open data is also beneficial for: a teacher, as it promotes sharing of resources, and enables teaching resources to be easily updated or modified; and a student, as it introduces data resources that can be used beyond the course.

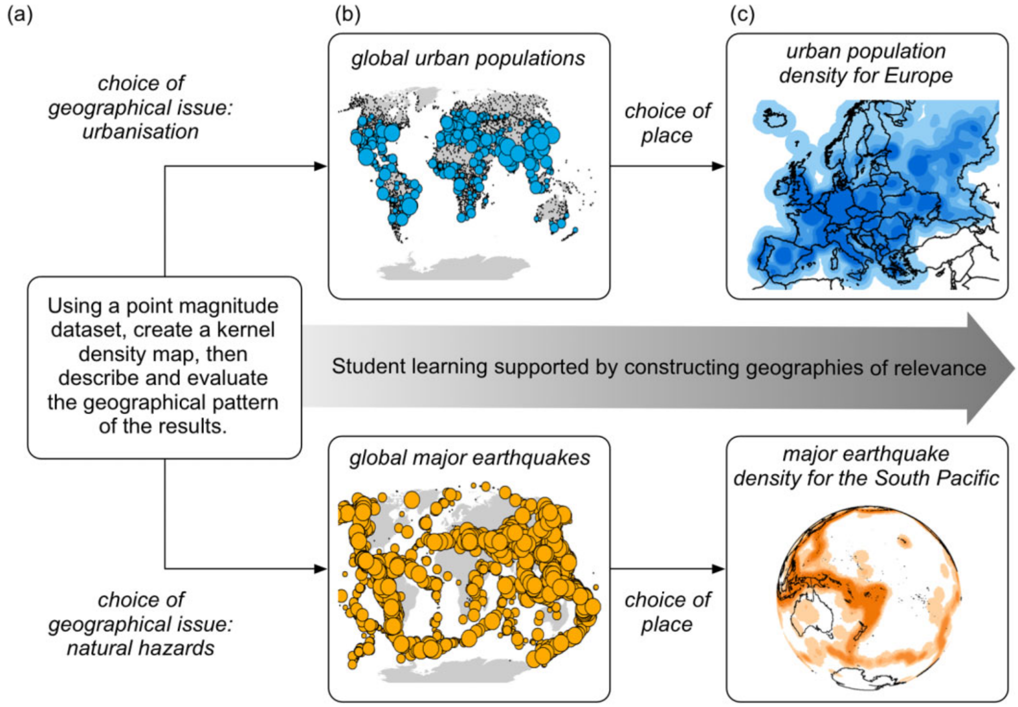

Figure 3 An example of using an open-ended assessment that enables students to learn GIS by constructing a geography of relevance. (a) open-ended assessment; (b) GIS datasets; (c) geographies of relevance.

Conclusion

The current geospatial skills shortage in New Zealand requires the development of more undergraduate GIS courses. Given the internationalisation of New Zealand tertiary education has resulted in an increasingly diverse tertiary student population, special consideration needs to be given to the way GIS courses are designed in order to maximise relevance to all tertiary students. One approach to this challenge is to internationalise the GIS curriculum through the use of open-ended assessments that provide students with the opportunity to learn GIS by constructing their own geographies of relevance.

As long as the GIS learning activities are carefully designed to preclude specific geographical requirements, the only limitation to this approach is access to relevant data that maximise the number of geographical topics and places that can be investigated by the students. However, the advent of open data has resulted in a proliferation of GIS data available for education purposes. This presents a significant opportunity for students to learn GIS with relevance, and teachers should consider beginning to design their courses with a more open-ended focus to enable students to use this resource to develop the GIS skills and knowledge that are required both within New Zealand and beyond. Finally, while the focus of my discussion has been on teaching GIS at the undergraduate level, I would also advocate a similar approach to be considered for postgraduate and even secondary level teaching.

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Table 1 Examples of open GIS data sources that could be used for educational purposes to support open-ended GIS assessments

GIS data or data portal	Brief description	URL
Natural Earth	Worldwide cultural and physical vector and raster data	http://bit.ly/1M95EJS
GeoNames	Global database of place names	http://bit.ly/1gAKxTH
OpenStreetMap	Worldwide cartographic data	http://bit.ly/1TBmDpn
Shuttle Radar Topography Mission	Near global raster elevation data	http://go.nasa.gov/1D6lleV
Global Multi-resolution Terrain Elevation Data 2010	Global raster elevation data	http://bit.ly/1Jg8pTk
OpenTopography	LiDAR data, primarily for the USA	http://bitly.com/chsKqf
GlobalLand30	Global land cover classification	http://bit.ly/1M9kWy4
Global Health Observatory	Global health statistics	http://bit.ly/1n6iwii
Socioeconomic Data and Applications Center	Data focussing on human interactions with the environment	http://bit.ly/1h7a9Sv
GeoNetwork	Data relating to a wide variety of global issues, but with particular reference to agriculture and food security	http://bit.ly/1splB6g
Environmental Data Explorer	Database of more than 500 variables related to numerous global issues	http://bit.ly/1dZwvJn
EarthExplorer	Database of Landsat imagery and other remote sensing data	http://bit.ly/1jz1vwi
National Centers for Environmental Information	Portal for data covering atmospheric, geophysical and oceanographic science	http://1.usa.gov/1I1N6IQ
NASA Earth Observations	Satellite derived about Earth's ocean, atmosphere and land surfaces	http://go.nasa.gov/1ObIf8R
Global Land Cover Facility	Remotely sensed data and products	http://bit.ly/1ObLdtR
Global Instrumental Earthquake Catalogue	Tabular data for over 20,000 major earthquakes during 110 years	http://bit.ly/1HJb0Ep
MODIS Active Fire and Burned Area Products	Point and raster data of active fires and burned areas around the world	http://bit.ly/1Jgdhbh
Aqueduct Global Flood Risk Maps	Current and future river flood risk estimates	http://bit.ly/1M9g0JM
WorldClim	Global raster climate data for past, present and future conditions	http://bit.ly/1dZwCo8
Global Carbon Atlas	Tabular data on carbon fluxes	http://bit.ly/1DwJTh0
Global Biodiversity Information Facility	Tabular data of over 500 million occurrences of over 1.5 million species	http://bit.ly/1pCqYHp
Protected Planet	World database of protected areas	http://bit.ly/1zCttkZ
Biodiversity Hotspots	Vector data delimiting areas of globally notable biodiversity	http://bit.ly/1V0lClV
Red List of Threatened Species	Ranges of species in threat of extinction	http://bit.ly/1f1rdhe
Ocean Biogeographic Information System	Biodiversity and biogeographic data and information on marine life	http://bit.ly/1ObxJOV
Argo	Global array of ocean floats that measure oceanic variables	http://bit.ly/1Sm4Obg
General Bathymetric Chart of the Oceans	Bathymetry data for the world's oceans	http://bit.ly/1ozpGi9
Atlas of Urban Expansion	Location and expansion of major urban areas around the world	http://bit.ly/1I0EILA
World Urbanisation Prospects	Global estimates and projections of urban and rural populations	http://bit.ly/1niybzm
Free GIS data	A categorised list of over 300 sites providing freely available GIS data	http://bit.ly/KSltb2

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