GETTING A START WITH GIS SKILLS ON A MEANINGFUL TASK

Approaching the question of using technology in the classroom with spatial technology

Presented by Malcolm McInerney, AGTA President

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Malcolm has received numerous awards for his work promoting GIS in Australian Schools. These include an a National Excellence in Teaching Award in 2002, an Australian Government Quality Schooling Award in 2006, and a Winston Churchill Fellowship in 2007.

Malcolm is presently the President of the Australian Geography Teachers Association and is heavily involved in the initiatives by geographers across Australia in developing a view on a national geography curriculum in Australia.

In 2001 Malcolm developed a GIS skill Development Course which is being used in over 600 schools across Australasia. 2001-2008 has also seen Malcolm become increasingly involved in the "teaching the teachers" process across Australia and beyond. The GIS Skills Course was awarded the 2002, 2006 and 2008 Australian Geography Teachers Association Award for a Geographical Education Publication and is the basis of this presentation. The course, including process documents, student worksheets and GIS project examples has been provided for all participants in the International Workshop on Geo-spatial Information Technology for School Education. This provided CD is for teacher tuition and personal use only. If participant wish to use the CD in their school for student tuition, a HK$400 school site license is available from TECHEOG at manning@chariot.net.au.

1. Preamble

Geography teachers around the world have most certainly heard about, if not used Geographic Information Systems (GIS) in geography classrooms. However for many, the steps towards introducing GIS technology and related concepts into their classroom seem rather daunting, if not insurmountable. There are a range of impediments to the introduction of GIS in the classroom, some real and some only perceived. They include factors such as software and data access, hardware availability, computer room access and teacher expertise. While not denying the existence of these very real implementation stumbling blocks, there is an urgent need to develop an achievable strategy at teacher and system level, to enable the use of GIS in the geography curriculum. This article aims to give some practical starting points that can be employed to introduce GIS into the geography curriculum. In simple terms, to introduce a teaching strategy that is premised upon the belief that GIS needs to be kept as simple as possible. Such customising of the area of GIS to the conceptual development of students and the capacities of teachers to learn the technology, is a technique that needs to be implemented if GIS is to become achievable in schools. GIS methodology developed by practicing teachers is an important ingredient in the development of GIS education. Such practitioner involvement will ensure that students and teachers feel comfortable developing the skills associated with GIS and embark on an inquiry and problem solving methodology which is the basis of good geographical education. GIS is a wonderful learning tool to enhance spatial education across the curriculum. The associated vocational outcome of making students aware of the employment opportunities for geographers in the Spatial Industry and related fields is a bonus but should not be the primary purpose of introducing GIS into schools.

2. Introduction

GIS is an innovative learning tool for the classroom and over recent years much time and effort has gone into the areas of teacher skill training and classroom resource development. This presentation will attempt to move the discussion on the use of GIS in schools into the area of classroom methodology and pedagogy. There is a need to create a philosophical and intellectual framework around the use of GIS in the curriculum. To shift the emphasis from discussing GIS as a thing to do, to a focus on an awareness of spatial learning and the role of GIS in enhancing our efforts to develop student spatial cognition and literacy. The introduction of GIS into the curriculum is more than just about the introduction and use of a new technology but really is concerned with engaging students in meaningful spatial learning. We have moved on from just using the technology as a "cool" tool.

In an effort to develop a framework to guide teachers using GIS, this paper proposes a spatial learning model as a starting point to discuss issues of methodology and approach. The processes involved in discussing the model are imperative if teachers are to crystallise their pedagogy and teaching approaches using GIS in their classroom.

Figure 1: 'Making GIS happen in the classroom' interactive CD Rom.
A comprehensive guide to using GIS in the classroom. Available from manning@chariot.net.au

3. Towards a Spatial Learning Model

To encourage a conceptual approach to the use of GIS to develop student spatial literacy, the following Spatial Learning Model has been developed.

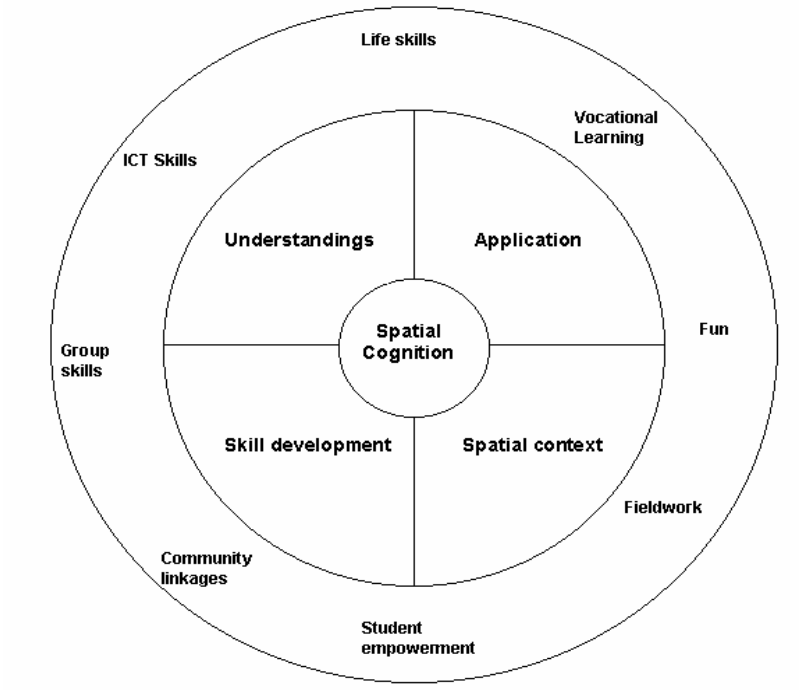


Fig 2: Spatial Learning Model to develop spatial literacy in schools

3.1. Components of the model

Various components can be identified as integral to the learning methodology of spatial learning. There is no one particular starting point but as the following pages show all components are integrated and the subsequent teaching and learning can be structured in a variety of ways depending on the needs and abilities of the student group.

Spatial context

Students to explore geographical concepts such as global referencing, scale, projections, symbols, directions and GIS application concepts such as geo-referencing, proximity, adjacency, buffering, over-layering etc. As a result, students have a spatial context and concepts within which to use GIS skills.

Application

To provide the opportunity for students to apply their GIS skills in a meaningful way via student generated project development and application.

Understanding

To reflect on the spatial processes for the purpose of developing an understanding of spatial trends and patterns that are involved in the spatial decision making of the GIS project. Associated learnings and understandings related to futures, interdependence, thinking, communication, literacy, numeracy and ICT's are identified.

GIS Skill Development

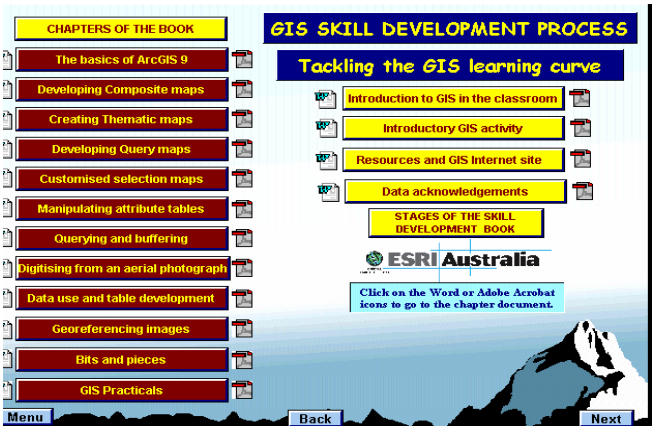
Students engage with the processes of GIS and develop skills that can be used for a wide variety of research applications.

4. The GIS Skill Development component

There is much debate whether this component should or should not be the starting point for the model. What is agreed however is that at some stage students need to be guided through an achievable and practical skill development process. Whatever skills are taught must meet the needs of the curriculum, the abilities of the students, the technology available and the capabilities of the teachers in the time available. If the skills are not required, then why teach them? Again, this topic has provided a vigorous debate between the classroom teachers, university lecturers and the spatial industry. Despite the rocky ground covered in this debate, teachers in Australia have developed a GIS Skill Development Process that has demystified and simplified GIS skills and provided a sequential approach to the acquisition of the required skills. As a result of the development of GIS skills, the use of GIS has become more achievable for teachers, more relevant to the curriculum and hence more likely to be introduced into the classroom. In short, why insist on high level GIS technical skills for teachers if their acquisition merely becomes a "roadblock" to implementation. The development of an achievable GIS Skills Development Course has customised GIS to the needs of the education system.

The GIS skills course is based on the following developmental stages:

Stage 1: The basics of the ArcGIS programme.
Stage 2: Developing uncluttered Composite maps. Cartographic skills involved in the layout stage.
Stage 3: Creating Thematic Maps.
Stage 4: Developing Query maps.
Stage 5: Making Selection maps.
Stage 6: Manipulating attribute tables.
Stage 7: Querying and buffering.
Stage 8: Digitising.
Stage 9: Data use and table development.
Stage 10: Geo-referencing images.
Stage 11: GIS Practical exercises.
Stage 12: Bits and pieces.

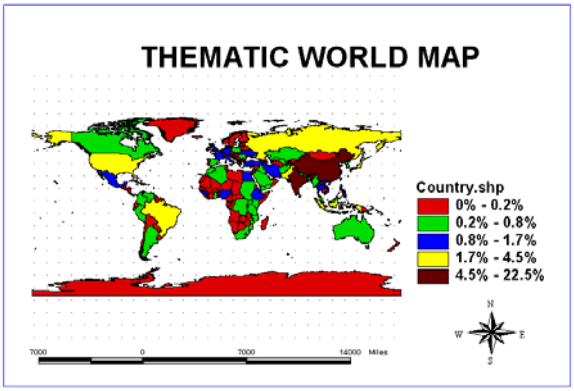


4.1. Stages of the GIS Skills Development Course

Stage 1: **Orientation to the programme**: Basic instruction in the use of the GIS software and a general awareness of the dynamics of the programme. At the end of this stage students should feel comfortable finding their way around the programme and be ready to create their first map using the programme.

Stage 2: The development of **uncluttered Composite maps:** For the purpose of simplification and student learning the phrase *composite maps* is used for maps that are simply the receivers of a diversity of data with no selection customising. Students open the provided databases and simply ask the programme to plot all the features that appear in the database. Considering the enormous amount of data involved, students finish with a rather cluttered map, showing all the layers requested. The key skills focussed on at this stage is that of map 'decluttering', making the map 'user friendly' that can be easily interpreted by the user. Some of the "decluttering" techniques employed are those of 'Map within Maps', label changes, legend creation, label moving and symbol creation.

Stage 3: **Thematic maps:** After building the *composite map*, students develop *thematic maps*. In this stage, students are given instruction on the opening of databases and the manipulation of layers via the 'Table of contents'. Such manipulation involves the customising of colours, shadings and labels to meet the cartographic needs of the map. The creation of *Layouts* involving the display of a scale bar, symbols, ruler, statistics and information are also introduced in this unit. Students should now be ready to start using and manipulating databases.



Stage 4: Query maps: This stage involves finding by search techniques, specific data from a database. This search or rather querying process and the resulting *query maps* provide a much-needed shortcut when students are searching through enormous databases. A common task for research projects is the searching of land use databases for specific land use relevant to the spatial problem. For example, searching for the location of accommodation or medical facilities for groups of visitors to a town could require a query select procedure

Stage 5: **Selection maps:** This stage involves the manipulation of data tables by selecting specific features and creating *selection maps*. These maps involve students opening databases (attribute tables) and selecting only the data that is required. For example instead of having 30 schools plotted on the map, students are asked to manually select only three from the data base for their map. Again a very useful skill when student's get to the stage of creating their research maps that may require the selection of certain items from a database.

Stage 6: Manipulating databases: Students learn how to manipulate *attribute tables*. Such tables are not meant to be static but dynamic, able to have features(rows) added or deleted and fields (columns) added or deleted as required, As a GIS skill stage it is important to get familiar with managing and manipulating data bases to develop customised maps to meet a particular purpose.

Stage 7: Query maps and buffering: This stage again involves finding by search techniques, specific data from an attribute table. This querying process and the resulting *query maps* provide a much-needed shortcut when students are searching through large databases. The process of buffering is introduced at this stage to develop student skills in the GIS techniques of intersection and proximity in particular.

Stage 8: Digitising: This stage involves the skill of digitising an image. If the data you want to use does not exist in digital format, it can be created in ArcGIS through a process known as digitising. Digitising allows you to encode geographic features in digital form as x and y coordinates. It is carried out in order to create spatial data from hardcopy maps and documents. There are two common forms of *Digitising - Table Digitising* and *Heads-up Digitising*.

Stage 9: The development of databases from the collection of data. As a teacher using GIS I am constantly looking for spatial problems that require the collection of data that can provide a quantitative component for students to develop their maps. Once the data is collected, the process of creating attribute tables ready to be represented as pie charts or thematic symbols on a map is remarkably simple and achievable for students. A good example of such an exercise was the Recycling study. In this project students created buffer districts within which to collect recycling data, that could then be mapped across the district. Following the mapping process students worked at analysing the maps so as to determine trends and patterns of recycling across the district and between different socio-economic areas.

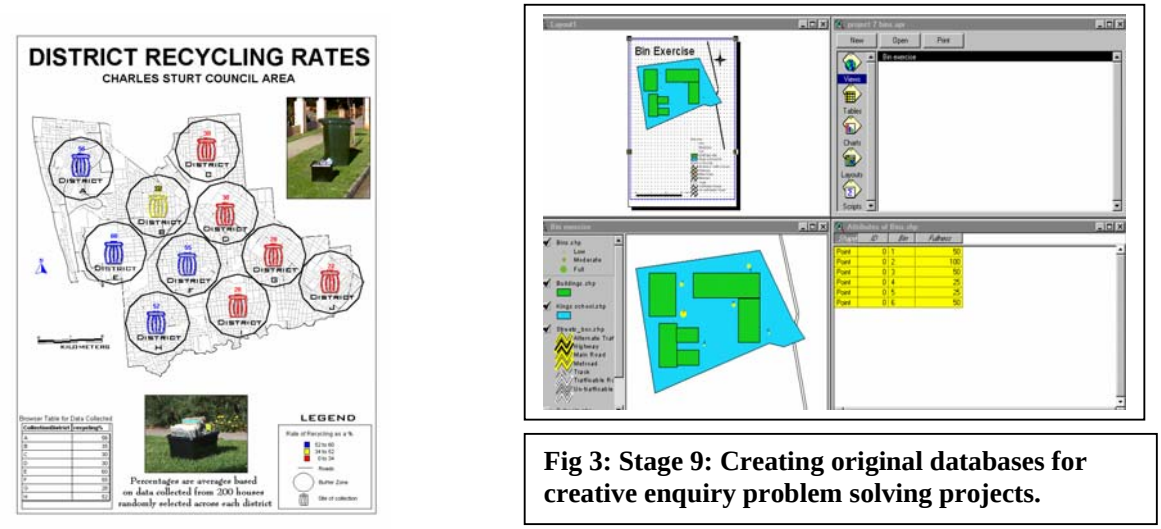


Fig 3: Stage 9: Creating original databases for creative enquiry problem solving projects.

Stage 10: Geo-referencing images: This stage involves developing the skills of registering an image to a geo-referenced vector Shapefile. Images such as aerial photographs, satellite photographs or maps do not have any geographical location/coordinates (default ArcGIS 9 places them at 0 degrees latitude and 0 degrees longitude). The process of geo-referencing adds location information to an image. It does this by creating a world file which gives the image latitude and longitude as well as other information such as scale. This is a great technique to make aerial and scanned images geo-referenced and integrated with other spatial data. With the availability of programmes such as Google Earth this opens up a whole new visual data resource to use for minimum cost.

Stage 11: Bits and pieces: This stage shows students how to:

- Export layouts in image format.
- Add pictures, tables and objects to layouts.
- Make maps within maps.
- Create graphs and importing into layouts.
- Create hyperlinks.

4.2. The philosophy of skill acquisition

By the time students have worked their way through this GIS Skill Development course they should have the array of skills and knowledge required to develop their very own GIS research project. Naturally the ability of the students will determine the complexity and demands of the project but the course up to this stage has given them all that they require to complete a successful project.

The process outlined above is not intended to be prescriptive and “set in cement”. However teachers have gained much comfort from the process being available and the stages of development have reduced the overwhelming feeling of anxiety many of us experienced when embarking on the GIS learning curve with no tertiary training in the area. The reality in Australia is that the majority of teachers left university before computer technology was accessible for educational purposes. It is indeed a “big ask” for teachers to be expected to pick up elaborate GIS skills in their spare time with no formal training. The skills course provides achievable entry points and realistic exit points for teachers grappling with learning GIS.

5. The Spatial context component

Many teachers consider that this aspect of spatial learning needs to be taught as a distinct entity early in any course while others consider that it can be integrated into the GIS skill development process. Much of the spatial context work involves concepts and content that has always been taught within the discipline of Geography. In fact, concepts such as global referencing, scale, and projections are nothing new to the teachers of Geography. What is relatively new is GIS jargon application concepts such as buffering, adjacency, proximity and overlayering. Again, the demystifying of GIS terms and theory is an important stage of the learning model. The Internet provides many excellent sites that make the teaching of the spatial context component a simple and creative task. As was the case with the skill development component, the spatial context component has seen healthy debate between teachers and university lecturers. What teachers see as appropriate and achievable spatial theory/context is often seen as inadequate and even as fallacious in its simplicity by those highly trained in the area. Our focus is achievability towards meaningful classroom implementation. The context must meet a curriculum need within the time, ability levels and the expertise available. If the theory is too difficult, the uptake of GIS as an across the curriculum and inclusive methodology for all students will be limited. Our philosophy with the use of GIS in schools is that all students should be exposed to this powerful and socially important technology. The spatial context and inherent theory must be focussed on the needs of the curriculum, student abilities and teacher achievability.

6. The GIS application component:

Once the students have developed appropriate GIS skills within a spatial context, the next and what is often considered the most exciting component of the model is the GIS Application component.

6.1. Consolidation v's creative enquiry methodologies

It is in this stage that the full potential of GIS in the classroom is realised. This component also provides us with the core methodological issue in relation to the use of GIS by students in schools. At this point it warrants signalling the warning that GIS could just become another 'busy tool' to occupy students for the purpose of 'crowd control'. Why not just give them some coloured pencils instead of the paraphernalia of high technology hardware and software? To avoid the mis-use of GIS we need to have a debate about the reason why we have introduced this technology into the classroom. Is it merely about providing a 'hands on tool' to make the subject more attractive? If so, that is fine, but why not make the tool work to its full potential? To do this we need to examine the pedagogy surrounding the use of GIS. Is the application component about using GIS to consolidate knowledge or is it about creative problem solving? The former is often the approach demonstrated by teachers. For example, the locating of capital cities or volcanoes around the world. Could looking at a provided map not do this? Do we have to produce our own map at great expense and teacher heartache to consolidate such knowledge? This is not saying that there is anything wrong with such an approach but GIS offers so much more to the educator and in turn student spatial cognition. The approach I am advocating can be loosely called the creative enquiry GIS approach. That is, the use of GIS skills to explore and possibly solve spatial problems. Once students have GIS skills within a spatial context they are extremely good at developing spatial problems to investigate. Such problems, depending on the ability of the students, can range from simple problems to highly elaborate investigations.

6.2. Project development

To make the issue relevant to students it is necessary to familiarise students with their local data. Armed with local data, field experience from living in the area and GIS skills, students can be incredibly creative in their project development. Here are some of the problems generated and explored by students in South Australia over the years:

- Are the medical facilities better in a country area or in a city area?
- Where in the local area would the environmental health be the best?
- Where would be the best location in the local area for a family (mother, father, two boys and a girl) with the following requirements to build their house? To be near a primary and high school, public transport to the city, park for jogging, gym and football club and shopping facilities.
- Would the facilities provided be better in a high socio-economic area than those offered in a lower socio-economic.
- Are the rubbish bins appropriately placed around the school? Are they placed to optimise collection?
- What are the football team allegiances across the local council area?

- Do student socio-economic profiles differ across the council area? Based on indicators such as car ownership and TV ownership.
- Is there a difference in health lifestyle across socio-economic regions? To develop buffer maps showing differences in smoking, drinking, food intake and exercise habits between zones.
- How do streetscapes differ between socio-economic areas and what can be done to improve the aesthetic appeal of a suburban area? Maps to be developed that show ratings of aesthetic appeal in buffer zones across the region. Custom made maps of the streets to be made showing urban renewal intervention strategies.

Once the problem/issue is developed, the students need to develop relevant maps and undertake analysis to explore the problem. The creative application process draws on the skills gained by the students during the skill development and spatial context stages of the course and as a result students undertake unique research using high order problem solving and thinking skills.

By the end of such a creative inquiry process the students have:

- ✓ Developed a problem.
- ✓ Collected primary and secondary data.
- ✓ Decided on maps to develop.
- ✓ Generated maps.
- ✓ Conducted spatial analysis, identifying trends and patterns.
- ✓ Drawn conclusions and future recommendations.

7. The Core business of the model: Spatial Cognition

At the core of the model is the area of spatial cognition. The components of such spatial literacy can be discussed under the following headings:

Perceptions involving:

- Location of features.
- Identification and location of environments.
- Distance and depth of features and environments.
- Distance between features and environments.
- Vertical and horizontal interactions at localities and between localities.
- Distribution patterns and trends within identified localities and across environments.
- Interdependencies of features and environments and the multiplicity of cultural and human features at a particular location interplaying and interacting with each other.

Appreciation of:

- Changes across space that occur over time.
- The diversity of environments across space.
- The relationships between places and landscape features.
- The transition and changes in environments across space.
- The reasons for the relative location of features and environments.

Ability to:

- Describe the relative location of features and environments.
- Estimate distance and depth.
- Analyse interdependencies between places and environments.
- Discuss and analyse the reasons for the relative location of features and environments.
- Identify and describe spatial trends, patterns, correlations and overall relationships between places and places, places and environments and between environments.

8. Related outcomes of GIS in the classroom

This paper has focussed on three of the core components of the learning model. However there are related outcomes to the incorporation of GIS in the curriculum. These appear as the outer circle of the model. They provide many of the reasons why teachers have so enthusiastically embraced GIS in Australia. They provide the reason why we do it beyond enhancing spatial learning alone. These can be any of the follows:

- Life skills
- Vocational learning
- Empowerment of learning
- Student motivation and fun
- Community potential
- Out of school learning
- ICT skills
- Group skills

9. Conclusion

As Geographers we see Spatial Learning as the essence of learning. GIS does provide the tool to provide new and exciting learning pathways for students. However we must now go beyond the "vow" stage of implementing GIS into the classroom and honestly and realistically examine why we want to use GIS and how we will use it in the future. Such methodology and pedagogical discussions are imperative if GIS is to be more than just classroom entertainment. I hope the draft learning model presented in this paper can provide a starting point for such discussions and encourage the next step in GIS implementation in schools.

Remember to visit http://www.spatialworlds.blogspot.com and http://malcolm.mcinerney.googlepages.com/home for more on the achievable use of GIS in the classroom