Model of Geo/Spatial Information Literacy (MG/SIL): an innovative model for transforming learning in GIS education

Maryam Nazari¹ and Sheila Webber²

Abstract

This paper aims to describe a Model of Geo/spatial Information Literacy (MG/SIL), derived from qualitative research, which can be used to enrich learning in GIS courses. We start by identifying challenges to GIS educators, including the nature of the discipline itself. We identify the key role of information, and learners’ understanding of Geo/Spatial information (GI), in the learning process, with reference to GIS educational literature and information literacy research. We summarise the research approach and methods of an ongoing exploratory case study investigating competencies that enable GIS learners to learn how to accomplish GIS tasks. The site of the research is a set of Online Distance Learning (ODL) programmes offered by three universities. As a key part of the research, four conceptions of GI have emerged. The four conceptions are briefly described, together with the associated competencies needed to form and transform GI geo/spatially. In the next section we present the MG/SIL which emerged from this work, and explain how a learner might interact with it to diagnose his knowledge and skill needs, and develop his understanding of GI and his ability to apply his knowledge. Finally we identify ways in which the model could both be incorporated in the curriculum and used as an evaluation tool.

Key words
Geo/spatial information conceptions/ GIS education/ Geo/Spatial Information Literacy/ Geo/spatial information behaviour/ GIS curriculum design and delivery/ transferring learning

1 Introduction

The expanding, technology-oriented, and evolving nature of Geographic Information Science/Systems (GIS) as a discipline (ESRI 2002; Libarkin et al, 2003; JISC 2007) is a challenge to GIS educators who want to transform learners’ understanding of GIS and enable learners to apply their GIS skills and knowledge to new situations and problems. The wide applicability of GIS in various disciplines and workplace contexts (Johnson 2006; Unwin 1996) attracts GIS learners from various educational and professional backgrounds. These learners have diverse personal and professional goals and ambitions for learning about and using GIS (Unwin 1997; Kemp 1994). This also creates diversity in learning- and skill-needs.

GIS as a technology-oriented discipline requires learners to use wide range of tools, techniques, and operations; this in turn requires a wide range of skill-sets. However because of the tightly scheduled nature of Online Distance Learning (ODL) GIS...
programmes it is not possible to cover such wide range of diversity in a GIS course or curriculum. Instead to empower learners with skills needed to handle their coursework, they are provided with step-by-step instructions on how to do certain operations usually without having the knowledge of relevant terminology and principles. Although this enables learners to accomplish their tasks following a set of steps, it does not guarantee that they will be able to recall and transform their knowledge and skills to more advanced tasks or to their real life experiences.

Furthermore, because of the diversity in the GIS learners’ backgrounds and goals they may want to use GIS in different ways and contexts. That would require wide range of skill-sets that would suit their particular needs, for a particular problem-scenario that may not be necessarily taught during their course of study.

Finally, GIS as an evolving discipline requires learners to be able to update their knowledge and skills. Putting such multi-dimensional diversity and challenges together, it is almost impossible for a GIS course, particularly an ODL one, to meet every individual learner’s skill-needs, and ways of using GIS. This, rather, requires GIS curricula and pedagogical approaches that facilitate and support learning which can transform learners’ understanding and enable them to apply their knowledge (JISC 2007; Johnson 2001; Jablonski 2004; Massey 2002).

In particular, it calls for approaches that put the learners in charge of diagnosing their knowledge- and skill-needs when dealing with a learning task. One of the key topics of GIS educational literature has been the need to produce GIS learners who are able to transfer their learned knowledge and skills to their workplace contexts (e.g. Gold 1989; DiBiase 1996, Unwin 1997, ESRI 2002; Johnson 2006 etc). According to Kemp (1994):

“Even within a discipline and region, there will still be differences in the education required by GIS users as opposed to that needed by GIS experts. While people training as experts will tend to have a background or interest in one of the spatial disciplines, users are unlikely to have any common background … these students need to have some choice in what and how they learn and to have the opportunity to design a learning situation that is tailored to their specific, individual circumstances”.

A number of dilemmas emerge from the literature. For example, the “depth versus breadth” and “education versus training” dilemmas of GIS education have been addressed by Gold (1989), Unwin (1997), DiBiase (1996), and Johnson (2006). Similarly, DiBiase (1996) argues for pedagogical and GIS curriculum design approaches that enable learners to connect the theories and principles of the GIS discipline to practice with GIS software. Likewise, several researchers have highlighted the need to develop GIS learners who are able to recall, and apply, their skills and knowledge when taking more advance modules, and more broadly, to transfer their knowledge to their real-life workplace experiences (Kemp 1994; Rahn and Zygo 2004; Baker and Bednarz 2003).

Although there is a well-developed awareness of the importance of an enriched approach to learning in GIS education (e.g. Rahn and Zygo 2004; DiBiase 1996; DiBiase et al 2006), Baker and Bednarz (2003, 232) identify a lack of systematic research that could underpin development of a “magic bullet” for GIS education. Additionally, Unwin (1997) notes the need for a learner-centred approach in which the curriculum design “begins by an examination of individual students’ needs and attempts to provide course materials to meet them”. However, due to the complexity of the learning process and environment, and also the learners’ shortage of knowledge of the field, this approach has received little attention from GIS educators (Unwin 1997).
Understanding ways in which information is perceived and used in the context of real teaching and learning experiences has been recommended as an effective approach to identify knowledge and skill-needs of learners (Webber et al. 2005; Boon et al. 2007; Bruce 1997). This is mainly achievable through exploring teachers’ and learners’ perceptions of information in the context of some learning modules and tasks. Although, as is indicated in the next section, there are some initiatives towards transforming learning in GIS education, there has been almost no research into GIS educators’ and learners’ perceptions of Geo/spatial Information (GI), and into the applications and implications of GI conceptions for transforming learning in GIS education (Nazari and Webber 2008). This paper focuses on these issues, including an elaboration of the concept of GI that emerged from our research in the context of an exploratory case study.

2 Initiatives towards transforming learning in GIS education

Looking at major initiatives in GIS curriculum development reveals that the main models of GIS core curricula tend to be community-centred; that is, several authorized GIS committees, with representatives from education and industry sectors, have determined the content and structure of the GIS curricula (Johnson 2006; Kemp and Frank 1996). This includes the National Center for Geographic Information and Analysis (NCGIA) Core Curriculum, the University Consortium for Geographic Information Science (UCGIS) Model Curricula Project, and the Body of Knowledge (BoK). These have been used as international models to develop various GIS educational programmes, degrees, and courses, in many different countries (Unwin 1997; Johnson 2006).

Mainly two design approaches, bottom-up and top-down, have been used to design the content and structure of the core GIS curricula models. In the “bottom-up” approach a set of lecture topics is combined into courses, and the collection of courses comprises the curriculum (DiBiase et al. 2006, 24). This approach forms the basis of the NCGIA Core curriculum and the UCGIS Model Curricula, and accordingly the GIS educational programmes and degrees that were developed based upon these models.

In the “top-down” approach the traditional way of curriculum development follows what is recommended in the “standard educational literature”. The design “starts from a clear statement of broad educational aims, refines these into a series of explicit and testable objectives, and then devises teaching strategies, content and assessment methods to meet these aims and objectives” (Unwin 1997). The foundation of the BoK has been built upon a “top-down” design approach (DiBiase et al. 2006, 24).

Although the BoK has been developed through a community-centred approach, its “outcome-orientation” involves learners in determining the destinations for their learning journey, and thus, involving them to some extent in designing their curriculum. Taking account of the multidisciplinary nature of GIS, the BoK has been designed in a way that provides learners with a more flexible approach to choose their learning destinations from “a diverse array of educational outcomes” (DiBiase et al 2006, 24) which they can achieve through multiple pathways of curriculum content. This includes ten areas of knowledge, each of which consists of several relevant units. By selecting particular learning outcomes, learners can master “several competency levels” that may suit their learning needs (DiBiase et al 2006, 24).

According to DiBiase et al (2006, 24) the BoK is “a resource for specifying course content, for designing educational objectives, and for assessing courses’ effectiveness in..."
achieving intended outcomes”. The “multiple pathways” take learners through several units and topics that end in various destination points where may or may not be their intended one(s).

Acknowledging the “outcome-orientation” characteristic of the BoK, it gives learners flexibility in determining their learning destinations, but only within the boundaries of the knowledge areas outlined in the BoK. However, due to the diversity in the GIS learners’ backgrounds, skill-needs, and ways they intend to learn and use GIS, they would require different arrival points to begin a GIS course or accomplish a GIS task. The abilities of learners when they begin a course or deal with a task may not be matched with the level of knowledge and abilities that the course or task would require them to have, and has been designed for. This is an area that, neither the BoK nor the other core models of GIS curricula have been concerned about, and it is still a dilemma (Kemp 1994; Goldin and Rudahl 1997; Unwin 1997; Baker and Bednarz 2003; Johnson 2006). Providing the learners with approaches that enable them to determine both the departure and destination points of their learning journey when dealing with a task is an area in which this study will make a contribution.

2.1 Using information literacy to enhance GIS education

The Chartered Institute of Library and Information Professionals (CILIP 2007) defines information literacy as “knowing when and why you need information, where to find it, and how to evaluate, use and communicate it in an ethical manner”. Critical thinking and information literacy have been identified as proficiencies that facilitate learning in GIS education. A few studies have used existing models of information literacy developed by librarians (Jablonski 2004; Massey 2002). Jablonski (2004) recommends using the “Big6 information problem-solving model” as a basis for developing the learning objectives of GIS courses to increase undergraduate GIS students’ ability to accomplish their assignments independently. The Big6 model provides educators and learners with a six-phase problem-solving process, and outlines the required activities and competencies for each phase. The six phases consist of task definition, information seeking strategies, use of information, synthesis, and evaluation (Eisenberg and Berkowitz 2007).

Similarly, Xgrain, e-MapScholar, and EDINA, funded by the JISC, were collaborative projects in the GIS field that provided undergraduate and graduate GIS students with different training and learning materials to help them with the “ever more imperative skills” (Massey 2002) of finding, evaluating and researching. In these projects they drew on the information literacy model developed by the Society for College, National and University Libraries (SCONUL 1999) to achieve their aim. This model, that targets the UK Higher Education, consists of seven pillars of information literacy.

The importance of information literacy was highlighted by DiBiase (1996) in his paper proposing a new approach to curriculum and learning design. To promote GIS learners’ information literacy, the Department of Geography at Pennsylvania State University (1996) proposed adding a new course on the “introduction to Geographic information” called “Mapping Our Changing World” which included an objective on developing “students’ understanding of the nature of geographic information, the technologies and institutions by which it is produced and disseminated, and the ways in which it is used (and sometimes misused) to address social and environmental problems” (DiBiase 1996, 63).
Emphasising the key role of GIS introductory courses in preparing and providing students with the “breadth” or multi-dimensional knowledge of GIS, DiBiase (1996, 62-63) argues for educational approaches that develop information literacy competencies in students. He proposes an instructional delivery model including laboratories incorporating both small-group discussions that develop collaborative and reflective skills, and independent computer-based activities. According to DiBiase, “labs focus more on developing the skills students need for advanced studies and subsequent employment” (p65), connecting theoretical aspects of GIS with its practical and technical aspects. However, the focus of both lectures and labs should be on “helping students to understand the unique properties of geographic information, and on developing critical appreciation of the social context and implications of its production and use.” (p66)

In another GIS introductory course, Rahn and Zygo (2004) set authentic, practical tasks that involved seeking out and engaging with information, helping the learners to assess their competencies and knowledge. Since “students from a wide variety of academic and backgrounds enroll in introductory Geographic Information System (GIS) courses”, Rahn and Zygo (2004, 139, 133) use learner-centred tasks including “lab creation and reference generation projects” to engage students fully in the learning process. Students are asked “to solve some GIS questions using resources other than the instructor(s)”. In this process students will realize that not all their skill-needs can be covered in their previous coursework. However, learners still follow step-by-step instructions provided in their course materials to accomplish their task. After accomplishing their task the learners generate a GIS reference manual that acts as “a resource to all students and faculty using GIS” (p133).

According to Rahn and Zygo (2004, 133), the projects engage them in “problem-solving and communication skills in addition to their GIS abilities” and such designed learning activities and exercises “cover a variety of pedagogical goals” including helping learners learn GIS in a way that they can transfer their knowledge to their real-life experiences.

3 Model of Geo/Spatial Information Literacy (MG/SIL): an exploratory case study

Exploring ways of perceiving and using information in the context of real learning and teaching experiences helps stakeholders to understand the nature and characteristics of information, and to illuminate ways in which people interact with, and make use of information (Webber et al. 2005; Boon et al. 2007; Bruce 1997). This is of particular value in a multidisciplinary area such as GIS, where learners use Geo/Spatial Information (GI) in the context of various subject and application areas.

The work reported here is part of ongoing PhD research designed as an exploratory case study to investigate competencies that enable GIS learners to learn how to accomplish GIS tasks, in the context of three ODL programmes in the universities of Leeds, Southampton, and Pennsylvania State University. Multiple methods of data collection and different sources of data were used, as is appropriate in case study research (Yin, 2003). In this study semi-structured interviews with academics and students, an open-ended questionnaire to students, document study, and students’ reflections, were used to gather the data.

The case study design was used to explore the nature and characteristics of GI in the context of study sites. Case study is an ‘ideal’ methodology when “a holistic”, “in-depth
investigation” is needed (Yin 2003) to gain deep understanding about a phenomenon or
selected issues in real-life contexts (Esienhardt 1989; Stake 1978; Yin 2003; Dooley 2002;
Denscombe 2003, 38). Particularly, it is suitable for exploring a complex phenomenon
(such as GI) and relationships between its ‘attributes’ (Kennedy 1979).
Overall three main outcomes have emerged from this study: a) conceptions of GI, b)
conceptions of GIS; and c) model of learning how to solve problems geo/spatially. This
paper concentrates on the conceptions of GI and a model of geo/spatial information
literacy that was constructed on the characteristics and properties of the GI
conceptions. In the following section, we will describe the methodology relevant to this
part of the research.

3.1 Methodology

The study population included 20 academics in charge of designing and delivering 23 GIS
modules in different subject areas of GIS, and seven students with various professional
and educational backgrounds and experiences of the GIS courses. Students were selected
based on their interest in participating in the study and their accessibility to the
researcher, as they were online distance learners from all over the world.
Due to the exploratory nature of this study, inductive analysis of open-ended in-depth
face-to-face interviews were employed to explore the GIS academic’ and students’
perceptions concerning the nature and characteristics of GI in the context of their
learning and teaching experiences of several ODL GIS courses. The study sites comprised
partners in ODL Masters degree GIS programme collaboratively delivered by Universities
of Leeds, Southampton, in the UK, and Pennsylvania State University, in the US. This
partnership programme is part of ODL programmes sponsored by the World Universities
Network (WUN), Global GIS Academy and delivered in a complementary articulation
model of e-learning.
To explore the phenomenon under study, the participants were interviewed and asked
to share their thoughts and experiences of GI by answering two main questions:
- How would you describe GI and what makes it unique?
- How would you describe the physical format of GI?
Interviewing is ‘a powerful way to gain insight into educational issues through
understanding the experience of individuals whose lives constitute education’
(Denscombe 2003, 164). It also ‘provides access to the context of people’s behaviour
and thereby provides a way for researchers to understand the meaning of that
behaviour’ (Seidman 1998, 4).
The interviews were fully transcribed and analysed, using grounded theory data analysis
procedure including coding data, memo writing, and writing theory (Mansourian 2006).
Simultaneous data collection and analysis, constant comparative analysis, and
‘conceptualising and interplaying with data’ are distinctive features of grounded theory
data analysis method that provide a strong foundation for constructing a valid theory,
emerged from the data (Glaser and Strauss 1967).
Using these features, the process of data analysis was started after transcribing the first
interview. The researcher coded each transcription in as many as categories or meanings
as emerged from the data and wrote her interpretation of each category. This ‘memo
writing’ helped to ‘conceptualise and gain analytical perspectives about the data
(Strauss and Corbin 1998) and establish a foundation for the framework of GI
conceptions.
To outline the core conceptions of GI, the written memos were sorted, i.e. connections between the memos were identified through conceptualising and interplaying with the data and similar categories were integrated into one. Ultimately, the ‘write-up of ideas’ and the integrated categories of concepts were ‘theorised’ and formed a framework of four main conceptions of GI, described in the following section.

The properties and characteristics of GI relevant to each conception were used to construct the components of the MG/SIL including informative and constructive frameworks of GI conceptions.

Following the four conceptions of GI, the MG/SIL, and its implication for transforming learning in GIS education are presented.

To anonymise the data, participants’ names were replaced with the abbreviations identifying the interviewee’s role (A for academic or S for student) and the study site at which s/he experienced GI. Code L was used for Leeds University, S for Southampton and P for Penn State. To reference an exact quotation, numbers from 1 to n are used after each code. For example, to determine a quotation from paragraph 10 of an interview transcript belong to academic number 6 in Leeds, the reference for the quotation will be 6AL-10.

4 Conceptions of geo/spatial information

This section describes the four conceptions of GI that emerged from data collected from GIS academics and students in three ODL GIS Masters programmes in the UK and US. These conceptions of GI are: 1) spatial; 2) temporal; 3) spatially technology-mediated, and 4) spatially contextualised. As it was mentioned in the data analysis section, these conceptions represent the four main meaning of GI that emerged from the academics and students’ perceptions and descriptions of this phenomenon. Thus, these conceptions do not map onto individual people but represent the overall meaning of GI as it was emerged from the data.

4.1 Conception One: Geo/spatial

The key characteristic of this conception is that GI is seen as information or data that has a location element associated with it, or data that has a geographic or non-geographic location. In this conception, GI has been described as a type of data that ‘has a spatial component’ (6AL-20, 2SL-10, 5AP-5, 2AP-23, 8AP-52) or ‘some location’ (2SL-37) associated with it.

There is a general agreement that ‘location’ associated to GI is the feature that distinguishes GI from information in other disciplines. According to 5AP-6, GI is ‘associated to a location whereas other subjects [disciplines] maybe associated to a subject or other things than location’. To highlight the importance of the location element of GI, there are several statements that identify subject of GI; ‘geography’ or ‘location’ (5AP-6, 6AL-20), using the term ‘geographic data’ (8AP-90). Although in the majority of GI concepts the ‘location’ element has been specified as a geographic location (2AS-4, 3AL-6), there are a few statements which do not consider this component ‘necessarily related to the earth and geography; anything on the space can have a spatial component’ (9AP-34). For example, in disciplines such as Molecular Biology or Medicine, the data can be diagrams or pictures of different parts of body, organs, or molecular (8AP-66) which are not necessarily geographically relevant to the
earth’s surface. However, the location of different parts of body in relation to each other can make the data GI.

Similarly, some descriptions of GI identify it as an abstract concept of the earth features, for example, 8AP-109 describes GI as ‘an abstract representation of the features on the earth in defined boundaries’. Likewise, 1AP-2/1 perceives GI as ‘representative of the earth features’ and 9AP-34 calls GI ‘anything on the earth’s surface [that] can have a spatial component’.

4.2 Conception Two: Temporal

GI is seen as a temporal phenomenon as it is about a dynamic phenomenon i.e. the earth. In other words, GI is data or information that represents a phenomenon at certain point(s) in time. 8AP-110 highlights the dynamic and temporal feature of the earth as the subject of GI. S/he identifies GI as data that ‘has a spatial component; where the thing is being described’. This ‘where’ has been identified as ‘the earth’ in several concepts of GI (8AP-109, 3AL-6, 1AP-2/1) which is ‘dynamic’ (1AP-2/1, 3SL-9, 45) and ‘temporal’ in its nature (11AP-24, 2AS-5). In other words, GI, as ‘four-dimensional information’, with the time element as the fourth dimension, is a temporal entity.

Indeed, to understand information with such characteristics, there is a need to conceptualise these components (11AP-24, 2AS-5):

‘It [GI] is conceptualised by being temporal in its nature as well as spatial (11AP-24).

4.3 Conception Three: Geo/spatially Technology-Mediated

GI is seen as any type of data that is readable and usable by GIS. From this perspective, GI needs to be mediated by spatially and non-spatially enabled technologies and tools. At the heart of this conception lies the importance of GIS for making sense of, and using, GI. This has been highlighted in the conceptions that identify GI as data or information that need to be formed and transformed using GIS or using other non-spatially enabled applications such as spreadsheets, word processing, etc.

The mediation can take various forms including, capturing, gathering, creating, manipulating, mapping, organizing, analysing, displaying, handling, presenting, and using GI. According to 4AL-5, ‘there is no GI but data that can be handled by GIS’. GI also has been identified as type of data that ‘can be computerised’ (8AP-52), ‘mapped’ (2AP-25), ‘presented and processed in MapInfo’ (3SL-9, 6), and ‘can be analysed with GIS … to present all the complexity of all the features of the earth’ (1AP-2/1).

This particularly can be explored in the participants’ conceptions of GIS that see GI and GIS inseparable components of GI concept. This particularly can be illuminated in the perceptions that identify the very nature of GIS ‘to do with having spatial information on computers and using that to analyze spatial patterns’ or more broadly ‘to do with maps on computers’ (1SL-1).

More holistically, 4AL-3 sees GIS as ‘a package solution, a set of standard techniques ... a four stage process’. 4AL-4 uses a retail task as an example to demonstrate how GIS needs to be involved to mediate GI:

a) to get information about customers and their characteristics - GIS as a capture, geocoding tool.
b) to get information about customers from the census data - GIS as a manipulation tool.
c) to use census data to see where the customers live - GIS as spatial analysis tool.
d) to map the data or to produce maps from the data - GIS as a mapping tool. Perceptions of GI that highlight tangible aspects of GI were also explored to illuminate the ‘spatially technology-mediated’ conception of GI and ways in which GI needs to be mediated by technology. This includes attributes associated with GI, or more precisely to the ‘location’ element of GI, and physical format of GI. In both areas mediation is needed to form and transform information or data to GI; or to make sense of, and use, GI.

4.4 Conception Four: Geo/spatially contextualised

The key characteristic of this conception is that GI is seen as a dynamic phenomenon, socially and geographically constructed, which needs to be spatially conceptualised and contextualised. According to 11AP-24, ‘most of geographical information is contextualised in our life, it’s not really absolute; there is a context that gives it a grounding meaning’. He identifies ‘social’ and ‘geographical’ contexts where such meaning would emerge (11AP-24).

In the field of GIS, it is not easy to formulate an information concept without contextualizing it, and therefore it is not easy to ‘encode information and understand it really and correctly’ (11AP-24). In this regard, 11AP-24 believes that ‘geographic data are socially constructed, for almost all part’:

‘We can talk about original maps that encode original property around the city; that’s the socially constructed thing, it doesn’t exist in nature. We can talk about a forest and I would argue that is socially constructed thing too. You call forest depending on, very much, where on the earth you are, there is no universal forest. It’s helping people to construct [meaning or concepts], to communicate’.

2AS-5 identifies this as distinctive feature of ‘spatial and temporal’ information used by ‘GIS scientists or geographers’ which make it challenging, in contrast to information used by ‘social and physical’ scientists.

5 The GI conceptions as foundation to construct the MG/SIL

The properties of the GI conceptions can be described in two frameworks: informative and constructive (see Figure 1). In the informative framework (upper part of Figure 1), the properties of the GI conceptions inform us of the unique features and characteristics of GI. This includes the multi-dimensional nature, characteristics and context of GI, various forms of user input that GI needs to be formed and transformed geo/spatially, and the GI’s need for various operations and skill-sets to become geo/spatially meaningful and usable.

Unlike many other disciplines, in the field of GIS data only becomes geo/spatially meaningful and usable when the user has engaged with it. In the construction of the conceptions of GI, “user input” is the inseparable component of GI that contributes to making sense of data geo/spatially. The formation of geo/spatial data and its transformation to geo/spatial information and knowledge requires “user input” which varies for each conception. The forms of use input required for each conception are as follows:

In the first conception, GI is seen as information or data that has a location element associated with it, whether geographic or non-geographic. It requires the user to have a
‘spatial way of viewing or perceiving’ GI. This may appear in the form of visualising, representing, or conceptualising time and location elements of GI.

In conception two; GI is seen as a temporal phenomenon as it is about a dynamic phenomenon i.e. the earth. The user input in this conception perceives GI as a dynamic phenomenon that needs to be kept up-to-date. This would include the object i.e. a particular location on the earth and its attributes, and subject i.e. the phenomenon is studied in that particular place of GI, since in case of any change in the location it may impact on the whole product or output as result of using GI.

In the third conception, the user needs to have knowledge of various geo/spatially and non-geo/spatially enabled technologies and tools and to be able to select and use appropriate ones to connect the different components of the GI together to make sense of, and use, data geo/spatially, hence contributing to the formation of the GI. This includes the time, location, and other attributes of the data. Such user input contributes to the GI conception as geo/spatially technology-mediated data. In the fourth conception, the user needs to understand the geographical and social contexts of the data. This enables him to contextualise the different components of the data geo/spatially, and apply the data, in the form of geo/spatial knowledge, for various purposes. Such user input contributes to the GI as geo/spatially contextualised data. In other words, the user will have some input into the transformation of the geo/spatial data or information to geo/spatial knowledge that mainly can be in the form of decisions and plans.

Need for various operations and skill-sets
To construct and make use of GI different competencies and skill-sets are needed. The features described for the nature and characteristics of GI explicitly show that to make sense of, and use, GI geo/spatially its different components need to be associated and contextualised appropriately. The different forms of “user input” highlighted in each conception, on the other hand, revealed that various preparations and operations are needed to construct and make use of GI. Drawing upon the conceptions, several competencies can be highlighted for each conception (see Table 1).

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<tr>
<th>Conception</th>
<th>Competencies</th>
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<tbody>
<tr>
<td>One</td>
<td>Ability to perceive and visualise information geo/spatially, that may require knowledge of the nature and characteristics of GI;</td>
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<td></td>
<td>Ability to conceptualize GI and its components;</td>
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<td>Ability to represent an abstraction of some of the earth’s features geo/spatially;</td>
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<td></td>
<td>Knowledge of the way that GI can be perceived geo/spatially by geo/spatially and non-geo/spatially enabled technologies and tools;</td>
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<td>Ability to use GIS to represent the association of the GI attributes to the location.</td>
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<td>Two</td>
<td>Knowledge of the ‘time’ component of GI;</td>
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<td>Ability to perceive GI as a temporal or dynamic phenomenon;</td>
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<td>Ability to maintain GI, its products, and the process of using GI.</td>
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<td>Three</td>
<td>Ability to:</td>
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<td>translate or convert the time and location components of GI in a language understandable by geo/spatially and non-geo/spatially enabled technologies and tools;</td>
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<td></td>
<td>delineate the attributes of GI to the location using geo/spatially and non-geo/spatially enabled technologies and tools;</td>
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Conception | Competencies
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geo/spatially enabled technologies and tools;  
- use GIS tools and capabilities as geo/spatially enabled technology to capture or create GI;  
- select and use appropriate GIS tools and capabilities to manipulate GI for a specific purpose;  
- select and use appropriate non-geo/spatially enabled tools to pre-process data so that it can be readable and usable by GIS;  
- select and use appropriate GIS tools and capabilities to analyse, organise, present etc. GI and make decisions and plans.

Four  
- Ability to perceive GI as three/four-dimensional information that is socially and geographically constructed;  
- Contextual knowledge of the subject of GI;  
- Contextual knowledge of the object of GI;  
- Ability to encode and understand information geo/spatially.

In the **constructive framework** (shown in the lower part of Figure 1) the properties of the GI conceptions illustrate the constructive nature of GI and how the concept of GI needs to be constructed in its multi-dimensional contexts including the task, subject, and application areas. In the framework of GI conceptions, GI is seen as information with three main components (i.e. time, location, and attributes). To become geo/spatially meaningful they need to be contextualised in the multi-dimensional contexts.

5.1 **Contribution of the MG/SIL to transforming learning**

The informative and constructive frameworks of GI conceptions provide us with a robust model to portray the competencies needed to interact with, make sense and use GI. The frameworks inform us about the way in which the meaning of GI is constructed and the various operations needed to make GI geo/spatially meaningful and usable for an intended task/problem.

Depending on the way, purpose, and context, of using GI, however, GI may need different operations, and corresponding skill-sets to make sense and use of it. Putting such variation in the context of the learners’ diversity implies that to be able to make sense and use of GI geo/spatially in the context of a task; GI properties need to be constructed, and its needed operations and skill-sets need to be diagnosed by the learner.

Putting this in perspective, the MG/SIL proposes a model that would engage the learner in using the informative and constructive frameworks to construct his way of viewing and using GI in the context of a task/problem. The following paragraphs describe how the MG/SIL facilitates transferring learning.

In the MG/SIL the learner is at the centre of the model and is seen as an individual with a unique knowledge base (KB) and value system (VS) that may vary from person to person, due to the diversity in their backgrounds (see the central section of Figure 1). By “KB” we mean the learner’s abilities and knowledge that is mainly influenced by his educational and professional background. By “VS” we mean the learner’s goals and ambitions of learning and using GIS that is mainly influenced by the learner’s cultural and professional backgrounds as well as his personal and professional interests and values.

Providing the learner with tasks that engage him in thinking and questioning his KB and VS, he will be able to have informed interactions with the informative and constructive
frameworks of the GI conceptions. As a result he should be able to diagnose and perform appropriate geo/spatial information behaviour to accomplish the task.

In fact, because the selection of the geo/spatial information behaviour is informed by the learner's KB and VS as well as the informative and constructive frameworks of the GI conceptions, the learner will be able to relate his achieved knowledge and skills to his KB and VS. Creating such connection will facilitate learning which can be applied both inside and outside the course. This includes recalling the skills and knowledge when dealing with similar or more advanced tasks as well as transferring the knowledge and skills to the personal and professional real-life experiences.
Additionally, viewing the learner with his KB and VS in the context of the MG/SIL, the learner will be able to link the theoretical and practical components of the task when interacting with the informative and constructive frameworks of the GI conceptions. Such informed interactions would enable the learner to:

a) understand the features and characteristics of GI and its properties, in its multi-dimensional contexts, and develop his way of viewing and using GI in the context of the task;
b) determine type of tools, techniques, and operations the data needs to become geo/spatially meaningful and usable;

c) determine the type of needed user input and skill-set;

d) diagnose and perform appropriate geo/spatial information behaviour;

e) make sense of, and use, data geo/spatially;

f) apply the GI for various purposes in different subject and application areas;

g) connect the achieved skills and knowledge to his KB and VS, and recall and transform the knowledge;

These processes will now be described in more detail.

5.1.1 To get involved in tasks that engage the learner in thinking and questioning his KB and VS

Putting the learner at the centre of the MG/SIL means he is in charge of recognizing and diagnosing his knowledge and skill-needs when dealing with a GIS task. To empower the learner with such ability he needs to get involved in tasks that require him to question his KB and VS, and also choose a topic of his own interest. Through such a process the learner will need to think and question his KB and VS in terms of: what I know or I do not, what I am capable of doing or I am not, and how the task would relate to my personal and professional interests and goals, when interacting with the task and the informative and constructive frameworks of the GI conceptions. As a result, the learner will be able to find his knowledge and skill-needs, and see how, and to what extent, the course and learning materials can satisfy them. He would then be in a position to investigate resources and places where he can achieve the remaining portion of his learning needs.

The informative framework of the GI conceptions provides the learner with knowledge of the features and characteristics of GI that will enable him to develop a way of viewing and using GI in the context of a task. It facilitates the learner to determine types of user inputs, operations, and skill-set that the GI requires in order to be formed and transformed geo/spatially. In fact, through this informed interaction with the informative framework of the conceptions, the learner will gain awareness and knowledge of the characteristics of GI. This helps the learner to determine his way of viewing and using GI in the context of the task/problem.

The constructive framework of GI conceptions, on the other hand, provides the learner with the knowledge and skills he would need to interpret and synthesise GI and its components/properties geo/spatially in its multi-dimensional contexts, i.e. context of the task, its subject, and application area. This enables the learner to synthesise and apply the GI for the purpose of the task.

Combining the knowledge of the characteristics of GI with the knowledge he would gain through informed interactions with the constructive framework of the GI conceptions, the learner will be able to determine the operations, tools, user input, knowledge, and skill-set he needs to make sense and use of GI geo/spatially.

5.1.2 To diagnose appropriate geo/spatial information behaviour

Having identified the needed operations, knowledge and skills, the learner will be able to diagnose and perform appropriate geo/spatial information behaviour to solve the problem or accomplish the task geo/spatially. However, in this stage the learner would
require knowledge of how the GI is produced, organized, and disseminated, and how to search for, evaluate, synthesise, and use GI geo/spatially.

In fact, geo/spatial information behaviour informs the learner of the what, where, how, and why of GI and using it in the context of the task. For example, he knows where and how to search for GI, and why to use a certain searching strategy or place to look for GI. Likewise, he knows what operations, tools, and techniques to use, and where to gain the skills and knowledge to do such operations, if there is a gap between the learner’s KB and the knowledge and skill-set that the course has provided him with, to make sense and use of GI geo/spatially for the purpose of the task.

5.1.3 To recall and transform knowledge and skills
As was mentioned earlier, to perform effectively within the MG/SIL requires tasks that engage the learner in thinking and questioning his KB and VS, and reflect on his learning. This facilitates the learner’s informed interactions with the informative and constructive frameworks of the GI conceptions. It also enables the learner to make informed decisions about his way of using GI, the type of operations and tools the GI needs to become geo/spatially meaningful and usable in the context of the task, and to diagnose and perform appropriate geo/spatial information behaviour to accomplish the task geo/spatially.

Such full engagement in the process of task accomplishment enables the learner to connect what he has learned through the course of his study and the task accomplishment to his KB and VS, particularly if he is asked to reflect on his learning process. Creating such meaningful connections enable the learner to not only recall his knowledge when dealing with more advanced tasks, but also to transform his knowledge and abilities to his personal and professional experiences. We would call the learner geo/spatially information literate if he were able to:

a) perform such informed interactions with the components of the MG/SIL;

b) develop his way of viewing and using GI;

c) diagnose and perform appropriate geo/spatial information behavior when dealing with a GIS task;

d) connect his achieved knowledge and skills to his KB and VS; and

e) recall and transform the knowledge and skills in his personal and professional real-life experiences, in various subject and application areas to solve problems geo/spatially.

5.2 Implications
We will concentrate on identifying implications for GIS education in practice, using the MG/SIL as a robust model to design, deliver, and evaluate GIS curricula.

5.2.1 Designing and delivering GIS curricula
The MG/SIL provides GIS curriculum designers with different components they need to design learning objective, tasks, materials, and environment they would need to facilitate transferring GIS learning. It can inform educators and curriculum designers of the approaches to developing learning objectives and tasks that would fully engage the learners in the thinking and questioning their KB and VS and reflecting on their learning, when interacting with the informative and frameworks of the GI conceptions.
It is seldom feasible for all potential learner requirements and preferences to be catered for in one course or curriculum. The MG/SIL helps educators identify the scope and depth of the learning materials that are required by a specific cohort of learners, through collaborative interaction with the MG/SIL in the context of authentic tasks which are designed into the curriculum. Iterative use of the model could enable learners to reflect on their progress and changing understanding of GI, GIS and GIS applications. This also implies increased emphasis on designing an environment which enables learners to identify ways in which they can meet their self-diagnosed learning needs. For example, in the ODL environments learners have the opportunity to navigate the learning environment, both inside and outside of the course. They need to be provided with an easily navigable learning environment and materials that would encourage them to go beyond the learning environment, materials, and facilities.

The learning environment should be designed in a way that guides learners to places where they can look for information and resources needed to gain the knowledge and skills they would need to accomplish their task independently. In particular it is very likely that the learners find that their KB is far from what they are expected to be capable of. In such cases, the learning environment needs to incorporate information pathways and resources learners would need to meet their knowledge and skill gaps.

5.2.2 Evaluating and enriching GIS curricula
Finally, the informative and constructive frameworks of GI conceptions can be used as measurement tools to evaluate the breadth and depth of the GIS curricula, depending on the aim and objectives of the curricula in terms of the conceptions of GI. Similarly, the frameworks can be used to evaluate the extent to which the current GIS curricula provide the learners with the knowledge and skill-sets they would need to make sense, and use GI geo/spatially in the context of various subject and application areas. Based on such evaluation the GIS curricula can be revisited and enriched.

6 Conclusion

Owing to its constructive feature and innovative approach, the MG/SIL provides the GIS stakeholders with a robust framework that would inform them of approaches to transforming learning in the GIS education. In particular, approaches that would enable them to construct their way of viewing and using GI, and to determine both the departure and destination points of their learning journey when dealing with a task. The nature of GI itself is fundamental to the content of GiScience/system discipline and thus we contend that our research illuminates part of that core, demonstrating the multifaceted nature of GIS. To grasp this complexity, learners need to engage explicitly with the concepts of GI. Combining these two together, this study contributes to developing geo/spatial information literate learners who are able to perform more informed and effective as practitioners in different workplace contexts, and become GIS lifelong learners.


7 Bibliography


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Please refer to: