Using the threshold concepts framework: a way to enhance students' conceptual understanding and promote disciplinary discourse in geographical information systems (GIS)

Sanjeev Kumar Srivastava

Sanjeev.Srivastava@usc.edu.au

School of Science and Education, University of the Sunshine Coast, Queensland, Australia

Geographical information systems (GIS), also referred as geographical information science and technology (GIS&T), is an area which is broadly sub-divided into a technological component (mainly in the form of user-friendly software packages), a theoretical component that draws on principles from a wide range of disciplines, and an application component that is resided within numerous disciplines (Figure 1). GIS can be integrated in diverse curricula and augments student graduate attributes such as problem solving, including critical spatial thinking (Lee & Bednarz, 2009).

The prevalence and technological complexity of GIS is constantly growing, with thousands of private and government organisations using GIS and millions of users worldwide (Dibiase, 2012). There is a rapid increase in the phenomenon of 'crowd-sourced' spatial data (Goodchild & Glennon, 2010), which involves citizens collecting geographical information, especially during natural or man-made disasters (Goodchild, 2007). Such online geospatial activities, variously known as neogeography, volunteered geographical information, wikimapping and GIS 2.0, are also rapidly expanding. Moreover, GIS is now converging with social media, where increasing numbers use this tool (Goodchild, 2007; Li *et al.*, 2013; Sui & Goodchild, 2011). Since GIS is a modern and emerging field with a rapidly increasing demand for skilled users (Dibiase, 2012), it is not surprising that a significant proportion of users practising GIS have only a superficial understanding (Srivastava & Tait, 2012). In addition, many examples of the misuse of this technology exist due to lack of proper understanding of underlying concepts (Devillers *et al.*, 2007; Srivastava & Tait, 2012; Sweta & Bijker, 2013). Traditionally, GIS courses have been offered in the degree programs of environmental science and management, urban planning and geography. Over recent years, GIS has gained popularity in disciplines such as health science (Richardson *et al.*, 2013), economics (Ye & Rey, 2013) and even the humanities (Goodchild & Janelle, 2010).

However, disturbingly, students undertaking GIS courses in undergraduate programs across a wide range of disciplines are often found to adopt a surface approach to learning (Srivastava & Tait, 2010). The term 'surface approach to learning' is widely used in education research to specify the approach to learning adopted by students to pass a course without a conceptual shift and influence on their practices (Biggs & Tang, 2007; Ramsden, 2003). One of the prerequisite for achieving conceptual shift is to have the key concepts identified for a discipline. For GIS, a Body of Knowledge already exists (DiBiase et al., 2006). This continually evolving Body of Knowledge, published and updated by the University Consortium of Geographical Information Science (UCGIS), is an ideal documentary basis for curriculum design and a useful platform against which to measure disciplinary discourse that is itself evolving. Additionally, there are many seminal papers that identify key concepts

for GIS and related disciplines (Battersby *et al.*, 2006; Kuhn, 2012). However, just learning discrete concepts of a discipline may not be the ideal way to promote deeper learning unless the learners understand interrelation among them as well as the sequence in which they learn the key concepts. This can be addressed by identifying threshold concepts of the discipline. Threshold concepts are those transformative concepts in a discipline that are often difficult to understand when first encountered, but when mastered they transform students, both epistemologically and ontologically in relation to the discipline. The threshold concepts for GIS has been identified which include map-scale and data models (Srivastava, 2013).

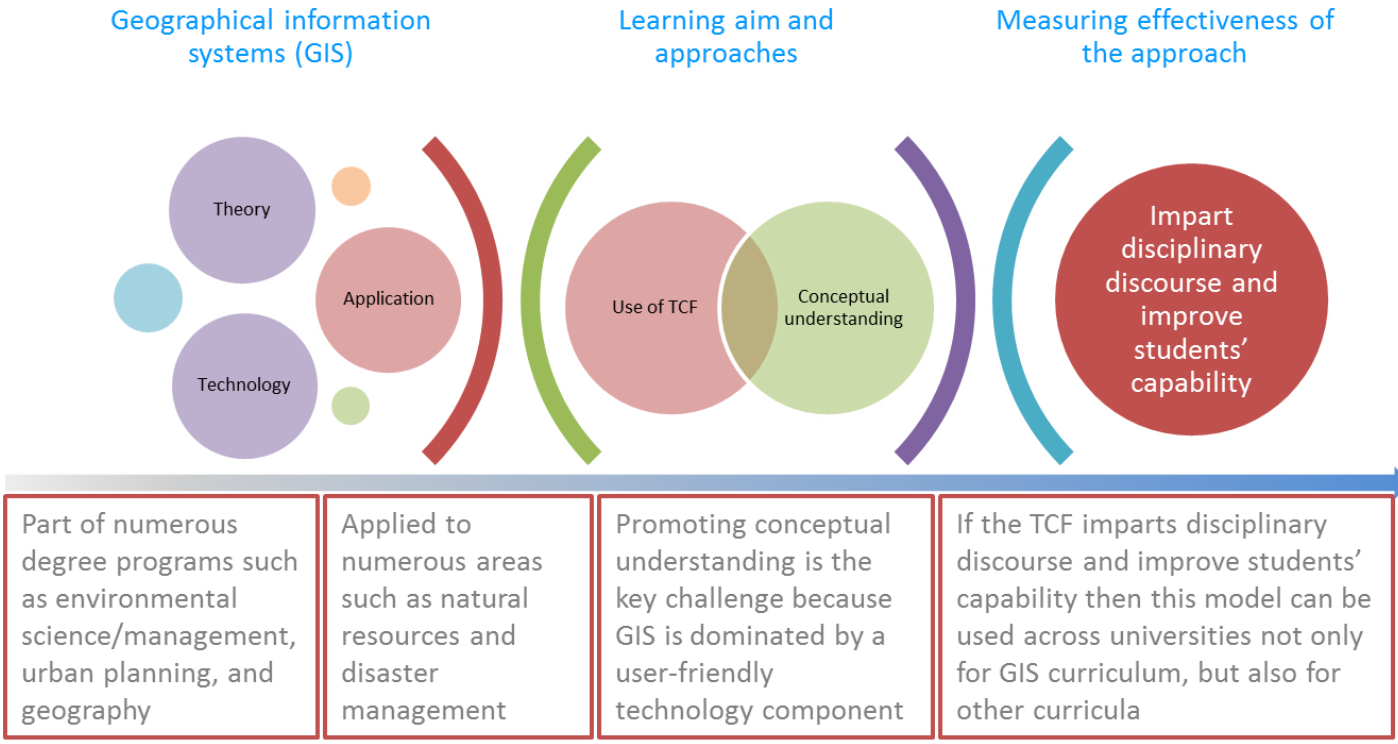

Figure 1: The model for transforming student learning to impart capability through TCF

The use of the Threshold Concepts Framework (TCF) can facilitate an opportunity to promote deep-level conceptual understanding in such disciplines. In the past few years, the TCF has become a popular learning framework because it draws on a number of theoretical perspectives both from different learning theories and the ways students learn across a diverse range of disciplines. The initial phase of research on learning using the TCF emphasised the identification of threshold concepts within disciplines. However, this emphasis has now shifted towards implementing the TCF in learning activities; especially in the assessment tasks.

Thus, throughout the university sector it is very important to effectively design and deliver course curricula that promote deep learning of threshold concepts with emphasis on well-designed assessment tasks (Srivastava, 2010). Such issues can be addressed effectively by using aspects of the Thresholds Concept Framework (TCF) in the curriculum. Threshold concepts have strong theoretical foundations (e.g. Constructivism, Phenomenography, Multidisciplinarity) and have eight defining characteristics that are for students—in varying degrees—transformative, irreversible, integrative, troublesome, bounded, discursive, liminal and reconstitutive (Baillie *et al.*, 2013). Since the TCF draws on a number of theoretical perspectives from both different learning theories and the ways students learn

in a diverse range of disciplines (Cousin, 2006), the identification of threshold concepts and their subsequent use in curriculum design can play a crucial role in students' GIS learning. The TCF involves identifying concepts in various disciplines that act as 'thresholds': that is, they need to be mastered before further progress towards capability can be made. Thus, the threshold concepts provide conceptual 'learning gateways' that students must negotiate before they transition to discipline experts. There are numerous examples of identifying and proposing threshold concepts across a range to discipline by expert, however, it is well recognised that their identification is full of methodological challenges (Barradell, 2013). Ideally, threshold concepts should be identified through 'transactional curriculum inquiry' which involve dialogue among educators, students and educational developers (Cousin, 2010). Moreover, this identification process can be further strengthened by including experts beyond education domain (Barradell, 2013).

For GIS, threshold concepts were identified using a deductive approach where threshold concepts where first identified, and thereafter supported by summative content analysis of seminal papers (Srivastava, 2013), where other key concepts of the discipline were linked to threshold concepts. The use of the TCF within GIS can play a vital role in improving the conceptual understanding of new learners (Figure 1): this approach emphasises and facilitates the learning of concepts whilst using the technological tools. Understanding of threshold concepts is likely to result in improved and increased use of the natural, symbolic or artificial language characteristic of a discipline (Baillie et al., 2013; Srivastava, 2013). Use of TCF has potential to promote and systematically enhance disciplinary discourse, the ability to use discipline-specific language, in the geographical information sciences. This will enable among GIS learners to promote not only learning of key concepts but also imparting associated disciplinary discourse as evidenced by an enhanced and extended use of natural, symbolic, or artificial language which is characteristics of a discipline (Baillie et al. 2013; Srivastava 2013). The assessment tasks for GIS courses can effectively use Threshold Concepts Framework. This will not only enable students to focus on conceptual understanding, but also will enable educators to provide feedback to students about their possible misconceptions (Srivastava, unpublished work).

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