Library & Information Science Research 38 (2016) 133–147

Contents lists available at ScienceDirect

Library & Information Science Research

The actuality of determining information need in geographic information systems and science (GIS): A context-to-concept approach

Maryam Nazari

Iranian Research Institute for Information Science and Technology (IranDoc), Tehran 13185-1371, Iran

ARTICLE INFO

Article history:
Received 12 September 2014
Received in revised form 8 July 2015
Accepted 26 April 2016
Available online 20 May 2016

ABSTRACT

Although context has been identified as the key to the manifestation of information literacy (IL), little is known about the actual context of IL in disciplinary areas. This is because disciplinary studies of IL have focused mainly on people's conceptions of IL, not on their lived teaching and learning practices. Introducing university assignments as a contextual construct for disciplinary studies of IL, this study demonstrates how students' and educators' conceptions and experiences of real university assignments and their constructive participation in conceptualization of IL helped to uncover the actual nature of information need in the discipline of geographic information science/systems (GIS) and to gain a better understanding of the concept of, and requirements for, determining information need in this discipline. Adopting an embedded case study design and a participatory approach for fieldwork, the data were mainly gathered from 27 semistructured interviews focused on GIS students' and educators' lived experiences of university assignments and their reflections on various aspects of IL in a master's degree GIS program jointly delivered by universities in the UK and USA. Each learning and teaching experience was treated as a unit of analysis. GIS assignments were found to be geospatial, technology mediated, subject free, and unique in requirements. Each characteristic uncovered a new facet for the concept of information need in GIS. Findings indicate that unless students have understood the multi-faceted nature of information need, they may fail to distinguish the various ways in which gaps may be addressed when dealing with GIS assignments. The context-to-concept approach proposed in this study can be of value to both IL researchers and practitioners who seek deeper insights into the nature of IL, especially those interested in the customization of generic models of IL to the actual needs of university programs.

1. Introduction

Context has been highlighted as the key to the manifestation of information literacy (IL) (Dorner & Gorman, 2011; Hoyer, 2011; Leckie & Fullerton, 1999; Lloyd, 2006, 2007; Nazari, 2011; Nazari & Webber, 2012; Webber, Boon, & Johnston, 2005; Wu & Kendall, 2006). However, methodological practices that focused more on the phenomenon and not on the context within which the phenomenon is experienced have resulted in a dearth of deep insights into the actuality of IL as practiced in real-life university programs. Instead of focusing on people's experiences of IL, as is the dominant approach in those types of exploratory studies, the present study offers a context-to-concept approach which recommends studying people's experiences of the contextual constructs of the phenomenon. It conceptualizes the nature of information need and the process of determining information need in the study of geographic information science/systems (GIS) as observed from students' and educators' learning and teaching experiences of GIS assignments in a real-life GIS program.

2. Problem statement: need for moving from "typicality" to "actuality" in the disciplinary research of IL

Higher education models of information literacy have been designed to help students dealing with their information need when accomplishing assignments or learning a subject. However, the methods and approaches used to discover the actuality of the information need across disciplines do not address the actual nature and characteristics of the university assignment as experienced in real-life university programs (Julien, Given, & Opryshko, 2013). Many of the IL standards and curricula listed on the Association of College and Research Libraries (ACRL) IL wiki (Association of College and Research Libraries, 2014) are the result of community meetings representing librarians' and disciplinary educators' perspectives of a typical assignment, rather than an actual assignment. Addressing the complexity of an actual assignment requires a different path, a context-to-concept approach, to understand the real IL needs of students across the discipline. By exploring the actual learning and teaching practices of a subject in a real-life university program, it is possible to move away from the typicality of what has been defined as university assignments across disciplines, and to see the actuality of the assignments as experienced or

E-mail address: maryamnazari76@gmail.com.

http://dx.doi.org/10.1016/j.lisr.2016.04.005

reported in a university program. Taking a context-to-concept approach, this study focuses on the participants' actual learning and teaching practices of student assignments, as a key contextual construct. Students are asked to reflect on various aspects of IL, including determining information need. Constructive participatory methods can be very effective in the design of fieldwork questions. Instead of focusing on people's experiences and conceptualizations of IL (phenomenon/concept), as is the dominant approach in IL research, the focus is on the contextual constructs (context) around which the participants' experience of the IL is developed.

Lack of understanding of the actual nature of university assignments in university programs may lead to failure to address the real information and IL needs of students across disciplines. Taking the context-to-concept approach becomes even more important when seeing IL as a socio-cultural practice and a contextual phenomenon for which reality is shaped by the educational, cultural, and other contextual constraints within which the experience and practice of IL take place (Wang, Bruce, & Hughes, 2011). Understanding how students accomplish their projects and how educators expect students to address their project requirements provides a useful evidence base for understanding the context for which the building blocks of IL are constructed. Such contextual understanding of IL, then, provides stakeholders with the insights they need about the actual nature of IL and the way it should be customized for the needs of specific disciplines and be integrated into the curriculum.

This study addresses two main questions:

- What are the nature and characteristics of GIS university assignments? What requirements do they need to be accomplished?
- What do the characteristics and requirements of GIS university assignments tell us about the nature of information need and determining information need in the GIS discipline?

3. Literature review

According to prevailing higher education models of information literacy (e.g., Association of College and Research Libraries, 2000; Society of College, National and University Libraries [SCONUL], 1999), the very first task of IL is recognizing that there is a need for information and determining the nature and boundary of this need. In the ACRL standards, the most used framework by universities worldwide, this area of IL competency has been identified as the ability to determine "the nature and extent of the information needed" which requires students to:

a. define and articulate the information need,
b. identify a variety of possible source types and formats,
c. assess costs and benefits of obtaining the information, and
d. reevaluate the information need.

Similarly, in the SCONUL model, this area of IL competency has been defined as the "ability to recognize a need for information" and the "ability to distinguish ways in which the information gap may be addressed" (Webber, 2008).

In both frameworks, and other generic models of IL, information need refers to a knowledge gap addressed in a typical university assignment (e.g., an essay), and it is usually met by the use of some textual resources such as books, journals, databases, web resources, and more recently wikis, blogs, YouTube videos, and so on. However, several disciplinary studies of IL (Boon, Johnston, & Webber, 2007; Leckie & Fullerton, 1999; Williams & Wavell, 2006; Wu & Kendall, 2006) suggest that the IL needs of students differ from those identified in the generic models of IL. For example, Webber et al. (2005) explain that the IL needs of students are conceptualized in the faculty members' meaning of information in the subjects they teach as well as the "internal and external factors (e.g., the nature of learning tasks and employment expectations) informed by the nature of disciplines" (Nazari & Webber, 2010, p. 335). This study focuses specifically on the academic study of GIS, which has been defined as a combination of "science" and "geospatial technology". GIS as science is "a multidisciplinary research enterprise that addresses the nature of geographic information and the application of geospatial technologies to basic scientific questions" (DiBiase, Demers, Johnson, Kemp, & Luck, 2006, p. 5), and GIS as geospatial technology is "the specialized set of information technologies that handle georeferenced data [from] geospatial sensing, land surveying, and global navigation satellite systems, to data analysis (e.g. software for statistical analysis and modelling) to display and output (e.g. geovisualization software and imaging devices)" (pp. 5–6).

Due to the interdisciplinary and technology-oriented (hence evolving) nature of GIS and the geospatial nature of information in this discipline (DiBiase, 2008; Nazari & Webber, 2010; West, 2008), the types of learning tasks that students have to deal with are more complicated than in most other disciplines. When seeing this complexity in the context of generic models of IL, it becomes very obvious that the typicality of university assignments assumed in these models does not address the actuality of the projects that GIS students have to deal with throughout their course of study (Nazari & Webber, 2012) and after graduation, at work (Baker & Bednarz, 2003; Environmental Systems Research Institute, 2002; Gold, 1989; Goldin & Rudahl, 1997; Kemp, 1994). This is also evident in the studies that have examined generic models of IL in GIS education (Jablonski, 2004; Massey, 2002).

Even in customized versions of the ACRL IL standards, the actual nature of real-life university assignments has not been considered when IL is adopted for specific disciplines, including GIS. This is because the customized versions of IL have been mainly grounded on the opinions of some group of experts rather than on empirical research in actual university programs. For example, in the science, engineering and technology disciplines, similar to GIS, the influence of the interdisciplinary and changing nature of these disciplines on the types and formats of information resources used in these disciplines has not been addressed in revisited standards in several areas. The ALA/ACRL/STS Task Force on Information Literacy for Science and Technology has highlighted the need for "knowledge of information resources in more than one discipline", knowing "how to keep up with new developments and new sources of experimental/research data", and the need for accessing a broad range of information resources in various different formats that are usually costly and need "manipulation and a working knowledge of specialized software, …[such as]…multimedia, database, website, data set, patent, Geographic Information System, 3-D technology, open file report, audio/visual, book, graph, map" (ALA/ACRL/STS Task Force on Information Literacy for Science and Technology, 2009). Although these, to some extent, address some disciplinary characteristics of GIS, they do not reflect the actuality of students' projects in real-life university programs. For a holistic view of the actuality of IL in the disciplines, this study suggests a different departing point in the design of the fieldwork; a context-to-concept approach. Adopting an embedded exploratory case study design, this article demonstrates how the design considerations, especially in the fieldwork phase of the study, facilitated the illumination of the actuality of IL in a GIS university program and that how these considerations supported the transferability of the emergent results.

4. Methodology

4.1. Design: an embedded single case study

The study adopted an embedded exploratory case study method in order to gain a holistic and in-depth understanding of the actuality of IL in a real-life university program through the exploration of the teaching and learning experiences of university assignments embedded in a GIS program. The case was a joint master's degree GIS program delivered online by the universities of Leeds and Southampton in the UK, and Pennsylvania State University in the USA. The program offers a wide variety of GIS modules to a broad range of students from various professional and educational backgrounds and with different ambitions for learning GIS. The program aims to provide learners with a wide range of skills enhancement in information acquisition, extraction and management, data analysis, computer modeling and mapping, applied to real-world problem-solving in the fields of business decision making, health management, planning, and environmental management.

Case study research is an ideal methodology when a holistic, in-depth investigation is needed for understanding a phenomenon or a few issues in real-life contexts (Denscombe, 2003; Dooley, 2002; Eisenhardt, 1989; Stake, 1978; Yin, 2003). The embedded design, suggested by Yin (2003), allowed for the exploration of several units of analysis in the context of the case (Fig. 1). This included the learning and teaching experiences of 20 academics and 19 students involved in GIS projects (as units of analysis) in the context of 22 different modules offered by the study sites (14 by the UK sites and 8 by the US site). The diversity in the modules delivered by the study sites (Appendix A) and the overlap in the content of some module (Table 1) provided the researcher with a theoretically suitable case and facilitated the emergence of a wide range of perspectives on the phenomenon under study. This, accordingly, enhanced the validity of the results (Pickard, 2007; Yin, 2003).

4.2. Key informants

The selected population included 91% of the educators, all in the UK sites (ten) and ten out of 12 in the US site. Due to some accessibility constraints, because of the online mode of the program, only 19 students participated in the study. However, certain considerations which were taken into account when selecting the students and approaching them for data collection helped to some extent to overcome the limitations.

- Students were selected from various educational and professional backgrounds, and included those who had extensive learning experiences of the program (Appendix B).
- Deep semi-structured interviews were conducted with seven students who were accessible to the researcher.
- An open-ended questionnaire was designed around the themes which had emerged from the interviews and was completed by 12 students who agreed to participate in the study. Fortuitously, there was also diversity in the educational backgrounds and learning ambitions of those who completed the questionnaire (Appendix C).

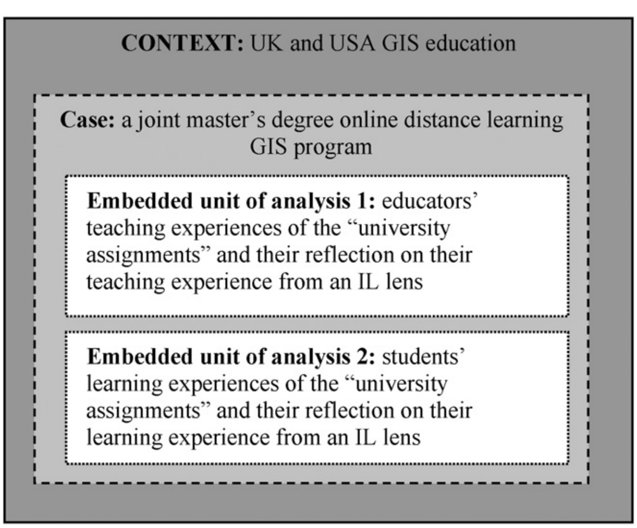

Fig. 1. Embedded design.
Adopted from Yin (1994, p. 40).

Table 1
GIS modules with overlaps, delivered by UK and USA sites.

UK modules		USA modules (Pennsylvania State University)
University of Leeds		
• Principles of GIS		• The nature of geographic information • Problem-solving with GIS • GIS database development
• Using databases and GIS		• Problem-solving with GIS • GIS database development • Cartography and visualization
• Spatial analysis	*overlaps with*	• Geospatial system analysis and design • Geographical information analysis
• GIS in the workplace		• GIS application development
• Dissertation		• Individual project work supervised by a graduate faculty adviser
University of Southampton		
• GIS for environmental management		• Environmental applications of GIS

4.3. Fieldwork design

Inspired by the participatory approach (Bergold & Stefan, 2012), the conceptualization of IL (the phenomenon) took place in the context of a real-life university program. The concept of IL was contextually constructed in the lived experiences of the teaching and learning practice of the student assignments (the construct). This approach follows the epistemological assumption that "knowledge is embedded in the lives and experiences of individuals and that knowledge is developed only through a cooperative process between researchers and experiencing individuals" (Borg, Karlsson, Hesook, & McCormack, 2012, p. 1).

To understand the actual meaning and practice of IL in the GIS context, the participants were implicitly asked to reflect on the various aspects of IL competencies, share experiences, discuss challenges and suggest approaches for inclusion of IL in the program, while they were fully situated in the context of their learning and teaching experiences of real-life GIS assignments. This context-to-concept approach minimized the disturbance of any non-contextual knowledge on IL throughout the conceptualization of the process. Thus, what emerged as determining information need (as the first area of IL competencies) reflected the actual nature of information need and the requirements needed to enable students determine and address their information need while dealing with GIS university assignments. This conceptualization is represented in Fig. 2.

4.4. Fieldwork process and data collection

Three methods were employed to gather the data: a) context-specific semi-structured interviews with educators and students; b) an open-ended questionnaire (for students) designed around the themes that emerged from the interviews; and c) analysis of the GIS module outlines (Fig. 3). The educator's interviews were treated as the main source of data as almost all the educators in the program participated in the study and they had a broad range of teaching experiences in the 22 modules. The patterns which emerged were then used in the design of the students' interviews. Although the student questionnaire was designed around the themes which emerged from the student interviews, its content also built upon the patterns from the educator interviews. Finally, the module outlines were used as complementary source of data used for a) design of the other three instruments, and b) for clarification of patterns which had emerged from other sources of data. From a design perspective, the module outlines acted as information sources which helped the researcher gain familiarity with the educational and disciplinary aspects of the GIS in the program and with the corresponding terminology. As a result the fieldwork questions were designed in a manner that could be easily communicated with the

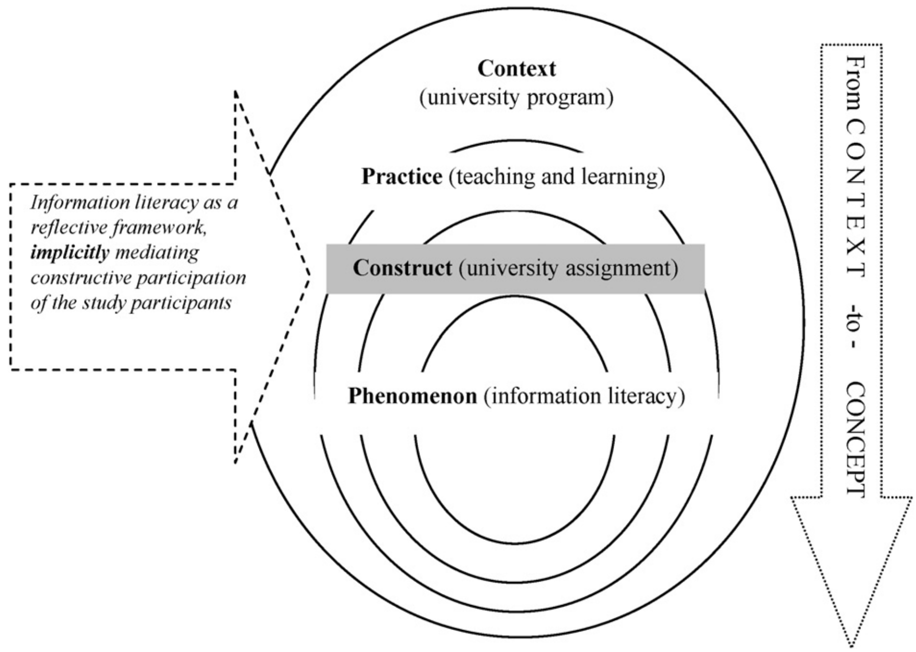

Fig. 2. Contextual conceptualization of IL in a university program.

study participants. Likewise, in the analysis phase of the study, the module outlines were consulted for spell-checking and clarification of any ambiguity that the researcher faced when transcribing and analyzing the data gathered from the other three sources of evidence. The three methods of data collection are more fully described below.

4.4.1. Contextually-designed semi-structured interviews with educators and students

As the study was probing the actuality of IL in GIS university programs, as a less-researched area, semi-structured interviews were used as the main method to explore the phenomenon. Unlike structured interviews that expose the interviewee to a set of predefined questions, semi-structured interview gives leeway for new issues to emerge during the interview (Denscombe, 2003; Seidman, 1998). To contextually uncover the actuality of IL in the program, the three-layer fieldwork design, discussed earlier, was used for the articulation of the interview questions, all situated in the context of the program (Fig. 2). These were the practice layer, the construct layer, and the phenomenon layer.

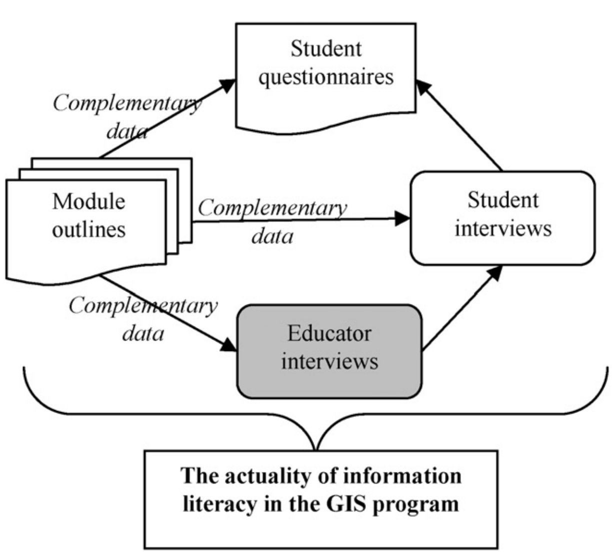

Fig. 3. Contribution of multiple methods of data collection to contextual conceptualization of IL.

4.4.1.1. The "practice" layer: Teaching and learning practices of the student projects. Taking a context-to-concept approach, the fieldwork began with the exploration of the practice (teaching and learning) in the context of the case (university program). It investigated the learning and teaching experiences of the students and educators, focusing on the following questions:

- For educators: What courses do you teach? Tell me more about your teaching experiences in this program.
- For students: What courses have you taken? Tell me more about your educational and professional background. Why did you select this course (program)? What do you want to do after graduation?

4.4.1.2. The "construct" layer: Students' projects. Having situated the participant in the context of their teaching and learning practice, the fieldwork moved onto the research construct, that is, university assignments. The study participants were asked to focus on one module and share their teaching and learning experiences of a project in that module. Educators who were in charge of more than one module were asked to focus on one module at a time. Students who had learning experiences of more than one module were asked to focus on a more advanced module that would require them to recall skills from earlier modules. Having focused on one module, they were asked to answer the following questions:

For educators: Can you describe a project that students have to accomplish in the module you are teaching? How do you expect them to accomplish the project? What steps do they need to take to accomplish the project?

For students: Can you describe a project that you had to accomplish? How did you accomplish the project? What steps did you take to accomplish the project?

4.4.1.3. The "phenomenon" layer: Information literacy competencies. Next, the IL competencies were used as a reflective framework to get the participants to reflect on the project accomplishment requirements (of any type: information, knowledge, skills, tools, etc.) and to discuss challenges and solutions in that context. To minimize the interference of the participants' existing knowledge and to give a voice to the real story of IL in the program, the IL framework (Fig. 2) was used as an invisible mediator throughout the fieldwork. This means the term IL was not directly exposed to the participants during the interview; instead they were asked to reflect on the various areas of IL when described their learning and teaching experiences of the students' projects.

For every project (and sometimes for every step in the project determined by the participant), the participants were asked to reflect on the various areas of IL competencies, so as to identify the requirements for the project accomplishment. The questions were designed around the five main areas of IL competencies:

– **Determining information need**: How is the student's project topic is defined—by student or educator? What knowledge and competencies do the students need to be able to select a topic and define their project? Does the program offer any instruction or learning support on this? What do you suggest to be included?
– **Searching and obtaining information**: What types of information are needed to accomplish the project? How do the students search for and obtain their needed information to accomplish their project? Where can the information be found or obtained? Does the program offer any instruction or learning support on this? What do you suggest to be included?
– **Evaluating information**: How do the students evaluate and select appropriate sources of information for their project? What evaluation criteria do they need to consider when selecting geospatial information? Does the program offer any instruction or learning support on this? What do you suggest to be included?
– **Synthesizing information**: How is the information analyzed and used in the context of the projects? Does the program offer any instruction or learning support on this? What do you suggest to be included?
– **Communicating information**: How are the project information and outcome(s) communicated? Does the program offer any instruction or learning support on this? What do you suggest to be included?

The semi-structured design of the fieldwork questions allowed for the emergence of the disciplinary-relevant aspects of the IL. This included new areas of IL competencies, such as creating, manipulating, handling, managing, and maintaining geospatial data, and also new facets for the information need. The present study reports findings on the nature of the first area of IL competency in GIS: determining information need, and examines how understanding the actual characteristics and requirements of GIS projects informed the actuality of the determining information need in GIS.

4.4.2. Open-ended questionnaire

The questionnaire (Appendix D) was designed around the patterns which emerged from the interview data. The patterns reflected the students' and educators' conceptions and experiences of the GIS projects, hence provided the respondents with contextually-emergent open-ended questions whose content and context sounded familiar to the respondents (GIS students).

Although, because of the online mode of the program, the researcher expected high participation in this phase of study, due to some constraints, only 12 students (out of 150) responded to the questionnaire. As several educators pointed out, responding to the questionnaire meant extra coursework, and that was a negative point for the educators and the program when evaluated by the students. Thus, the researcher received objections when they asked for permission to place an online questionnaire on the program web space. Instead, the researcher was given a list of students who were more suitable for the purpose of the study, as there was a significant diversity in their educational and professional backgrounds as well as their learning experiences of the program (Appendix C). This provided a reasonable spectrum of learning experiences on the phenomenon under study (Eisenhardt, 1989; Pickard, 2007; Yin, 2003).

4.4.3. Analysis of the GIS module outlines

As mentioned earlier, the module outlines were used as complementary data sources. In the data collection phase, the module outlines helped the researcher to gain familiarity with the terminology and context of the study and communicate the fieldwork questions in a language familiar to the study participants. For example, the researcher learned that "GIS data" is used by the GIS community as a term which is equivalent to the term "information". Once the data were collected, the module outlines were consulted for spell-checking and clarification of ambiguity in the patterns which emerged from the interview data. This facilitated modification of the questions in every round of the data collection, and helped the researcher to better understand the patterns and make sound interpretations.

4.5. Transferability facilitated by the design

The use of multiple methods of data collection and sources of evidence facilitated triangulation in the patterns and established validity in the results (Nazari, 2010). The design considerations also arguably supported the transferability of the results from this study. Geographically, the selected case was in the UK and USA, representing the dominant educational systems worldwide. The patterns which emerged as to the nature of information need and the depth and breadth of the determining information need in GIS reflected the perspectives of both students and educators, the two key role players in higher education university programs. Due to the broad coverage of the GIS modules taught in the program, the conception of determining information need emerged from a wide range of teaching and learning experiences of GIS projects, each representing some real aspects of information need and identifying requirements for determining information need in GIS. These points, taken together, support transferability of the results from this study to similar contexts.

From a methodological perspective, the research construct (students' real assignments) and methods can be used in other disciplinary studies exploring the actual concept and practice of IL in university programs. Depending on the design considerations, the results can be transferred at a discipline or program level.

4.6. Data analysis

As the study was an embedded case study, Eisenhardt's (1989) within- and across-unit analysis was used in every unit and across the units (teaching and learning experiences of the student projects) in the program. Due to the qualitative nature of the data in this study, Glaser and Strauss's (1967) four-phase grounded theory approach was adopted for the analysis of the data from each source of evidence, including 27 interviews with students and educators and the 12 questionnaires completed by students.

Due to the inductive nature of this study, data analysis began immediately after the first interview and the pattern which emerged from each interview informed the scope of questions used for next. Every interview was transcribed and coded. In order to provide for anonymity, the data from interviews, questionnaires, and the module outlines were coded as follows:

Interviews with Educators: (Educator-1 through Educator-20).
Interviews with Students: (Student-1 through Student-7).

Student Questionnaires: (Q1 through Q12).
Modules: (MO-1 through MO-24) (Appendix A).

The codes were supplemented with some memos based on the researcher's interpretation of the interviewee's statements. The memos facilitated the conceptualization of the emerging patterns on the phenomenon under study (Cutcliffe, 2000; Strauss & Corbin, 1998). Based on their similarities, the codes and corresponding memos were grouped under several themes, each explaining several codes and quotes. The same process was applied for the qualitative part of the questionnaires, where the respondents shared experiences.

The themes formed the foundation for the narration of a series of reports on the actuality of the IL story in the GIS program. This included 28 within-unit reports on the 27 learning and teaching experiences of the student projects, and one report on the questionnaire data. Corresponding module outlines were used to modify or complete the content of each report as needed. These documents helped to better understand the context of every individual teaching and learning experience and to better interpret the patterns emerged from the interviews. Each report was composed of three parts: a) the nature and characteristics of the student projects and requirements for the accomplishment of the projects; b) the influence of the characteristics of the student projects on the depth and breadth of the various areas of IL competencies; and c) challenges and solutions for the development of information literate students in the GIS program.

Finally, through the across-unit analysis of the 28 reports, one single report, consisting of the three parts, was written on the actuality of the IL in the GIS program, aimed at exploring the main focus of the study: what IL means in the GIS discipline and how it should be implemented in a way that supports the development of information literate GIS students in real-life university programs.

5. Findings: Actual nature of GIS university assignments

GIS projects were found to have four key characteristics, each of which relates to a different facet of the information need in the GIS discipline.

- Geospatial: GIS projects address problems with a location component;
- Technology-mediated: GIS projects need various tools and techniques to be accomplished;
- Subject-free: GIS projects address problems in almost any subject or application area;
- Unique in requirements: Every GIS project requires a unique set of data, tools and skills.

Each of these characteristics involves certain tasks and addresses certain requirements (Table 2).

Table 2
Characteristics and requirements of GIS assignments.

Project characteristics	Project tasks	Project requirements
Geospatial	Selecting feasible topics in terms of data availability and required skills	Being resourceful (being aware of data availability) Knowing own abilities in, and ambitions for, learning GIS
Technology-mediated	Visualizing problem geospatially, using GIS software Using appropriate GIS and non-GIS technologies to make data geospatially meaningful and usable for the project	Being skillful in using technology, of both GIS and non-GIS type Willing to learn new skills
Subject-free	Using both geospatial- and non-geospatial information	Having subject knowledge Knowing subject-related resources
Unique-in-requirements	Diagnosing ways in which GIS projects' multi-dimensional gap may be addressed	Understanding the nature of GIS projects and their multi-dimensional requirements Doing requirement evaluation Doing requirement gathering

5.1. GIS projects are geospatial

GIS projects address queries or problems with a location or "where" component in different subject or application areas, ranging from health, environment, retail to transportation (Educator-1 in Penn State, Educator-5 in Penn State; Educator-6 in Leeds). This means GIS problems are geospatial, requiring multi layers of data to be conceived and communicated geospatially. For example, in a project in the geodemographics and database management module (MO-6), students are expected to investigate the impact of pollution on children's diseases in London during 2005–08. This requires data on the various aspects of the problem, including:

a) Data on pollution and its distribution in different areas of London during 2005–08.
b) Data on children's diseases and their distribution in different areas of London during 2005–08.
c) Data about the relationship between pollution and children's disease" in London during 2005–08.

To accomplish this project, students need to have a geospatial understanding of the two core concepts of pollution and children diseases during 2005–08 (considering the location and time components of the problem). They also should use multiple layers of data to visualize the problem geospatially, that is, in association with its location and time components and corresponding attributes. Thus, location and time are two key elements that define the geospatial nature of problems in the GIS discipline. Although geography has been identified as the dominant context of GIS projects, depending on the subject of problem, context may go beyond geography and could include social, cultural, environmental, educational, and political contexts within which the problem is addressed (Educator-5 in Penn State).

This characteristic of GIS projects highlights two key tasks and some requirements for accomplishment of the projects. Firstly students need to select topics that are feasible. They need to ascertain availability of data and assess their own abilities to make sure that they are able to use GIS tools and software to accomplish the project. Secondly, they need to visualize the problem geospatially to be able to conceive of it in relation to its location component and corresponding contexts.

5.1.1. Selecting feasible projects

It is time consuming and expensive to create GIS data (or geospatial information [GI]) as information in GIS is multi-dimensional, having a time and location component. The location component represents the earth's features in particular time span. Because earth is a dynamic phenomenon, any data attached to it should be updated and maintained. For instance, if GI is about types of sand in a particular geographical location, it may not be the same two years later. Similarly, if GI is about distribution of pollution in a particular location at a particular time, it keeps changing (Educator-1,-8,-11 in Penn State, Educator-3 in Leeds; Educator-2,-3 in Southampton), and hence needs updating.

Due to the importance of data availability, before selecting a project topic, students need to think about the feasibility of that topic to make sure that they have access to needed data. Although universities usually provide students with the datasets they need to do their projects, it is important to make sure that the needed data or GI is available when students decide on their project topic and that they already possess or are able to develop skills in searching and finding or creating data if the GI is unavailable. Also, in this phase, students should be able to develop a clear picture of their project output as it helps them focus more when developing their understanding of the problem that their project addresses.

Students' professional backgrounds and workplaces are additional factors that affect their choice of project topic. Students need to select a topic that relates to their workplace demands so that they can develop skills in a real-life context. This may include a wide range of application areas, such as crime, education, and retail. For example, students who work in the education sector they would be likely to be more interested in education (Educator-2 in Leeds).

Likewise, students should select a topic that suits their abilities, as GIS projects tend to be technology-oriented involving use of a wide range of GIS and non-GIS tools. Due to the diversity in students' abilities, however in some modules, such as the GIS in the workplace module (MO-4), students are given the freedom to choose from both research-oriented and data-oriented types of projects. Data-oriented projects mainly require students to use various types of GIS and non-GIS tools and GIS data which require manipulation to become useable. According to Educator-2 in Leeds, “students who are less comfortable with GIS [software and tools] tend to choose an essay and do some research using web resources, and students who are more comfortable with data and GIS, choose a project that involves GIS tools. Each of these would require a different skill set”.

5.1.2. Visualizing the problem geospatially

To be perceived geospatially, a problem needs to be conceived of in the context of its location and time components. This is because GIS problems focus on studying phenomena in a certain location on the earth's surface and within a specific period of time. Some examples can highlight the geospatial nature of GIS problems:

- Where is the best place to establish new Tesco supermarkets in the UK? (MO-9)
- Is there any relationship between pollution and cancer in South Africa? (MO-6)
- How can we plan the distribution of health care facilities in Sheffield? (MO-15).

Although the time component is not always explicitly addressed in GIS problem scenarios, it does plays a key role in analyzing and understanding GIS problems as it affects various aspects of the problem. For example, pollution in South Africa may have different meanings in different periods of time. Accordingly, this may influence the attributes and the overall concept of pollution as the core subject of the scenario. This may require understanding different variables, such as transportation, population, traffic, and so on, representing and illuminating the concept of pollution in that particular location. In other words, GI is “contextually-constructed”; it carries different meaning in different social and geographical contexts, mentioned by Educator-10 in Penn State:

“Most of geographical information is contextualized in our life, it's not really absolute; there is a context that gives it a grounding meaning”.

This implies that the time and location components of GIS problems need to be conceptualized in the broader contexts in which the problem is addressed. Thus, in this phase students need to contextualize the GIS problem in its time and location components and in corresponding contexts to be able to develop their understanding of the problem geospatially. Due to the geospatial and multi-dimensional nature of information in GIS, the contextualization usually requires mediation of some GIS and non-GIS tools (Educator-2, -8 in Penn State; Student-3 in Leeds). This means that students need to be able to select and use appropriate GIS and non-GIS tools to conceive and contextualize the problem geospatially, considering its time and location components.

Likewise students should have spatial awareness and be familiar with maps and directions. According to Educator-7 in Leeds, spatial awareness is an expected competency whose deficiency may create a barrier in conceiving GIS problems. This educator believes that this problem may be related to not having maps around at an early age and it can make a substantial difference in people's spatial awareness and map literacy (Educator-7 in Leeds).

In sum, there are two aspects to the perception of, and defining of, GIS problems:

- *Understanding the problem holistically*; *considering the various contextual aspects of the problem when conceiving the problem.* This involves some information searching, reading and synthesizing activities. It highlights a need for sufficient knowledge of relevant information resources and the ability to search for information through appropriate channels and to evaluate and synthesize information in such a way that it can contribute to students' holistic understanding of the problem.
- *Understanding the problem geospatially*; *considering location and time components of the problem when conceiving the problem*. This involves using GIS and non-GIS tools to process and prepare GI for the project at hand. It highlights a need for sufficient knowledge of the capabilities and limitations of GIS tools and the ability to use the tools appropriately in GIS projects.

5.2. GIS projects are technology-mediated

Information that is used in GIS projects is geospatially technology-mediated. It requires mediation of GIS tools to become geospatially meaningful and usable as GI has a location component and some attributes associated with it; all need to be overlaid properly in the GIS software to become usable in the project (Nazari & Webber, 2010). The mediation of GIS and non-GIS tools is a requirement for making sense of, and using, GI throughout the project accomplishment process (Table 3). For instance, to evaluate GI, students need to use GIS software

Table 3
Ways of using GIS and non-GIS tools to make sense of, and use, geospatial information (GI).

Project tasks	Reasons for, ways of, using GIS and non-GIS tools
GI manipulation	To overlay multiple layers of data To transform data to a format (e.g. x, y, and z coordinates) that is usable in project To customize existing tools to make them usable for manipulation of GI To do programming to create new tools that are capable of manipulating GI
GI creation	To use land survey and GPS (global positioning system) information to create maps To use online mapping systems to create thematic maps and legends
GI evaluation	To check accuracy of GI in GIS software, that is, to make sure that the multiple layers of data are properly overlaid To use metadata (source of data) to check reliability of GI
GI analysis and synthesis	To use appropriate methods and models inside and outside of GIS to analyze and visualize problem geospatially and to synthesis solutions
GI management	To develop or adopt appropriate information management systems to manage different layers of GI and project files, all in one space To create and/or record metadata
GI communication	To present project results in a geospatially communicable way (e.g., using multi-layer maps, charts, and analytically commentary texts), in printed and digital formats
GI maintaining	To use GPS and survey equipment to observe any changes in location components of GI and to update GI, if necessary

to check the accuracy of GI, and to make sure that the multiple layers of GI are correctly overlaid.

The technology-mediated characteristic of GIS projects is also highlighted in different GIS modules. For instance, in the retail decision support systems module (MO-9), students need to use certain tools to do some catchment analysis in order to identify the density of population of customers in the places where retail stores have been located and to see how well the stores fit within that pattern. They need to consider where the competitive stores are, and what market they are serving. From this analysis, students should identify stores that are in certain locations, the types of customers living within a mile, and they should buffer those areas. Then they need to ask questions such as "Am I missing areas where I have got potential customers that I am not serving?" (Educator-4 in Leeds).

The technology-mediated characteristic of GIS projects highlights four main tasks and requirements for accomplishment of the project. Firstly, students need to search for existing solutions to prevent replication. Secondly, they need to determine the necessary geospatial and non-geospatial information. Thirdly, they need to determine the operations needed to make sense of, and use, GI. Finally, they need to identify the appropriate tools (of both GIS and non-GIS type) to perform operations on the GI.

5.2.1. Searching for existing solutions

Because of the time-consuming and costly nature of GI (Educator-2 in Southampton), in the GIS discipline there is a tendency towards searching for existing solutions before searching for needed data. Students need to investigate whether and how other people or organizations have dealt with similar projects (Educator-3 in Leeds). People and organizations are two core sources of information in the GIS used by students in this phase. To exploit these sources effectively students need to have communication and networking skills (Educator-2 in Southampton; Student-3).

As mentioned earlier, GIS projects are very diverse as they may address problems in any subject area. Depending on the nature of the problem, different data and tools may be needed and each may require a specific set of operations and skills. Therefore, students should determine the scope of their needed data, tools, and competencies that both suit the level of their abilities and lead them to the production of a solution for the problem at hand. These are described below.

5.2.2. Determining necessary geospatial and non-geospatial information

Depending on the nature of the problem different types of information may be needed. The example detailed above, on the impact of pollution on children's diseases in London, illustrates the complexity of such a project. Developing a geo-demographics system is another example. To determine the scope of the information needed, students should have a clear idea of the variables needed for the design of the system. This includes information about purposes of system development as well as the users of the system (MO-6). Depending on the availability of information and existing solutions, the project may require producing some census data or gathering data from existing resources.

In the retail decision support systems module (MO-9), students need to have some information about retail supermarkets' customers, their characteristics, and where they live. Using GIS, students then need to map the customers' information to present a visual image of the distribution of customers in the geographical location (Educator-4 in Leeds). They also need to have some knowledge and understanding of census data, such different scales and other characteristics. They need to understand techniques used to construct the census data indexes and to be able to construct such indexes for specific purposes. For example, "one student constructed his own index to capture the issue of spatial polarization rather better" (Educator-5 in Leeds).

Students were found to use a wide range of data to deal with their projects (Table 4). Both geospatial and non-geospatial types of information may be needed to deal with a GIS project. The necessary information may be in the format of articles available in journals and databases, or in the form of statistical or census data, maps obtainable from organizations, and other sources of information.

Table 4
Types of data used by GIS students (extracted from questionnaires).

Code	Type of data/information
SQ1	Economic and demographic or census data
SQ9	Data about critical infrastructure transportation network, political boundaries, environmental resources, and hazard information
SQ2	Demographic and telecommunications data, and any other data that are useful in GIS applications to sustain an ecologically healthy environment
SQ8	Data maintained by the US state and federal agencies, county-created data, state-supplied data, and data from municipal partners and engineering firms
SQ5	Coordinate data, planner map data, 2-D cross-sectional geologic and hydrologic information and parameters

5.2.3. Determining operations needed to make sense of, and use, geospatial data

GI is technology-mediated, that is, it requires the mediation of GIS tools to become geospatially meaningful and usable. This is because although GI can originally be data in any format (e.g., text, number, image, or map), it becomes geospatially meaningful only when its location, time, and attributes are overlaid and attached to each other properly. This requires the mediation of geospatially-enabled tools, that is, GIS software. GI also needs to be in a specific format (e.g., x,y,z coordinates) to become readable by GIS software. This requires some pre-processing using spreadsheet applications such as Excel and Access. In preparing data, students need to recognize different geospatial data formats and to know how to import data into a standard format (Educator-1 in Southampton). For example, in the GIS and planning module (MO-10) students use both GIS and non-GIS tools, including SPSS and Excel, to manipulate and join data to make maps (Educator-2 in Leeds).

Due to the tightly-scheduled nature of GIS program in almost all GIS modules, students are provided with the necessary data and they usually do not need to do operations on the data (Educator-8 in Leeds; Educator-1 in Southampton). However, in their workplaces they are expected to be capable of recognising appropriate operations and to be able to process data to make it usable (Educator-8 in Penn State; Educator-7 in Leeds). In this regard, Educator-1 in Southampton states:

"…learners also need to be asked to identify, download and prepare data for exercise themselves, but this would at least be double, or probably triple the length of this task and make this a more daunting exercise for the learner".

5.2.4. Identifying appropriate tools and techniques, inside and outside of GIS software

The nature of problem as well as the type of GI used in GIS projects determine the types of tools needed to do the operations. Tools likely vary from one project to another. For example, according to Educator-2 in Penn State, in the transportation field, "you would need to know how to work with road networks and use the particular tools that allow you to do dynamic segmentation to figure out different segments of the route in the road network.… [this requires]studying what is actually the road they are going to work on, or what's the most traffic congested, however, it would be difficult to know what tools are necessary for a certain discipline or problem because there are so many tools.".

Diversity in GIS problems and variation in the methods of using GIS tools highlights the need for an ability to select appropriate tools and skill in using the tools in completion of the project. To select appropriate tools for data processing students need "to know what kind of data they are working with and where they are looking to [as] there are local governments, military, private sector, environmental; and also different disciplines where GIS can be applied and there are particular tools that work for those areas or disciplines" (Educator-2 in Penn State).

Students may also need to use some non-GIS tools to pre-process GI. This has been illustrated in several learning experiences. Students' responses to the questionnaire show that some students use tools outside of GIS software to accomplish their projects. For example, Q1, Q4, and Q11 used Excel and Access as complements to GIS to produce charts and manipulate data. Q11 used Project and Visio for GIS project management tasks. Q12 used "AutoCAD to create a detail image of the intersection at a larger scale, geo-reference the image and store it in an image catalogue".

Overall, in this stage students need to have some knowledge of the limitations and capabilities of GIS. They also need to be familiar with other technologies and tools that can be used additionally or alternatively in their projects.

5.3. GIS projects are subject-free

Due to the wide applicability of GIS to almost any discipline and context, GIS projects address problems in almost any application area, ranging from healthcare to retail and transportation. Regardless of the context or subject, any problem with a location or geographical component can be addressed in the GIS. However, the selection of a project very much depends on students' personal and professional backgrounds; students' knowledge of, and abilities in, using GI and GIS; and the availability of data needed for their project. In addition, GIS students have a wide range of reasons for attending GIS programs. Some have attended the program to boost themselves professionally or initiate a career path (Fig. 4). Those who already work in a particular sector, on the other hand, see GIS as a tool for problem-solving that can be used in various subject areas.

Students who expressed interest in learning GIS software wanted to use it for the purpose of problem-solving in the areas of planning, project management, airport, geology, environment, and engineering, and one intended to use GIS for recruitment purposes. There were also students who had personal interests in technology and computers, GIS and spatial representations, and maps and geography in particular. When they asked what they expect to learn from the GIS program, some mentioned they want to become skillful in using GIS software; others were more interested in the science aspect of GIS and wanted to learn the underpinnings and principles of GIS. Finally there were a few students who had their own company or had managerial roles. They wanted to understand GIS and its functionalities to be able to supervise employees and to communicate spatial concepts (Appendices B and C).

This highlights a need for students to conduct self-evaluations of personal and professional interests before commencing a GIS project. Self-evaluations would guide students to focus on the application areas that would best match workplace demands or personal interests. This, especially in the context of next characteristic of GIS projects, is particularly important because every GIS project may require a unique set of data, tools and skills. Therefore, it is important that students reflect on their own resourcefulness and abilities in dealing with their selected projects.

5.4. GIS projects are unique in requirements

Findings revealed that every individual GIS project may require a unique set of data, tools and skills, depending on the problem scenarios and the application areas of GIS projects as well as availability of necessary data. This characteristic of GIS projects is informed by other characteristics of GIS projects (Fig. 5). The geospatial, technology-mediated, and subject-free characteristics of GIS projects make it likely that a unique set of data, tools and subject knowledge will be needed for any given project. The set of data, tools and knowledge needed to deal with a retail-related GIS project in one location may differ from set of data, tools and knowledge needed for a similar project in another location. This is because similar phenomena (e.g., sales and population.) may vary over different locations and times simply because the context within which the problem is defined and addressed may vary. Hence, each GIS project may require a different set of locational or spatial data, a different set of tools to make sense of, and use, the data in the project, and different subject knowledge to understand the phenomenon in its time, location and subject and application contexts.

For example, the retail and decision support system module (MO-9) focuses on issues such as establishing a new supermarket in a specific geographical location. To understand and analyze this problem, students need to gather and use various types of data, including distribution of people and supermarkets in that particular area, and they need

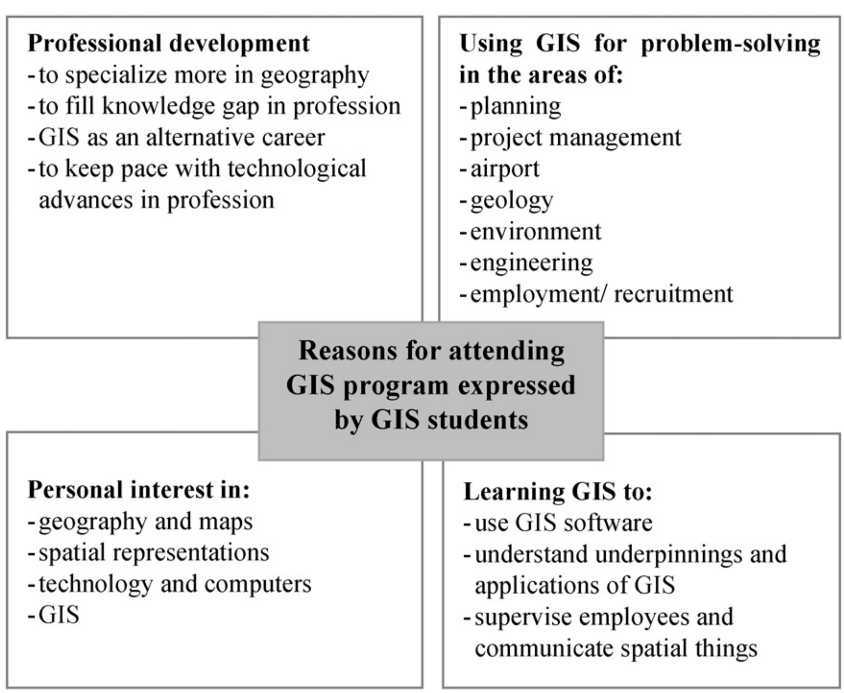

Fig. 4. Motivations for attending GIS program.

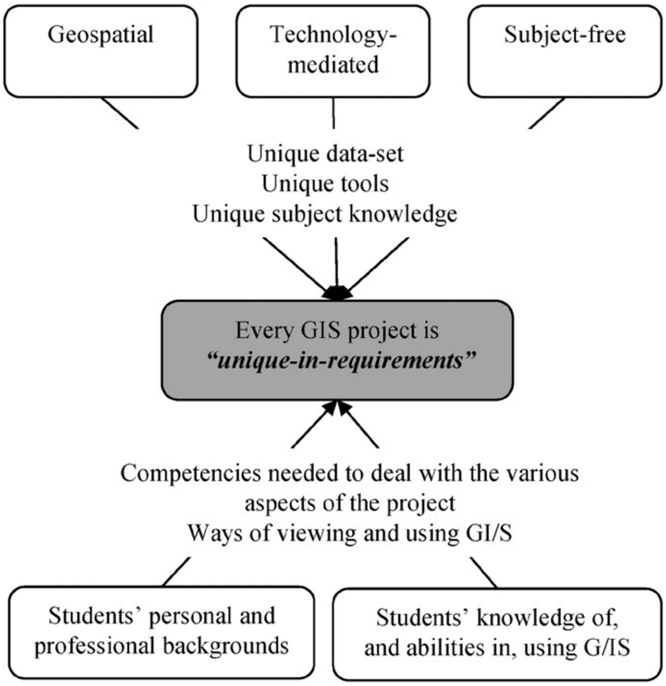

Fig. 5. "Unique-in-requirements" characteristic of GIS assignments.

to use GIS software to understand the problem geospatially in its location and time contexts. They also need to have some knowledge of the underpinnings of retail, business, and marketing to be able to translate the data and understand the problem holistically.

In the healthcare management module (MO-15), the projects mainly focus on access to different health facilities. Educator-2 in Southampton points out that background knowledge about each case (i.e., problem scenario) may vary. Students should be able to convert conceptual models for the representation and to understand how to organize the actual datasets. However, "there are probably low intermediate statistical skills in being able to combine data from different accurate sources and to build appropriate indicators".

In the geo-demographics and database management module (MO-6), students are supposed to build a geo-demographics system. This requires an understanding of the practical and theoretical strengths and weaknesses of geo-demographics and lifestyle classifications and knowledge of how to build such systems. Students also need to understand the ethical issues around the use of such systems and classifications. According to Educator-2 in Leeds, in this module student projects involve using tools and software inside and outside of GIS. It also requires learners knowing about how to use the tools.

Another reason why GIS projects are unique in their requirements lies in the personal and professional backgrounds of students as well as their knowledge of, and abilities in, using geospatial data and GIS tools. Each student brings to the project their own unique way of viewing and using GIS. This underscores the need for students to determine their own abilities when they approach a project.

5.4.1. Determining necessary competencies

Every individual student needs to be able to diagnose their competency gaps and identify the scope of knowledge and skills they may require to cope with their project. According to Educator-8 in Leeds, diversity in students' knowledge and background makes it challenging to offer a learning package that would meet the learning needs of every individual student. Students need to have a wide range of skills that are not specifically GIS-relevant. Similarly, Educator-4 in Leeds states that "although students are provided with wide range of learning materials, it is difficult to diagnose the real learning needs of learners and what extra they may need". The need for identifying appropriate skill sets has also been highlighted in the "applied environmental GIS" module (MO-11) as a requirement for students so that they can handle their project of choice (Educator-2 in Leeds).

To deal with this challenge, Educator-8 in Leeds recommends approaches that enable students to diagnose their learning and skill needs by looking at their experiences and knowledge bases. Students need to look at what they are able and what they are not able to do, and identify their competency gaps.

The need for determining competency gap can be seen in two situations. The first is when students have to make data geospatially meaningful and usable to produce solutions for their projects. Because of the variation in the types of GI used in various phases of GIS projects, every project may require a specific dataset (Table 1). In this situation, students need to develop skills to be able to determine types of operations they need to make sense of, and use, the data in their projects and to be able to perform the necessary operations.

The second situation is when students need to use non-GIS tools or to customize GIS tools within GIS software. In addition to having a good conceptual understanding of the capabilities and limitations of GIS and non-GIS tools, students should be able to work on a practical level with appropriate non-GIS tools. Students need to determine the scope of competencies they need to use and customize existing tools or create new geospatially-enabled tools to produce solutions for their projects.

Although two modules have been devoted to developing programming and customization skills in students (MO-5, MO-22), because of the diversity of GIS problem scenarios and students' abilities, the need for recognising competency needs remain important in the GIS discipline.

5.4.2. Maintaining self-knowledge and competencies

Due to the evolving and technology-oriented nature of GIS, students need to update their knowledge and competencies to be able to use advanced tools and techniques. This can be accomplished using various resources, including GIS communities and forums, and new releases by GIS software developers (Educator-5; Educator-17). Findings revealed additional resources, including colleagues, the Internet, discussion forums, software companies' products and services, attending conferences, and online workshops and courses. Additionally, because of the

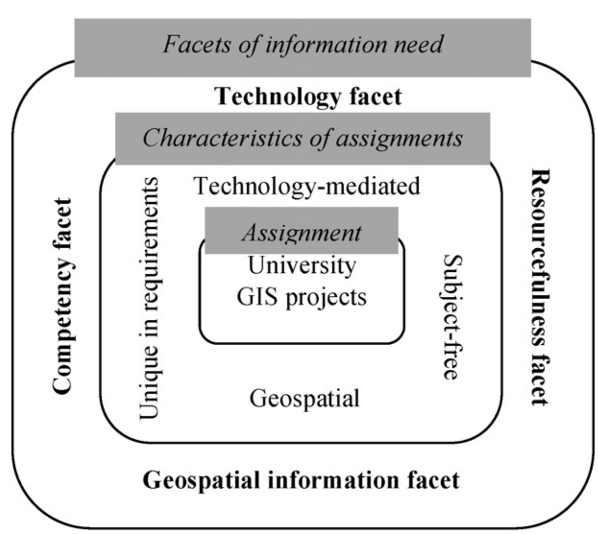

Fig. 6. Multi-faceted nature of information need in GIS.

wide applicability of GIS and the multi-dimensional nature of GIS problems, students also need to keep up to date in the application area of their projects.

6. Discussion: Actual nature of determining information need in GIS

Unlike the generic models of IL that identify information need as a knowledge gap in a typical university assignment (ACRL, 2000; Society of College, National and University Libraries, 1999; Webber, 2008), this study revealed that information need is more complicated in real-life university programs. GIS projects are geospatial, technology-mediated, subject-free, and unique-in-requirements (Fig. 6). Each of these characteristics uncovers a new facet for information need in GIS, and highlights new ways in which the multi-dimensional gaps in GIS project may be addressed.

6.1. Geospatial facet

The geospatial facet of information need addresses a gap in the existing geospatial data and the processes required for data to become usable in a project. This includes operations and manipulations that the data would require to become geospatially meaningful. A major task would be to transform data (which could be in any number of formats) into a format that is readable by GIS software (x,y,z coordinates), using a wide range of tools inside and outside of GIS. To distinguish the ways in which the geospatial facet of information need may be addressed, students need to have a sound knowledge of the nature and characteristics of GI and what it requires to render data geospatially meaningful and usable in the project at hand. They also need to have realistic view of own knowledge and abilities in manipulating or creating GI. These, together, will help students determine requirements for making sense of, and using, GI in their projects. It will also guide them on selecting a topic that is feasible, considering data availability and self-abilities in manipulating existing data or creating new data.

6.2. Technology facet

The technology facet of information need addresses a gap in existing tools and the type and quality of tools needed to make sense of, and, use, GI in the projects. Existing GIS tools may not always be capable of manipulating and processing GI in a way that is needed in a given project. Students may need to either customize existing GIS tools or to create new geospatially-enabled tools. Thus, the technology facet of information need addresses a gap in the existing tools that students need to diagnose when dealing with GIS projects and then need to be competent in to be able to accomplish their project.

6.3. Competency facet

The competency facet of information need addresses gaps existing in the abilities and knowledge that students would require to deal with the geospatial and technological aspects of their projects and gathering requirements for their project. This includes competencies that are needed to make sense of, and use, GI in their projects, in other words, their abilities in using tools and techniques both inside and outside of GIS software.

6.4. Resourcefulness facet

This facet of information need addresses a gap in the student's resourcefulness or their knowledge of the existing resources available for their project. This includes the student's knowledge of existing data, solutions, and tools needed for the project. Students should be able to diagnose this gap to be able to gather the requirements for their project and to accomplish it effectively.

Thus, due to the multi-faceted nature of information need in GIS, students need to be able to distinguish these four facets to address the multi-dimensional gaps in GIS projects and to understand how each facet addresses a particular gap in their project. It is through such holistic understanding of the multi-faceted information need that students will be able to determine information need when dealing with GIS projects.

7. Conclusion

When viewed in real-life university programs, information need is more than just a knowledge gap in a typical university assignment, because the actual nature of university assignments in real-life university programs is different from those identified in the generic models of IL. GIS projects, for example, are geospatial, technology-mediated, subject-free and unique-in-requirements and each uncovered a new facet of information need in this specific discipline.

In the very first task of determining information need, students need to identify the “gap” between what they know, and what they need to know to complete their assignment (SCONUL, 2008). However, as found in this study, very little is known about the quality and dimensions of this “knowing” in specific disciplines. Unless students have a holistic understanding of the actual nature of their assignments, they may fail to understand the multi-dimensional aspects of “knowing” and may fail to address the gap holistically and correctly when dealing with assignments. There are several different ways in which the gap may be addressed. Each facet informs a particular aspect of the “knowing” that students need to be aware of to be able to diagnose the corresponding requirements when dealing with a project (Table 5 illustrates this in the context of GIS).

Unless we understand actual nature of university assignments, we may fail to uncover the actual nature of IL in the disciplines and to exploit its capabilities as an enabler for learning. IL acts an enabler for learning when students are enabled to conceive the context-dependent nature of information need when dealing with assignments. To empower students with such a way of viewing and practicing IL, we first need to understand and conceptualize the actual nature and characteristics of university assignments in real-life university programs and to customize IL to those needs.

This study highlights a need for the development of a body of knowledge on the actuality of the university assignment and to use that

Table 5
Facets and types of information need in GIS.

	Facets of information need in GIS			
	Geospatial facet	Technology facet	Competency facet	Resourcefulness facet
Types of information need	Requirements needed to make sense of, and use, GI in GIS projects	Requirements needed to create or customize appropriate tools to manipulate GI and to make it usable in GIS projects	Competencies needed to diagnose and gather project requirements	Resources needed to meet project requirements
	Gap in format and quality of GI	Gap in the functionality of GIS tools	Gap in students' knowledge and abilities to deal with geospatial and technological aspects of GIS projects	Gap in students' resourcefulness (knowledge about availability of resources needed to meet project requirements)

knowledge to customize higher education models of IL to the actual needs of disciplines.

The findings of this study are in line with research that identifies the nature of learning tasks and employment expectations as key factors influencing the conceptualization of IL in the disciplines (Leckie & Fullerton, 1999; Webber et al., 2005; Wu & Kendall, 2006). However, this study took a step further and demonstrated how the contextual exploration of these factors can advance our understanding of the actual nature of IL in the disciplines.

Treating students and educators as builders of the building blocks of IL whose constructive participation in the study brought new perspectives on the actual nature of IL also confirms the socio-cultural nature of IL as a practice "embedded in the activities of particular groups and communities" (Wang et al., 2011, p. 299). However, unlike other studies that have directly focused on communities' conceptions and experiences of IL to illuminate the context-dependent nature of IL (Wang et al., 2011), this study focused on the context itself. It conceptualized the actual nature and characteristics of university assignments in a real-life university program and used that to uncover the actual meaning of IL as an enabler for learning. The implicit mediation of IL framework, used in the fieldwork phase of this study, facilitated the constructive participation of students and educators in the conceptualization of IL in the context of university assignments. While the findings of this specific study can be of use to stakeholders who seek insights on the actuality of IL in other technology-oriented disciplines, the context-to-concept approach proposed can be of value to any IL researchers and practitioners who seek further insights on the actual nature of IL, especially those interested in the customization of the generic models of IL to the actual needs of students in university programs.

Acknowledgments

This study received awards and scholarships from the Worldwide Universities Network (WUN) and John Campbell Trust. It also received the sincere support of the University of Sheffield as well as several academics and students in the Universities of Leeds, Southampton and Pennsylvania State. The author would like to acknowledge all their contributions.

Appendix A. GIS modules

Module (MO)	UK sites	Module (MO)	US site
1	Principles of GIS	15	The nature of geographic information
2	Using databases and GIS	16	Problem-solving with GIS
3	Spatial analysis and GIS	17	GIS database development
4	GIS in the workplace	18	Geospatial system analysis and design
5	Introduction to Java programming	19	Cartography and visualization
6	Geo-demographics and database management	20	GIS programming and customization
7	Census analysis and GIS	21	Environmental applications of GIS
8	GIS and geo-computation	22	Individual project work supervised by a graduate faculty advisor
9	Retail decision support systems		
10	GIS and planning		
11	Applied environmental GIS		
12	GIS for environmental management		
13	GIS for analysis of health		
14	GIS for health care management		

Appendix B. Profile of interviewed students

No	Code	Site	Modules taken	Background	Reason
1	Student-1	UK	▪ Principles of GIS ▪ GIS in databases ▪ Spatial analysis ▪ GIS in workplace	Computers, IT as first degree. PhD in town planning.	To become professional in her main field of work. For self-satisfaction Just loving geography and computers.
2	Student-2	UK	▪ Principles of GIS ▪ GIS in databases ▪ Spatial analysis ▪ GIS in workplace ▪ GIS for analysis of health ▪ GIS for health care management ▪ Geocomputation and GIS	First degree in psychology and math. Working in the geography field in academia. Using GIS for mapping and analysis.	Learning GIS to fill the knowledge gap in his current profession.
3	Student-3	UK	▪ Principles of GIS ▪ GIS in databases ▪ Spatial analysis ▪ GIS in workplace	First degree in geography. Computer or IT background only with Microsoft Office (Excel, Access, Word). Very limited experience of statistical packages and GIS. Works as GIS analyst.	Taking the GIS distance modules to make him a better professional at his workplace.
4	Student-4	US	▪ The nature of geographic information ▪ Problem-solving with GIS ▪ GIS database development ▪ Environmental applications of GIS	BA, MS, PhD degrees in geology.	Thought it would be useful to learn the basics of GIS because these techniques are now used so much in the geology, environmental, and engineering professions.
5	Student-5	US	▪ Geographic information ▪ Problem-solving with GIS ▪ GIS database development ▪ GIS programming and customization	BS in regional planning. Working as airport planner.	To solve problems with GIS in the airport field.
6	Student-6	US	▪ Geographic information ▪ Problem-solving with GIS	First degree in geology. Work as environmental consultant.	To keep pace with technological advancements in his field of work and gain the ability to use GIS in his profession. Personally interested in and fascinated with

(*continued*)

No	Code	Site	Modules taken	Background	Reason
					maps and representing things.
7	Student-7	US	▪ Geographic information ▪ Problem-solving with GIS ▪ GIS database development ▪ GIS programming and customization	BS in biology, token undergraduate classes in engineering principles and design. Profession: project management.	For project management. Personal interest. A way to communicate with people about spatial things, to people who don't know anything spatially.
8	Student-8	US	▪ Geographic information ▪ Problem-solving with GIS ▪ GIS database development ▪ GIS programming and customization ▪ Geographical information analysis ▪ Geospatial system analysis and design ▪ GIS application development ▪ Geospatial technology project management Geographical information analysis	BA in geography and sociology. Working in geography field. Worked in a computer software company as a programmer and database administrator.	To specialize more in geography advances.

Appendix C. Profile of students who responded to the questionnaire

Code	Site	Background		Reason
		Educational	Professional	
Q1	US	BS and MS in biology.	Senior extension educator	
Q2	US	Master's degrees in political science, community and regional planning; BS in criminology	Teaching in the fields of geographic information systems, regional planning and geographic information systems for Walter Rand Marketing Systems. Managing Director of Geodemographics.	
Q3	US	Master's degree in forestry	Working for the US Forest Service.	To expand my set of skills.
Q4	US	PhD in microbiology and biochemistry	Environmental consultant and teacher.	To understand the principles and power of GIS. Using GIS as a valuable tool in the evaluation of potential employees.
Q5	US	Master's degree in geology	Mathematical modeling and hydrogeology.	To fill a knowledge and skill gap in his education and profession.
Q6	UK	MA in business	IT investment banking. Mobile telecoms industry.	Personal interest in geography and the world. As educator

(*continued*)

Code	Site	Background		Reason
		Educational	Professional	
				learning GIS can open some opportunities the future.
Q7	US	BA in geography	IT administrator.	To keep pace with technological advances in his profession.
Q8	US	BS in geography, GIS certification	GIS coordinator of a medium sized county in Pennsylvania. Worked for a public utility doing GIS work and for a private sector engineering firm as a GIS specialist/analyst.	To improve his profession and work with GIS software.
Q9	US		Planning leader of a region in the US.	Planning encompasses GIS. In order to be successful at his profession and expand his knowledge.
Q10	US	MS in geography	US Geological Survey. Assistant Professor in the field of geography. Software scientist. Systems engineer.	To become proficient in the use of the ESRI product line.
Q11	US	BFA in illustration (graphic and structural design)	Digitizing stereo images, and assisting in the development of emergency management software.	To improve in her profession.
Q12	US	BS in economics	Computer networking, specifically in sales for 15 years.	To explore other career options. Personal interest in geography, maps, and data.

Appendix D. Student questionnaire

Dear GIS learner,

Please use UNDERLINE instead of TICK ☑ to answer optional questions and use number for questions need priories.

I really appreciate it if you take your time and give me as much as information you can.

3- How do you use GIS?

To solve a problem ☐
As a tool ☐
Others ☐ Could you please explain.

4- How do you go about solving a problem? Could you please priories the following items:

Searching for data ☐
Searching for solution ☐
Searching for tools ☐
Others ☐ Could you please explain briefly.

5- Where do you search for data?

6- What type of data do you use?

7- How do you make sure that the data is correct?

8- To use data, do you do any manipulation on data?

Yes ☐ No ☐
If yes, do you use tools or techniques inside of the GIS software ☐ or outside of the software ☐ or both ☐

9- Do you create any data?

Yes ☐ No ☐
If yes, how do you create data, what techniques and tools do you use?

10- Do you do any customization on the tools or in the GIS software to create or use data?

Yes ☐ No ☐
If yes, what sort of techniques or methods do you use?

11- Do you use any tool or technique outside of the GIS software?

Yes ☐ No ☐
If yes, could you please give me an example.

12- Do you do anything outside of the GIS to manipulate data or customize a tool? For instance; doing any programming or using any software outside of the GIS like Access, Excel, etc.?

Yes ☐ No ☐
If yes, could you please give me an example?
Also if your answer is yes, how or from what resources do you learn how to use the tools outside of the GIS or do a new technique that you are not familiar with?
The Internet ☐
Discussion forums ☐
Colleagues ☐
Hiring somebody else who is expert ☐
Others ☐ Please explain.
I appreciate it if you explain about your approach.

13- How do you manage your data?

Creating a data management system by yourself ☐
Following data management system created by other colleagues in your company ☐
Using the GIS software data management tools ☐ Could you please explain about your approach.

14- Do you do any documentation of the process of problem-solving?

Yes ☐ No ☐
If yes, do you share it with your clients?
Yes ☐ No ☐

Do you share the documentations with other users?

Yes ☐ No ☐
If yes, how?
Online ☐
Others ☐ Could you please explain.

15- Do you create metadata?

Yes ☐ No ☐
If yes, do you follow specific standard or method?
Yes ☐ No ☐
If yes, could you please name the standard or method you use.

16- How do you keep yourself update on using new tools, new techniques, and the new advancements in GIS? Please **priories** the following items:

The Internet ☐
Discussion forums ☐
Colleagues ☐
Software companies products and services ☐
Others ☐ Could you please explain.

17- To what extent do you think the GIS courses helped you to learn the skills you need in your workplace?

Very much ☐
To some extent ☐
Little ☐
None ☐
How?

18- Could you please give me brief information on your educational and professional background and why did you decide to take GIS course(s)?

19- What course(s) have you taken?

20- How would you describe a successful GIS user?

References

ALA/ACRL/STS Task Force on Information Literacy for Science and Technology (2009e). *Information literacy standards for science and engineering/technology*. Retrieved from http://www.ala.org/acrl/standards/infolitscitech

Association of College and Research Libraries (2000). *Information literacy competency standards for higher education: Introduction*. Retrieved from http://archive.ala.org/acrl/il/toolkit/intro.html#highered

Association of College and Research Libraries, Instruction Section (2014). *Information literacy in the disciplines*. Retrieved from http://wikis.ala.org/acrl/index.php/Information_literacy_in_the_disciplines

Baker, T. R., & Bednarz, S. W. (2003). Lessons learned from reviewing research in GIS education. *Journal of Geography*, *102*(6), 231–233.

Bergold, J., & Stefan, T. (2012). Participatory research methods: A methodological approach in motion. *Forum: Qualitative Social Research*, *13*(1). Retrieved from http://nbn-resolving.de/urn:nbn:de:0114-fqs1201304

Borg, M., Karlsson, B., Hesook, S. K., & McCormack, B. (2012). Opening up for many voices in knowledge construction. *Forum: Qualitative Social Research*, *13*(1). Retrieved from http://nbn-resolving.de/urn:nbn:de:0114-fqs120117

Boon, S., Johnston, B., & Webber, S. (2007). A phenomenographic study of English faculty's conceptions of information literacy. *Journal of Documentation*, *63*, 204–228.

Cutcliffe, J. R. (2000). Methodological issues in grounded theory. *Journal of Advanced Nursing*, *31*(6), 1476–1488.

Denscombe, M. (2003). *The good research guide: For small-scale social research projects*. Maidenhead, UK: Open University Press.

DiBiase, D. (2008). Scoping geographic information systems for education: Making sense of academic and practitioner perspectives. *Geography Compass*, *2*, 1–23.

DiBiase, D., Demers, M., Johnson, A., Kemp, K., & Luck, A. T. (Eds.). (2006). *Geographic information science and technology: Body of knowledge*. Ithaca, NY: University Consortium for Geographic Information Science.

Dooley, L. M. (2002). Case study research and theory building. *Advances in Developing Human Resources*, *4*(3), 335–354.

Dorner, D. G., & Gorman, G. E. (2011). Developing contextual perceptions of information literacy and information literacy education in the Asian region. In A. Spink (Ed.), *Library and information science trends and research: Asia Region*. *2* (pp. 151–172). Bradford, UK: Emerald Publishing.

Environmental Systems Research Institute (2002). *Guidelines for developing a successful and sustainable higher education GIS program: An ESRI white paper*. Redlands, CA: ESRI.

Eisenhardt, K. M. (1989). Building theories from case study research. *The Academy of Management Review*, *14*(4), 532–550.

Glaser, B., & Strauss, A. (1967). *The discovery of the grounded theory: Strategies for qualitative research*. New York, NY: Aldine de Gruyter.

Gold, C. M. (1989). Breadth versus depth: The dilemma of G.I.S. education. *In Proceedings: GIS, Geographic information systems: Challenge for the 1990s, Ottawa, Canada, February 27-March 3, 1989*. Ottawa, Canada: Canadian Institute of Surveying and Mapping. Retrieved from http://www.voronoi.com/wiki/images/c/c1/Breadth_versus_depth.pdf

Goldin, S. E., & Rudahl, K. T. (1997, October). *Why is GIS difficult?* Paper presented at the 18th Asian conference on remote sensing, 20–25 October, 1997, Kuala Lumpur, Malaysia. There is no publisher - this is all part of the conference name.

Hoyer, J. (2011). Information is social: information literacy in context. *Reference Services Review*, *39*(1), 10–23.

Jablonski, J. (2004). Information literacy for GIS curricula: an instructional model for faculty. *Journal of Map & Geography Libraries*, *1*(1), 41–58.

Julien, H., Given, L. M., & Opryshko, A. (2013). Photovoice: A promising method for studies of individuals' information practices. *Library and Information Science Research*, *35*, 257–263.

Kemp, K. K. (1994). GIS education in the global marketplace. In J. J. Harts, H. F. L. Ottens, & H. J. Scholten (Eds.), *Proceedings of EGIS/MARI '94*. *1* (pp. 538–541). Paris, France: EGIS Foundation.

Leckie, G. J., & Fullerton, A. (1999). Information literacy in science and engineering undergraduate education: Faculty attitudes and pedagogical practices. *College and Research Libraries*, *60*, 9–29.

Lloyd, A. (2006). Information literacy landscapes: An emerging picture. *Journal of Documentation*, *65*, 570–583.

Lloyd, A. (2007). Recasting information literacy as socio-cultural practice: Implications for library and information science researchers. *Information Research*, *12*(4). Retrieved from http://InformationR.net/ir/12–4/colis34.html

Massey, M. (2002, Marchh). *National collaborative projects for information and spatial literacy*. Paper presented at the International Conference on Information Technology and Information Literacy University of Glasgow, Scotland, March 20–22.

Nazari, M. (2010). Design and process of a contextual study of information literacy. *Library and Information Science Research*, *32*, 179–191.
Nazari, M. (2011). A contextual model of information literacy. *Journal of Information Science*, *37*(4), 345–359.
Nazari, M., & Webber, S. (2010). What do the conceptions of geospatial information tell us about information literacy? *Journal of Documentation*, *67*, 334–354.
Nazari, M., & Webber, S. (2012). Loss of faith in the origins of information literacy in e-environments. *Journal of Librarianship and Information Science*, *44*(2), 97–107.
Pickard, A. J. (2007). *Research methods in information.* London, England: Facet Publishing.
Seidman, I. E. (1998). *Interviewing as qualitative research: A guide for researchers in education and the social sciences.* New York, NY: Teachers College Press.
Society of College, National and University Libraries (1999). *Information skills in higher education: Briefing paper.* London, UK: SCONUL Advisory Committee on Information Literacy.
Stake, R. E. (1978). The case study method in social inquiry. *Educational Researcher*, *7*(2), 5–8.
Strauss, A., & Corbin, J. (1998). *Basics of qualitative research: Grounded theory procedures and technique (2d ed.). London, England: Sage.*
Wang, L., Bruce, C., & Hughes, H. E. (2011). Sociocultural theories and their application in information literacy research and education. *Australian Academic & Research Libraries*, *42*(4), 296–308.
Webber, S. (2008). *The seven headline skills expanded.* Retrieved from http://wikifoundryattachments.com/O4GP7WTlsZXPXnjOTtirOQ==24655
Webber, S., Boon, S., & Johnston, B. (2005). A comparison of UK academics' conceptions of information literacy in two disciplines: English and marketing. *Library and Information Research*, *30*(93), 4–15.
West, B. A. (2008). *Conceptions of geographic information systems (GIS) held by senior geography students in Queensland* (Unpublished doctoral dissertation). Queensland University of Technology, Brisbane, Australia. Retrieved from http://eprints.qut.edu.au/16682/1/Bryan_Andrew_West_Thesis.pdf
Williams, D. A., & Wavell, C. (2006). *Information literacy in the classroom: Secondary school teachers' conceptions.* (Research report, 15). Aberdeen UK: Robert Gordon University.
Wu, Y. D., & Kendall, S. L. (2006). Teaching faculty's perspectives on business information literacy. *Reference Services Review*, *34*(1), 86–96.
Yin, R. K. (2003). *Case study research: Design and methods.* London, UK: Sage.

Maryam Nazari holds a PhD in information science from Sheffield University, UK. She is a consultant at the Iranian Research Institute for Information Science and Technology (IranDoc) and a board member of the Iranian Scientific Association of Information Management (ISAIM). She specializes in information literacy contextual research and practice and works as an enabling consultant for several universities and organizations in Iran. She has published several articles in the *Journal of Documentation*, *Journal of Information Sciences*, *Library* and *Information Science Research*, and *Journal of Librarianship and Information Science*.