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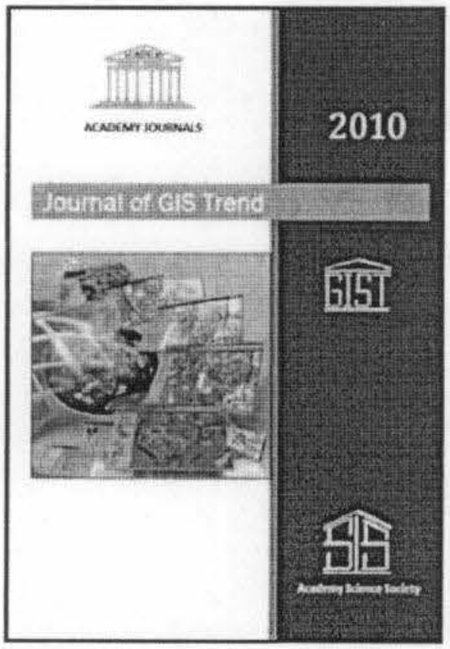

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Review Paper

Empowering GIS Education Program: Is GIS as a Science, Art or Tool?

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Abstract

The technology of Geographic Information System (GIS) is demanding nowadays as to provide professional to perform research science and administration in various disciplines. The higher education institutions plays a crucial role in providing the GIS education programs or courses in promoting the growing use of GIS at university level especially for undergraduate's, master's and Ph.D. This paper reviews and discusses the strength of GIS position as GISystem and GIScience, and our perspective in empowering students to answer the question to GIS communities: is GIS as a science, art or tool? It is important for the related department, users and public to aware and understand the GIS different position as the GIS education nowadays become more challenging to be taught in the higher education institution.The answers for the term "a GIS as a tool" and "a GIS as a science" are based on definitions of GIS and the area/disciplines involved in GIScience. We relate our discussion to the student's awareness and competences in different level of GIS education program required to fulfill by the students after they graduated. In term of "a GIS as an art", our opinion dominantly relates to cartography as the discipline that highly contributes to the visualization and presentation capability in GIS.

Keywords: *GISystem, GIScience, GISart, GIStool, education program, definition*

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INTRODUCTION

Geographic Information System (GIS) is one of technological innovation that rapidly growing and applied to solve problem in various areas. Over the past decades, awareness has grown incredibly where GIS have been taught in one form or another in every higher education around the world. In higher education there is a huge need to intensify Science, Art, Technology, Engineering and Mathematics programs where GIS has an important role in empowering students in geo-visualization and use GIS for exploiting the power of geographic thinking and creative problem-solving. But there is still much to be understood throughout GIS as a curriculum, beyond the traditional meaning to modern GIS definition.

Obviously, the advancement in the use of GIS technology is growing up rapidly. The impact of high demand on GIS specialist and analyst lead to increasing number of education programs both including Diploma's, Bachelor's, Master's and Ph.D degrees, and non-formal including short courses and training. Each GIS program provides different competency level for student to fulfil. Higher educations institutes need to differentiate whether a GIS programs offered are structured to fulfil the GIS specialist with a GiScience, GisArt or GisTool? The philosophy or basic concept of GIS curriculum is important for GIS Program Coordinator to develop a successful GIS program such as in deciding the type of teaching materials as well as to establish GIS laboratories and other related facilities. GIS has different role as a science, art or tools, but can be triple as science-art and tool. While there are many education or training programs for learning about GIS, it appears that there are a few concerns for learning about the connection between GIS as a science, art and tool. In this regard how we see the connection between them together with the current state of role? It is exciting to see the goal of teaching and research using GIS successful.

Time changes as well as knowledge and technology. Over the time the reason we received knowledge and technology also changed. We learn and develop new thought about spatial data in our life, where new design and application can be created. Time changes and growth leads to new idea and perception, where sometime what was accepted in the past become blurring and requires new establishment at another level in different perspective. New expectation in the near future for GIS terms arise and our expectation is GISystem is capable to deliver some more things, with a real opportunity to define the future of GIS and to make a real difference.

GISYSTEM AND GISCIENCE

Geographic Information System (GIS): A GIS is a special type of information systems. Information systems consist of hardware, software, data, people, and procedures that work together to produce quality information. All components in information systems cooperate one and each other to collect, to manage and to distribute information to individual or organizations. GISs have one characteristic that makes them special and differs from other types of information systems that is location of objects. According to Harmon and Anderson (2003) a GIS is composed of people as the users of the system, applications as the processes and programs they use to do their work, data needed to support those applications, software as the core of GIS and hardware in which the GIS runs. An information system, geographic or not, is supposed to support people in decisions making providing them consistent results with high level of confidence (high accuracy).

In most literature we read a GIS is defined as a computer system with much functionality for spatial data processing. Here are some definitions of GIS: David Rhind (1988) in Demers (2000) defined a GIS as "a computer system for collecting, checking, integrating, analyzing information related to the surface of the earth. The GIS has the following subsystems (Demers, 2000): a data input subsystem, a data storage and retrieval subsystem, a data manipulation and analysis subsystem, a reporting subsystem. A data input subsystem collects and preprocess spatial data from different resources. Preprocessing phase including the spatial data transformation step results clean spatial data to furthermore store in the data storage and retrieval subsystem. As a database in a non-geographic information system, this subsystem organizes the spatial data that allow retrieval, updating and editing. A data manipulation and analysis subsystem performs tasks in the data, aggregates and disaggregates, estimates parameters and constraints, and perform modeling functions (Demers 2000). The analysis subsystem is the most important part in the GIS. This subsystem allows users to analyze the contents of databases, to perform data aggregation and data reclassification for further analysis. Results from the querying databases or from analysis subsystem are displayed in the reporting subsystem in form of tabular, graphic or map. According to Worboys and Duckham (2004) GISs are computer-based information systems that are used to capture, model, store, retrieve, share, manipulate, analyze, and present geographically referenced data). According to this definition, the databases system is the most important technology underlying GIS. Databases organize data in a form that is easy to store and retrieve. Besides defining a GIS as a computer-based information system, Worboys and Duckham (2004) consider GIS as a special interest in computing science.

The task of computing practitioners in the field of GIS is to provide the application experts, whether geographers, planners, utility engineers, or environmental scientists, with a set of tools, based around digital computer technology, which will aid them in solving problems in their domains. Computational tasks such as data structures modeling enhance a GIS as a tool that will allow efficient storage and retrieval spatial data. Chang (2008) defined GIS as a computer system for capturing, storing, querying, analyzing, and displaying geospatial data or geographically referenced data. Geographically referenced data are the data that describe both the locations and the characteristics of spatial features such as roads, land parcels, and vegetation stands on the Earth's surface. The important aspect that distinguishes a GIS from other types of information systems such as management information systems is the ability of GIS to handle and process geospatial data. In other words, a GIS provides a means of linking databases to maps, creating visual representations of statistical data, and analyzing how location influences features and events on the earth's surface. A GIS combines software with hardware and information stored in computer databases to assist a user in solving complex research, planning, and management problems (Fischer and Nijkamp, 1992).

Geographic Information Science-GIScience: Geographic information science (GIScience) is a new science with vast opportunities for growth. Goodchild (2006) defined GIScience as "research on the generic issues that surround the use of GIS technology, impede its successful implementation, or emerge from an understanding of its potential capabilities". GIScience might take two essentially distinct forms: *research about GIS* that would lead eventually to improvements in the technology; and *research with GIS* that would exploit the technology in the advancement of science. In term of *research with GIS*, a GIS is redesigned to support the process models of the sciences, rather than generic and simplistic representations of form.

The content of GIScience includes data collection and measurement, data capture, spatial statistics, data models and theories of spatial data, data structures, algorithms, and processes, display, analytic tools, as well as institutional, managerial, and ethical issues (Goodchild 2006). GIScience can be defined as a philosophy of academic theory behind the development, use, and application of GIS that answer a science questions. Many disciplines contribute to GIScience such as cartography, geodesy, photogrammetry and spatial statistics. As the GIS became cost-effective and user friendly tool, GIScience began to emerge as the challenging discipline to understand, focus, and direct to the technological revolution. Therefore, GIScience seeks to provide the theoretical foundation of GIS into science. GIScience provides researchers in numerous disciplines with scientific facts and advanced methods to analyze and display data, develop and test models, and integrate data from multiple sources to solve problems.

Currently, GIS research community, for example National Center for Geographic Information and Analysis (NCGIA) in California, U.S.A. makes focused effort to integrate the science and the systems of GIS to improve the theory and applications of this discipline. NCGIA is an independent research consortium dedicated to basic research and education in geographic information science and its related technologies, including GIS (http://www.ncgia.ucsb.edu). Another community namely Association of American Geographers (AAG) also concern with the science elements in GIS development. The AAG has just published the first edition of the Geographic Information Science and Technology Body of Knowledge. It is a community-developed inventory of the knowledge and skills that define the GIS & Technology field. It is designed as a reference work for use by educators, curriculum planners, and evaluators; current and prospective students; certification and accreditation bodies; human resources personnel; and geospatial professionals. The GIS & Technology fields includes Analytical Methods, Cartography and Visualization, Design Aspects, Conceptual Foundations, Data Modeling, Data Manipulation, Geocomputation, Geospatial Data, GIS & Technology and Society, Organizational and Institutional Aspects (University Consortium for Geographic Information Science 2006).

GIS AS A SCIENCE, ART OR TOOL?

What we present in this part is our own view as an academician and researcher to answer the question "is GIS as a science, art or tool?" The point written here are based on a review of a few references about geographic information systems and geographic information science explained in the two previous sections, as well as other related references. Our thought to comment "a GIS as an art" dominantly relates to cartography as the area that closely link to maps producing. Based on our learning in GIS course, maps are one of the important outputs of GIS representing spatial modeling results. As software and hardware became more cost-effective and user-friendly, the benefits and applications of GIS technology became better understood, the use of GIS spread into many disciplines such as planners, engineers, and land use managers.

The impact of widely use of GIS in many disciplines is highly increasing number of education programs that offer GIS course. Many disciplines and departments at colleges and universities incorporate GIS into their teaching and/or research. These include geography, geology, sociology, archaeology, computer science, forestry, agriculture, engineering, environmental science, business, biology, drafting, economics, surveying, engineering, political science, journalism, public health, history, urban planning, and many more. The types of programs are range from vocational or workforce programs, which focus on basic-level technology education and training, to academic courses with in-depth mathematical and scientific foundations in GIScience. According to the GIS definitions reviewed in the article, a GIS is a computer-based information system with three main functionalities including 1) spatial data management: capturing, storing, retrieving, sharing and manipulating; 2) spatial data analysis; and 3) spatial data visualization. An important aspect need to concern in developing GIS program is what are competences needed to achieve by students after they graduated from the programs. This aspect relate to the question how deep do the students deal with the three major functionalities in GIS: spatial data management, spatial data analysis, and spatial data visualization. Based on this aspects GIS program managers decide the program curriculum, teaching and learning methods, facilities needed, and education management. Different levels of education and majors in GIS provide different competences for students to fulfill.

A GIS as a Science: "Science" is often used as a generic synonym for "research," particularly research of a basic and systematic kind. Thus "science" often functions as a rather crude but convenient shorthand for academic legitimacy (Wright et. al. 1997). GIS is widely regarded by people as a subset of geographical science. They assume geography's affiliation with GIS thus pairs it with the computer. There are two terms to describe the emergence of a science based on GIS. The first is geomatics or geoinformatics, a term favored in many countries because of its simplicity and its ease of translation into French; secondly, geographic information science, where the term is well-known in the English-speaking world. Geographic information science is actually the science of GIS. It is concerned with geographic concepts and is the primitive elements used to describe, analyze, model, reason about, and make decisions on phenomena distributed on the surface of the earth. These usually deal with the geometric primitives of points, lines, and areas to the topological relationships of adjacency and connectivity through the dynamic relations of flow and interaction to domain-specific concepts as such as neighborhood, geosyncline, or place. One of programs focusing on spatial data processing and related fields is geoinformatics that covers specialized areas such as remote sensing, surveying, GIS, GPS, photogrammetry, has gone through tremendous development and has become similar to an engineering discipline (Tripathi 2005). International Institute for Geo-information Science and Earth Observation, Enschede, The Netherlands (now become the Faculty of Geo-Information Science and Earth Observation of the University of Twente), http://www.itc.nl/, offers Postgraduate study in Geoinformatics. The objective of the program is to improve the understanding and engineering skills of course participants in the application of technology for spatial data infrastructures including the relevant base collection of technologies, policies and institutional arrangements that facilities the availability of and access to spatial data.

Postgraduate students in Geoinformatics from ITC finish some basic and core modules in 12 months. Some of them are principles of remote sensing, geographical information systems, mathematics and computer programming language, spatial data modeling, database design, and visualization. Students in this program not only use a GIS as a tool in problem solving but also study about underlying technologies in the development, use, and application of geographic information systems (GIS). GISs deal with both spatial and non-spatial data (attribute data) from various sources and formats. Researches about GIS are performed in Master's and Ph.D degrees in postgraduate programs, for example Geoinformatics, to enhance technologies applied in GISs related to the three main functionalities in GISs: spatial data management, spatial data analysis, and spatial data visualization. The GIS research conducted by many universities and research communities such as National Center for Geographic Information and Analysis (NCGIA), California, U.S.A. integrates the science and the systems of GIS to improve the theory and applications of this discipline. Students and researchers who perform *research about GIS* consider a GIS not only as a tool but also as a science. In term of "a GIS as a tool" they as information systems specialists focus on integrating information technology solutions in spatial data handling to meet the information needs in organizations. As the comparison, computer scientists do research in computer science spanning a wide range, from its theoretical and algorithmic foundations to cutting-edge developments in robotics, computer vision, intelligent systems, bioinformatics, and other exciting areas. Students and researchers who consider a GIS as science, we call them as Geographic Information Scientists (GIScientists), conduct scientific works in the content of GIScience including data collection and measurement, data capture, spatial statistics, data models and theories of spatial data, data structures, algorithms, and processes, display, analytic tools, as well as institutional, managerial, and ethical issues (Goodchild 2006). Education program for graduates as GIScientists need to develop the structure of curriculum by adopting the contents of GIScience and technology provided by some institutions such as Association of American Geographers that just published the first edition of the Geographic Information Science and Technology Body of Knowledge. Therefore the program graduates have both competences as GIS engineers and the analytical competence to work with GIScience and technology fields including analytical methods, cartography and visualization, conceptual foundations, data modeling, data manipulation, geocomputation, and geospatial data.

GIS research will most likely implement those concepts and procedures that are the simplest, most logical, and most rigorously defined, for example, the most primitive and/or the most scientific. These include issues of recognition and measurement in the field; the choice between alternative representations; the roles of generalization and multiple representations; the representation of uncertain information; methods of analysis and modeling; problems of describing the content of geographic data and evaluating its fitness for use; and methods of visualization. Thus these sorts of issues underscore the multidisciplinary nature of geographic information science.

A GIS as an Art: In most of the situation, we work with and visualize the geographic data in the forms of maps and hence GIS is most often associated with a map. A map is only one type of product generated by a GIS. A GIS can provide a great deal more problem-solving capabilities than using a simple mapping program or adding data to an online mapping tool. The position for GIS as an art form is in cartography as an art form. Cartography, by definition is likely to be brief and similar to 'the art and science of making maps'" (Robinson 1989). Since GIS is commonly associated with maps, so there is always a link between the GIS and cartography.

One of major capabilities of GISs is spatial data visualization providing the users interesting patterns and valuable information resulted from spatial data management and analysis. GIS specialists need to build a friendly user interface to relate GISs and the users, enabling them to easily understand and to use the information provided by the GIS in decision support making. In our opinion, the term a GIS as an art emerge in such the work. In system information development, system analyst or other IT specialist design an user interface considering the important questions what are the user's goals?, what are the user's skills and experience? And what are the user's needs? The answers of the question are important to the system designers in order to construct a friendly user interface that allows the user to see clearly what functions are available in the information systems. For example, they will concern how are toolbar, menu item, submenu item, and dialog box created and located in the pages to provide easy exploring of information. In addition to knowing and understanding about principles, methods and technical skill in user interface design, the designers are advisable to have a sense of art.

GIS specialist may consider a GIS as an art in their work in constructing visualize module to communicate GIS results to users. A map is the main GIS output. A map is a representation or abstraction of geographic reality. It is a tool for representing geographic information in a way that is visual, digital or tactile (Blok 2006). In GIS environment, maps can be used to input for GIS, communicate GIS results and support spatial analysis. The important question to answer in the map production are "how to say, what to whom, and is it effective"? Our opinion, GIS specialists who focus on spatial data visualization especially in form of maps may view a GIS as an art form. The term art here refers to how GIS specialists create a map as a product of their touch based on their knowledge in cartographic methods and techniques. For example, to construct population density maps (inhabitants per sq km), they should know how to select color composition in such a way that value is used to display the density from low (light tints) to high (dark tints).

Andrienko and Andrienko (1999) developed a visualization module to automatically generate maps enabling users to view results of Knowledge Discovery in Databases (KDD) in the spatial context. They applied the C4.5 classification algorithm, the commonly used decision tree algorithm in data mining, on spatial data. Integration of KDD techniques with GISs allows users to analysis spatial relationships and interesting patterns in data distribution. Some fields in GIScience and information technology contribute in this work including data models and theories of spatial data, data structures, algorithms, and data mining. In our view, sense of art influences the design phase in constructing such the tool for interactive classification of spatial data. Several aspects are important for designers' i.e. cartographic methods and techniques as well as principles in the user interface design. Therefore the tool displays appropriately maps representing interesting patterns namely list of rules in spatial context.

A map visualizing a tree node relates to other maps displaying further division of the tree node (Andrienko & Andrienko 1999). Endelman (1999) explained the links between art and maps. One of the relations is "art in maps" in which art can be present as an element in a map. Meanwhile, according to Woodward cited in Endelman (1999), "Cartographic elements, such as color, symbols, and lettering, are shared with other visual arts." This forms the basis for the category of art in maps. There are four major relationships or links that exist between GIS-art and maps. Firstly, art can be present as an element in a map. Secondly, art can function as a map. Thirdly, a map can be in a piece of art. Frothily, a map can be viewed throughout distant and modern history. Besides that, cartographic elements, such as color, symbols, and lettering, are shared with other visual arts. This forms the basis for the category of art in maps. While every tool in a GIS toolkit offers potential for artistic expression, there are broad areas of benefit that can be categorized. GIS provides a spectrum of possibilities where every pixel can be portal to new understandings. By definition, cartography is linked to art (Endelman 1999). Cartographers use GIS as an art form because a GIS provides unique capabilities and methodologies for artistic expression. GIS has the potential to allow new and old users to model the geography of whatever they can perceive or imagine. Using some form of GIS technology, interactive models of a view of reality or a view of imagination are presently more than just possibilities.

A GIS as a Tool: Many universities and colleges offer vocational programs in diploma (2 or 3 years program) or bachelor degree focusing on basic-level technology of GIS. Students in these programs study routine uses of basic GIS technology, develop a GIS and use a GIS as a tool to solve non-complex problems. They do not deal with underlying theory in GISs as computer based information systems. Some departments at colleges and universities such as Geography, Geoinformation, Geodetic and Geomatic Engineering, and surveying incorporate GIS as a core discipline into their teaching and/or research. In addition GIS courses may also be available to Bachelor's degree students in other disciplines, for examples forestry, agriculture, and environmental science, as elective or supporting courses. Students in these programs develop a GIS using given GIS software or use available GISs to solve problems related to their fields. For example, a bachelor degree student in the Soil Science and Land Resources Department, Bogor Agricultural University used a GIS as a tool to map the forest fire risk in Rokan Hilir and Rokan Hulu districts, Riau Province Indonesia (Astria, 2008). He used GIS softwares: ArcView, ArcGis and Erdas Imagine to process spatial data related to forest fires as the input to create some forest fire risk maps as the output. In this case he is not directed toward understand the theoretical aspects of GISs such as how to implement the indexing methods in spatial databases in order to provide efficient data queries or how is fuzzy logic applied to handle uncertainty in spatial data. We viewed a GIS for the students in the above mentioned education programs as a tool to solve non-complex problem in their disciplines.

In one of the GIS definitions, Burrough (2001) defined GIS as a set of computer system tools that facilitate the storage, retrieval, analysis and display of spatial data. From this definition, we can regard GIS is a tool, specifically, a computer system tool. GIS can be looked as the use of a particular class of software, the associated hardware tools such as digitizers and plotters, and digital geographic data in order to advance some specific purpose. The tool itself is inherently neutral, its development and availability being largely independent of its use which is driven by application. The term "doing GIS" is always be used. In this context, "doing GIS" is rather the making use of the GIS tool to advance the investigation of a problem. If the investigation merits the label "research," then "doing GIS" is probably "doing science" as well (Wright et. al. 1997). In some of the projects or research, the use of GIS as an analysis tool always plays an important role. In some of the titles, such as "The use of GIS in monitoring water quality", "Crime pattern analysis using GIS", "Estimating non-point source pollution using GIS" and etc, obviously these kinds of research have the objectives which are to some degree "methodological,". In these cases, the tool may assume a greater role in directing the research, and hence be given greater prominence in documentation, and case studies may be used to illustrate the technique rather than to provide generalizable empirical results.

The university is a place where the GIS based knowledge tool can be spread. In some University, GIS courses are taught by faculty or staff in computing facilities; in others, they are taught in departments such as surveying, civil engineering, or forestry (Morgan & Fleury 1993). Basically, these courses be taught has two main purposes. Firstly, they prepare students to do their own research by using GIS as analysis tool and secondly, they provide students with useful job skills in which the student acquire the knowledge regarding GIS skill.

THE AWARENESS OF STUDENT ON GIS EDUCATION

GIS educations in higher institutions are rapidly changing. These changes are impacting the needs for highly trained, knowledgeable and capable employers. Higher education is attempting to adapt and to provide a solution to these demanding and changing circumstances. This includes developing GIS with concerning of triple concept of science, art and tool, and "the content of GIS courses must be reviewed and updated".

Nowadays, GIS is more widely used compared to those days. Many colleges and universities in Malaysia now offer undergraduate and graduate programs with certification diploma, degrees and masters that are related to GIS. One of the advantages is to make sure the student is exposed to the latest technology and this will help in development of the nation. There are several universities which offer the courses related to GIS such as University Putra Malaysia (UPM), University Sains Malaysia (USM), University Teknologi Malaysia (UTM) and University Malaysia Sabah (UMS). Meanwhile, UPM offers GIS courses in the program such as forestry, agriculture, environment, landscape and civil engineering (Mohd Hasmadi 2008). Courses in GIS are more likely to be offered to reflect their essentially technical and service orientation.

Some of the university which has the geography department, the using of GIS is mostly on the basis that probably would not claim GIS as a research specialty or not encourage its students to regard GIS as a substantive subfield of the discipline (Wright et. al., 1997). For the educator in GIS the perspective of the role "the science of GIS", is basically concern with the analysis of the fundamental issues raised by the use of GIS. In some cases, the department adopting the toolmaking position as their basis of GIS education would probably offer a GIS courses related to the toolmaker's tools, programming languages and the GIS would be regarded as a research specialty and encourage students to make significant contributions as toolmakers. But such a department might also expect continuing tension between research and teaching in GIS and in more substantive fields. In some of the educational institutions, GIS courses are located within the geography department and engineering, while instead specialized GIS courses may be found in others department such as environment, fisheries, forestry and oceanography. GIS courses offered in departments other than geography will provide a different perspective on what is important to students in pursuing natural resources degrees (Mohd Hasmadi 2008).

In empowering student with GIS education and their awareness we have to know do the students know enough about GIS? In a study of GIS knowledge among UPM's student by Mohd Hasmadi and Farah Dayana (2008), they found that almost 80% of the students do not aware about the use of GIS in which some just know the meaning of GIS without exactly understanding its operation system and the way to implement it. The main reason is lack of knowledge and information about GIS and lack of opportunity to expose them to any GIS resource. Hence, one of the steps suggested is make the GIS courses as an open and elective subject to provide the opportunity to the interested student from any program for learning and gaining GIS knowledge. Student around the world are discussing GIS in common topic; How can I get a job using GIS? There are many opportunity exist, but student also discussing about what they need to learn to get a job in GIS? They may be need to know the programming skill and looking an opportunity GIS job in market and may need to move to where the jobs are. In fact students are learning GIS better today than before because they have more opportunities to do better with GIS technology. However in practice many students do not take full advantage of the possibilities and capabilities of GIS. They are not fully exploiting the technologies, as GIS evolves rapidly.

CONCLUSION

The basis nature of GIS is built upon an expectation to solve a specific problem using geodata and GIS. It can be used for multitude of objectives and in different way to create, manage, analyse and represent geospatial information. With several definition used around the world about what is a GIS, the role and position of GIS in science, art or tool, what we considers to be the right way for understanding GIS? As a conclusion, a GIS may be considered as a science, an art or tool, depend on the answers for the following questions; (i) who a GIS developers are, whether they are GIS specialists graduated from different degrees of education programs focusing in GISs or GIScientists as postgraduate students and researcher in universities or other institutions, (ii) what its capabilities of GIS are. In general GISs have three main capabilities: spatial data management, spatial data analysis, spatial data visualization. The tasks in these features span from basic spatial data and computer understanding to advanced GIS researches enhancing these capabilities of GIS, and (iii) what such a system might be used for, whether GISs are used to solve non-complex problem or applied in solving sophisticated task that require theory and methods underlying the GIS technology. Within these positions, student must be careful not to confuse the use of GIS itself, with an analysis of the issues surrounding the use. Some may try to derive legitimacy from the proposition that GIS is so uniquely fundamental to geography that to do GIS is necessarily to do science or, more extremely, that to do GIS is to do geography scientifically. The concepts of GIS may be familiar to professional geographers, they must be taught a new to each generation of students. Without conceptual courses, the use of GIS is likely only to degenerate to data management and map making, but the complex of the tool's capabilities is for scientific analysis and modeling.

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