A 'ROAD MAP' FOR THE DEVELOPMENT OF AN INTERDISCIPLINARY GISCIENCE PROGRAM AT HIGHER EDUCATION INSTITUTIONS

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Abstract. Higher education has been charged with the development of professionals to serve the rapidly developing spatial technology industry, but is just beginning to arrive at a consensus concerning the types of courses, sequence of courses and specialty areas. *Geographic Information Science and Technology Body of Knowledge* (DiBiase et al., 2006) developed under the auspices of the University Consortium for Geographic Information Science (UCGIS) represents a major step in Geographic Information Science (GIScience) education which may lead to more consistency among programs in Geographic Information Science (GIScience.) Concurrently, there are movements for the accreditation of GIScience programs and formal GIS certificates. However, there is a significant gap from these promising but incipient efforts to the coherent development of GIScience programs at the university, college or technical school level. What should be the direction for those who are developing GIScience programs in institutions of higher education in the absence of more definitive direction? In this confusing transitory environment, the authors in this paper propose an outline or "road map" for the development of an interdisciplinary GIScience program.

Keywords: Interdisciplinary Education Programs, Geographic Information Science, Geographic Information Systems, Remote Sensing, Cartography

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1. Introduction

Twenty years ago, when GIS and Remote Sensing were first being taught in institutions of higher education, teaching these technologies were considered as 'add-ons' and specialties and not part of the basic courses of the different departments. At this time, if one took a couple of courses in GIS then you were considered by many to be a GIS professional. Since this time, instruction in spatial technologies has grown due to the great demand for those that are suitably trained in the spatial technologies either as a specialist in GIS, Remote Sensing and Global Positioning Systems (GPS) or as an expert user who will use it as a tool in various disciplines such as urban planning, environmental analysis or geographic education (Wilke & Finchum, 2003) The increased usability of the software, their relative affordability and the decreasing cost of hardware has realized that most colleges and universities have the capability of providing instruction in spatial technologies. (However, the capability of a higher education institution to teach GIScience in terms of adequate software and hardware does not translate to its ability to effectively train students for the GIScience market.) Presently, Geographic Information Science (GIScience) education is now occurring in multiple institutions (technical schools, universities, software companies etc.), numerous departments and often cross-disciplinary and through various means of delivery (e.g., distance education.) (Wilke & Finchum, 2003). Berdusco[1)] identifies 514 institutions worldwide that are offering some kind of GIS courses, of which 44 offer undergraduate degrees and 80 graduate degrees in GIS. Curricula in GIScience are extremely varied and it is difficult to state that they are moving toward any level of commonality. This 2003 estimate is a conservative one and is estimated to be significantly higher in 2007.

A major step has been taken with the University Consortium for Geographic Information Science (UCGIS) publication Geographic Information Science & Technology Body of Knowledge (GIS&TBoK) (DiBiase et al., 2006.). This seminal book outlines what areas should be taught in higher education institutions to adequately equip GIScience professionals to enter the job market. As GIScience education has been maturing, there has been development of an emerging literature related to certification and accreditation (DiBiase, 2003; Elmes, 2005) Most of these discussions were addressed in the GIS&TBoK. In June 2007, the United States Geospatial Intelligence Foundation (USGIF) has initiated an accredidation process[2)] for GIScience program, but as of yet no insitution has been accredidated and its impact has not been fully realized. Although these developments are promising, it is still difficult to judge which programs are better than others for producing professionals that are proficiently trained.

It is clear that spatial technologies and GIScience are approaching maturity similar to other disciplines. There is some indication of possible directions as previously mentioned but GIScience education is still nebulous and somewhat freewheeling. In this environment, how should higher education institutions proceed in developing GIScience degrees? The authors suggest an outline or "road map" for such a process. This process is based on the authors' experience in the developing of GIScience programs. While this process is not perfect and will vary according to the institution, it is believed that outlining the process will clarify the necessary elements and steps that will lead to a robust interdisciplinary GIScience program. The next section discusses the development of the milieu which surrounds GIScience education and helps explain why constructing a GIScience program is problematic at higher education institutions.

2. Emergence of information technologies, spatial technologies and geographic information science

The emergence of spatial technologies and GIScience would have been impossible without the development of the computer and information technologies (IT) The crucial role of IT and computing plays in GIScience is sometimes taken for granted by those that are immersed in these fields. Clearly, the computer and IT are the enabling elements that have realized the unprecedented ability to utilize, manipulate and analyze geographic information. It is also the reason why GIScience has been evolving at an incredible rate and expanding its scope. It is within this backdrop that GIScience education must be viewed as it is intimately linked to IT.

During the last twenty years, the concurrent development of technology and greater access to information could only be called a revolution. It has transformed almost every spectrum of society in the developed world and is having a significant impact on the developing world. With these new technologies, the world has entered what many have referred to the "Information Age." The key elements of the Information Age have been the Personal Computer (PC), the micro-processor and the Internet. Until about the 1980's, most computing was done on mainframe computers. With the introduction of the PC, computers became available to a larger segment of society. By the 1990's, millions of people owned computers in developed countries due the relatively affordable price. Overall, since the 1980's, computer prices have gone down with ever increasing speed and capacity (Kurzwell, 1999) While computer ownership is not as widespread in developing countries, its influence is significant (i.e., prevalence of Internet cafes.) It has also allowed small and medium size companies to have access to complex and robust computer programs. As in any technology or paradigm shift, it is still developing. As the Industrial Revolution changed many aspects of economy, culture, economic, art and music, so is the case and will continue to be in the Information Age.

IT has gone through a variety of stages.[3] In the beginning, computers were huge mainframes locked away in air conditioned rooms maintained by "experts in white coats." They were not owned by individuals but by government organizations and large private companies. To have access to them, one had to have affiliation with the public or private entity and have some knowledge of computer programming. Nevertheless, computing in such an environment was often excruciating as one had to deal with batch processing and the 'Byzantine' nature of computing in this period. In the early 1980's, the Personal Computer (PC)-made possible by the development of microprocessors-entered the technological environment and revolutionized computing. Private individuals and small companies could now have a computer. Improvements in graphics, speed, operating systems such as Microsoft Windows and more specialized programs greatly expanded the audience of the PC. In the late 1980's, the first beginnings of the Internet started to make its appearance. By the middle of the 1990's, the Internet became a major force and at present is a household word. The availability of information has never been as accessible. It is almost certain that the pace of the Information Age will not slow down. Ray Kurzwell (1999), a futurist concerning computers and technology, reasons that the computer and the Internet are just parts of the continual development of technology. In his estimation, the growth of computing power is exponential with ever decreasing costs. It also appears that we are entering a new stage of the Information Age with: computing and communication technological devices (such as cell phones) being linked to the Internet; increasing band width to allow for very high definition transmittal of images for commercial and academic applications, intelligent robotics and developing areas in chaos theory, fuzzy logic and experimental mathematics. The lifetime of specific technologies are ephemeral as new technologies arise and then are surpassed by better technology or merge into other technology (Ayes & Williams, 2004). In summary, there are two phenomena occurring. One is the inevitable development of IT. The other is the rise, fall, maturity and obsolescence of individual technologies. Specific spatial technologies should be seen in this overall technological development.

The development of spatial analysis tools is part of a mankind's continuing need to understand space and analyze it for the improvement of operating within the spatial realm. The map, whether it was on stone or paper was a major technological tool in making spatial relationships understandable. GIS, Remote Sensing and GPS are fascinating and powerful tools, but still part of an overall continuum and are intrinsically linked with the Information Age and the development of information technology.

GIScience has its roots in cartography, geodesy and photogrametry. A GIS was first developed in Canada for the inventory and analysis of its natural resources in the 1960's (DeMers, 2005). At this time, GIS was linked to the main-frame computer and was limited primarily to academia. With the advent of the PC this changed the accessibility of GIS such that GIS has become the most widely used for spatial analysis by both the private and public sector for numerous tasks from emergency management, urban planning, store location, resource development, transportation planning, gas and water line planning and numerous other tasks. The Internet has allowed for unprecedented sharing of geographic data. It has now become a multi-billion dollar industry employing thousands world-wide (DeMers, 2005).

Developing at the same time were the interrelated disciplines of Remote Sensing and Global Positioning Systems (GPS) and spatial modeling. Developing and giving the foundation for this triad of spatial technologies has been mathematics, cartography, computer science, and information technology (Fig. 1). The amalgamation of all these elements has been referred to as Geographic Information Science.

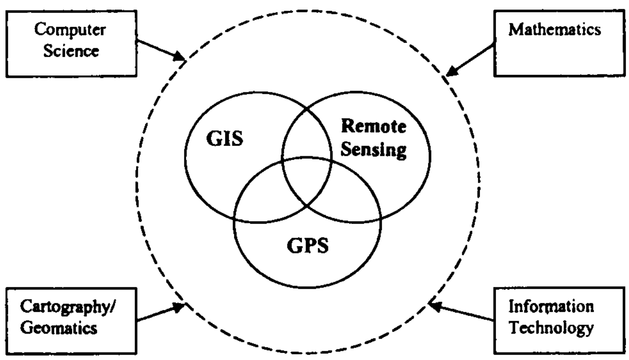

Figure 1. Relationship of GIScience Elements

The term Geographic Information Science is a relatively new one. The National Center for Geographic Information and Analysis (NCGIA) defines Geographic Information Science in this manner: *Geographic Information Science (GI Science) may be defined as the basic research field that seeks to redefine geographic concepts and their use in the context of geographic information systems (GIS.) GI Science also examines the impacts of GIS on individuals and society and the influences of society on GIS. GI Science re-examines some of the most fundamental themes in traditional spatially-oriented fields such as geography, cartography, and geodesy, while incorporating more recent developments in cognitive and information science. GI Science also overlaps with and draws from more specialized research fields such as computer science, statistics, mathematics, and psychology, and contributes to progress in those fields. It supports research in political science and anthropology, and draws on those fields in studies of geographic information and society.*[4)]

An alternative definition by Goodchild[5)] which was included in one of the course outlines as part of the core curriculum developed by the NCGIA, states that GIScience is "the science behind the technology (and) considers fundamental questions raised by the use of systems and technology." According to Goodchild it is not just the association of related technologies and supporting disciplines, but a complete and robust field examining the different aspects of spatial analysis. He refers to GIS, GPS and Remote Sensing as GIScience tools. GIScience is definitely more that the sum of its parts or technologies and is evolving beyond its intitial impetus. Since defining the original concept of GIScience, Goodchild (2006) states that GIScience is moving beyond its original links with IT and probing into the nature of geographic information. Others such as Schuurman (2006) have been one of the key leaders in defining the ontology and epistomology of GIScience and its impact on society. These developments are signals that GISciene is mature science and not one only concerned about spatial technologies, geographic data and spatial related computer programming.

One of the most important developments in GIScience is its impact on advanced spatial analysis which could have one time been considered separate or 'loosly coupled' with spatial technologies, Goodchild & Haining (2004) state the incorporation of spatial analyis tools into the software of spatial technologies is realizing the merger of spatial analysis and spatial technologies. For those who are newcomers to GIScience, the difference between spatial analysis and spatial technologies may not be evident because of the recent incorporation of spatial analyis tools into GIS and Recence of individual technologies. Specific spatial technologies should be seen in this overall technological development.

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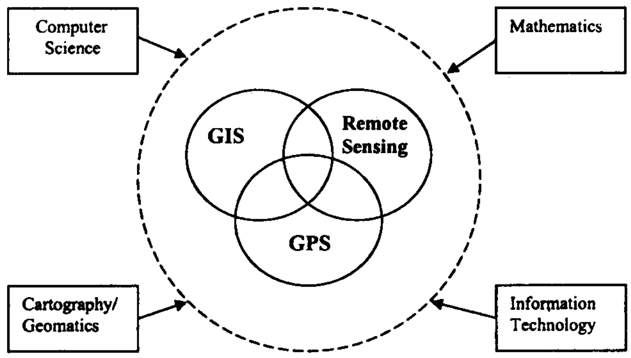

Figure 1. Relationship of GIScience Elements

mote Sensing software (i.e., ESRI ArcGIS.) Those have been using these programs for more than 10 years know that this has not always been the case. The intergration of spatial analysis tools into spatial analysis software is a major step, indicating the increasing sophistication of spatial technologies and GIScience.

Attempting to bring focus to GIScience education, given the 'shifting sands' of spatial technologies and the its emerging nature is not an easy task. The next section briefly explores the nature of GIScience education and how the educational community is progressing in the to construction of suitable curriculums to adequately train GIScience professionals.

3. Nature of GIScience Education

GIScience has progressed from being taught in a few locations with one or two courses to whole programs and departments devoted to GIScience. GIScience lead departments vary from Geography, Environmental Engineering, Civil Engineering, Urban Planning, and Computer Science. GIScience has numerous journals, web sties, conventions and organizations devoted exclusively toward GIS, Remote Sensing and GIS and their applications. It has been integrated in many disciplines (i.e. environmental engineering, sociology, political science, agriculture, archeology, history, urban planning.) With most disciplines having a spatial component, there are very few that are not using GIScience tools. Nevertheless, the understanding of how to use these tools varies and the knowledge of the overall field of GIScience would seem to be rare among those outside of Geography. Many in other fields do not perceive GIScience as a discipline. Their knowledge may be limited to awareness of specific software programs such as ArcGIS or ERDAS and thus to these individuals it is merely a matter of learning a new software like a new word processing program. Obviously, it is much more. This ignorance which is apparent at all levels of many academic institutions is a significant barrier to the development of robust GIScience programs around the globe.

Institutions of higher education that deliver GIScience courses are often ill equipped in terms of equipment, curricula, faculty and infrastructure to deal with the rapid rate of change in: GIScience technology, software and analysis techniques which are further associated with: IT; the job market; and their student base.[6] The market for GIScience education is increasingly among non-traditional students (> 25 years old) which maybe already working as spatial analysts or technician which are often accommodated bettered via Internet based instruction (DiBiase, 2000) There are now several higher education institutions that are offering complete GIScience degrees via the Internet (i.e., University of Pennsylvania, USA). The nature of GIScience being based on several disciplines is inherently interdisciplinary. While GIScience education was initiated in Geography Departments, presently there are numerous GIScience programs that exist in higher education institutions which do not have Geography Departments. However, in institutions which have Geography Departments, they often take the lead in the coordination of these programs.

In an extensive review of courses by the authors of various institutions world wide, it was clear there is not any consensus in GIScience curricula. One can see some similarity such as Cartography and Introduction to GIS courses, but others are courses are ambiguous and do not indicate the nature of the material that is being taught (i.e., GIS I, GIS II, Advanced GIS etc.). Prerequisites may be indicated, but generally there is limited information about specific tracks with a GIScience degree and the progression of courses. These general observations are further supported by the research and findings of Wikle & Finchum (2003). They found that: GIScience degrees ranked from Associates', Bachelors', and Masters' degrees specializing in GIScience; there were mixtures of theory and practice with no obvious difference between beginning and expert levels; the contents of specific courses were well documented but the progression of classes not very well addressed; and the 'home' for GIScience varied from cartography departments in Europe to geography departments in the United States. Interdisciplinary GIS or GIScience programs were found by Wilke & Finchum (2003) at: Ohio State (USA) between Environmental Engineering and Civil Engineering, Curtain University (Australia) through its School of Spatial Sciences where students take a variety of courses; and the University of Florida (USA) among various departments where students can pursue various tracks or concentrations of study. They further identify several sequences of courses: permissive, hierarchical and specialized as illustrated in Fig. 2. The permissive approach is one where the students choose between a clusters of courses based on their interest. The hierarchical approach, probably suited to a more general education in GIScience, relates to advancing from basic to more advance levels of GIScience. While the specialized approach is concerned with a few introductory class and then letting students pick areas which they wish to concentrate, such as applications, spatial modeling, GIScience software program development and Remote Sensing.

The article by Wilke & Finchum (2003) is the most definitive on the construction of GIS and GIScience degrees. While there may be a need to refine their findings, it would be redundant to document again the curricula in the worldwide GIScience community. From the "gee whiz" days of GIScience, With the publication of the GIS&TBoK (DiBiase, 2007), there is a definitive document that can be used for the basis for licensing of professionals and educators, program accreditation and certification built on the discussions of others previously in the GIScience community[7] (DiBiase, 2003).

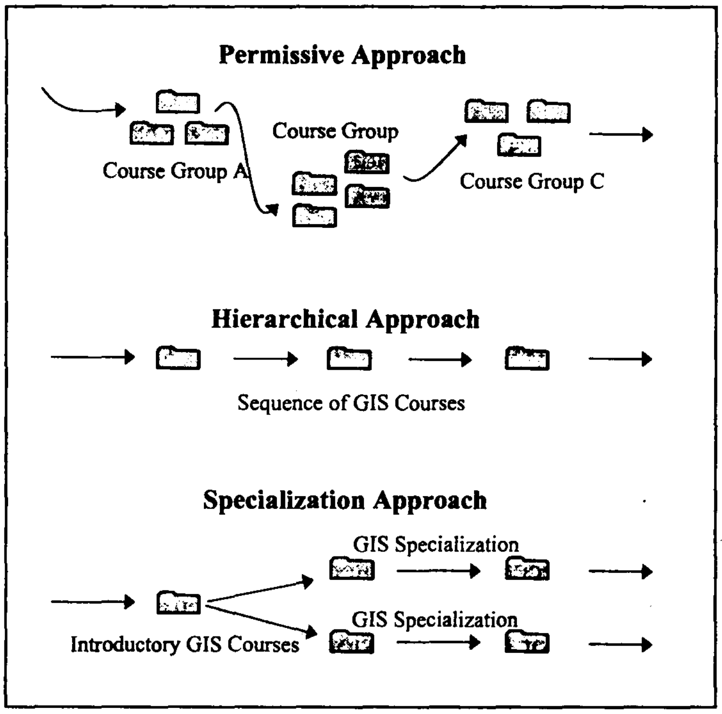

Figure 2. Progression of GIScience courses (Wilke & Finchum, 2003)

Huxhold[7] stated seven years ago that, 'Today anyone can teach anything and call it GIS education... Who knows whether the skills being taught in these programs are needed to become a GIS professional?" It is the authors' opinion that this situation has changed little, although there has been considerable discussion about this topic.

There is an emerging leadership in GIScience curriculum development. The groups leading the investigating of these issues are the University Council of Geographic Information Systems (UCGIS) and the National Council of Geographic Information Association (NCGIA) which has developed a set of core GIS courses. The GIS&TBoK represents a major body of work and is certain to be instrumental in shaping GIScience programs (DiBiase et al., 2006). In Europe, Association of Geographic Information Laboratories for Europe (AGILE) is one of the leading groups in investigating GIScience education.[8] An associated member of AGILE, the Geographic Information Technology Training Alliance, based in Switzerland and member of AGILE, provides on-line modules for GIS instruction which would be a sound foundation for determining the key components of a GIScience curriculum.[9] In addition, there appears to be several European universities that could be used as models for GIScience curriculum development (i.e., Geography Department, University of Edinburgh.) The leading GIS company, ESRI, has developed a set of guidelines for developing a higher education program which is useful for some of the mechanics of setting up a GIS Program.[10] In June 2007, The United States Geographic Intelligence[2] developed a procedure for accreditation of GIScience programs, primarily focused for institutions in the United States and geared toward national security. This is a significant development in GIScience education, but needs further evaluation. Other organizations and institutions such as the University of Southern Mississippi, Association of American Geographers (AAG), the Urban and Regional Information Systems Association (URISA), the Geospatial Information & Technology Association (GITA), the American Society for Photogrametry and Remote Sensing, and recently the United States Geospatial Intelligence Foundation (USGIF) are struggling with developing curriculum. There is also presently a certificate for GIS professionals.[11] These developments are promising, but still coalescing. In this environment, how should higher education institutions proceed in developing GIScience degrees?

4. An outline for interdisciplinary GIScience Education programs

The major purpose of developing an interdisciplinary GIScience pr gram is to adequately prepare students for future employment in differe organizations that are using geospatial technologies or are developing n geospatial programs or systems. So in this light, GIScience programs shou be considered vehicles for the development of professionals similar to pı grams in urban planning, social work, law, dentistry, pharmacy, environme tal science, chemists etc. The difference between GIScience professiona or 'geospatialists' and other professionals such as urban planners, lawye and dentists is that these professions have recognized accreditation boar for their respective programs and professional licensing bodies while GI Science does not. This disparity realizes that GIScience students are not sur that they have received the necessary education to prepare them for the jol market and potential employers are not sure that students applying for job will have the ability to undertake assigned tasks without substantial in-house training. It is also widely recognized that academic programs that have to undergo review by an accreditation board are less vulnerable to funding cuts than those that do not. For a GIScience program, this may mean that there may be a lack of funds to hire additional faculty or upgrade equipment to enable it to adequately train students for the geospatial job market. Having reached a level of maturity as a discipline, GIScience is presently at the crossroads that many disciplines have faced earlier.

The Geographic Information Science & Technology Body of Knowledge (GIS&TBOK) (DiBiase et al., 2006), as acknowledged by its authors, is the beginning of a process possibily leading to accredidation and uniform certification programs. The next phase of this project is the developing of more specific curriculum tracks. This document represents a major guide in assembling the necessary elements of a GIScience program and likewise a foundation to establish criteria for an accreditation board and certification body. Nevertheless, for those at the ground level who are just developing GIScience programs there is still a great deal of uncertainty without some uniformity in GIScience curriculums and uncertain assurance that their programs will match up to the market needs. The development of more formalized curricula or certificate systems will be helpful, but ineffective is there is not a suitable structure in institutions of higher education which are developing GIScience programs. The establishment of a suitable framework for a GIScience program will enable an institution to cope with developing GIS curriculum and the needs of students to be well prepared for the varied and evolving GIScience job environment.

Although ESRI[10] delineated some essential guidelines for establishing a GIScience program which are also contained in our 'road map', new developments have occurred since this publication that should be included. It was also believed that some clarification and simplification would augment this document and assist those who were starting interdisciplinary GIScience programs. As in any model, there are numerous variations within this general framework that would lead to same result. The authors in this section would like to suggest a set of procedures for establishing a robust GIScience program. This procedure is outlined in Fig. 3. Stage 1 consists of the establishment of an environment for the development of a GIScience degree involving the development of a University Interdisciplinary Committee and an Industrial Council. This Committee would be formed from responsible persons from key departments (i.e., geography, computer science, information technology, environmental engineering, civil engineering, urban planning, industrial engineering. mathematics, physics, public administration, biology, anthropology etc.) that would be participating in the program or would be providing support services (i.e. computer support.) Subsequently, an Industrial Council composed of GIS, Remote Sensing, GPS companies and public and private entities that heavily use geospatial tools should also be established.

The Industrial Council is essential to give advice on the relevancy of the courses and their sequence is responding to the market and developing technological needs. But, the Industrial Council's role should not be only an advisory one. It should be actively involved in providing support to the program in other areas such as providing free or reduced price software, GIS data, internships, technical support and by participating in joint research projects with the GIScience faculty. This is an appropriate role and mutually beneficial for members of the Industrial Council because the students that will be trained by the program could become their employees. After inspecting the particular institution and GIScience programs at other university, these two bodies would together develop appropriate GIScience degree or degrees (i.e., Associate, Bachelor, Masters', Doctoral.) It would also determine the type of program: progressive, hierarchical, or specialized. The Industrial Council and the Interdisciplinary Council could suggest staging for the embryonic GIScience program. For example, the Committees could decide that at this point, only an Associate Degree would be appropriate and at a later time other degrees could be developed. As a guide for curriculum development, the GIS&TboK should be consulted. However, because the GIS&TBoK was developed to be a comprehensive description of what an ideal GIScience program should contain, its interpretation is left to specific institutions that are in the process of developing or revising GIScience programs as to what should be the appropriate scale of their particular program. It is anticipated that the next phase of the project will bring some of these items into greater focus.

The development of the curriculum and sequence of courses is not the end product, but the beginning. Stage 2 consists of setting up the necessary prerequisites for a robust and effective program. What is often ignored in GIScience programs is that the program is inherently dependent upon software, and hardware. The establishment of a multi-annual capital improvement program is good vehicle for planning for anticipated needs and also alerting the institution of funding needs. Computers and software can not be supplied by a one-time grant, but must be a steady investment by the University and members of the Industrial Council. An active research program among members of both committees is crucial to insure that educators are current with relevant technology and applications. Most important is the availability of faculty and staff that would be qualified to teach the proposed courses. The proposed curriculum and related plans would also indicate that new faculty and staff may have to be hired. An essential element could be the hiring of part-time faculty, who are employed by private geo-spatial companies or public organizations, for specialized courses (i.e., Internet GIS, GIS programming etc.) to fill in the skill gaps that the full-time academic do not possess. As GIScience education is primarily geared toward preparing professionals for jobs in the public and private sector, internships are crucial. Internships and co-op arrangements have been standard for other professions particularly engineering and proven to be portals for future employment for students and gaining valuable experience beyond the classroom. As previously stated, the Industrial Council should be active participants in establishing internships for the program's students.

The implementation of the GIScience degree should take place only after the previous program elements in Stage 2 have been established. Although it is ideal to have the two previously mentioned committees established before the initial establishment of the curriculum, this may be feasible. An alternative would be consultation with participating departments and selected representatives from the GIScience industry to assist in the beginning curriculum and later formalize these informal processes and relationships this into established committees. Stage 3 involves the implementation and monitoring of the GIScience degree program. Monitoring is crucial and include such tasks as: determining students performance in internships; periodic evaluation of what classes should be modified or added/replaced; evaluating GIScience faculty research; the success of students in finding jobs and departmental efforts for assisting them with the job search; exit evaluations of graduating students; and alumni tracking. (It is has long been recognized that successful programs are often due to alumni urging their workforce/associates to continue their education in the department/program where they received their degree. They are also excellent contacts for future employment for graduates of a program. In addition, alumni could be a good source for future members of the Industrial Council.)

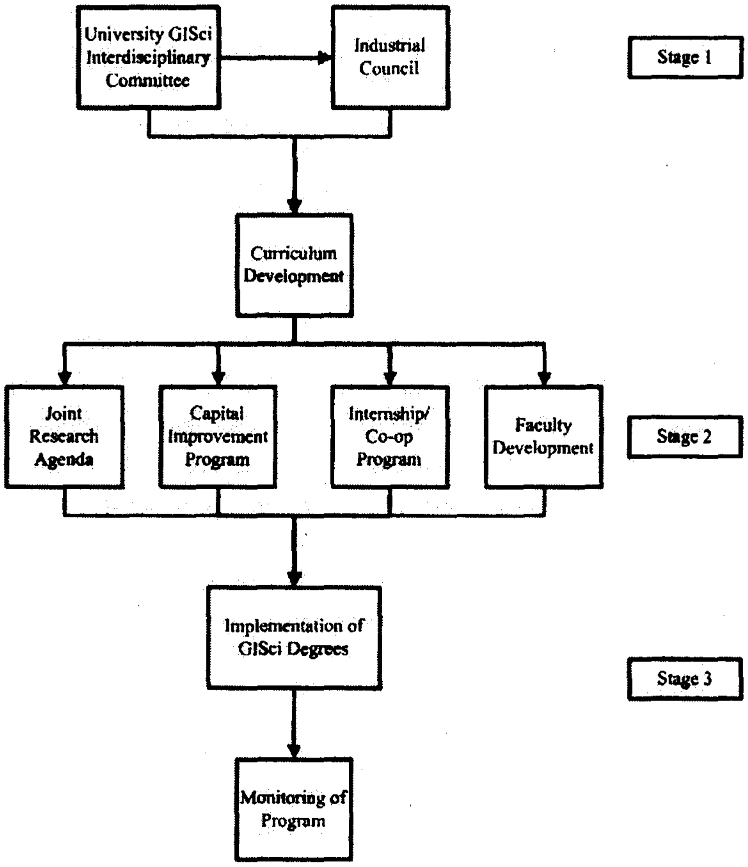

Figure 3. Development of GIScience Degree

5. Conclusions

GIScience is the overriding body of knowledge and the guiding force for spatial technologies. The spatial technologies are constantly changing. Given the rapid change in spatial technologies which are growing in response to the increasing market and the phenomenal growth in IT, it is very probable that spatial technologies will not look the same in another five to ten years. It is now becoming increasingly difficult to separate GIS, Remote Sensing, GPS and spatial modeling. They are all merging together to become one seamless spatial technology group. The spatial technologies are also being transformed by the availability of data from the Internet, and their increasing availability, affordability and usability. Advanced mathematics such as cellular automata, agent based modeling, fractal analysis, artificial intelligence, and neural networks are increasingly becoming a part of these disciplines such that spatial technologies are at the frontier of doing very advanced spatial modeling. However, before one can even approach these areas, there has to be a basic knowledge of the principles of GIScience. Spatial technologies and their companions can all be understood under the rubric of GIScience. However, GIScience is not static and can not be so. It is essential for the development of spatial technologies as it represents their theoretical foundation.

The GIScience academic environment is confusing and diverse. It is promising that there is recognition that there is a need for the development of consistent GIScience interdisciplinary programs. However, there appears to be very slow movement toward any kind of consensus. As the international GIScience community is maturing, the need for standardization and an accreditation process should become greater. Practically, institutions offering GIScience courses are charged with training professional for the rapidly developing GIScience market which can not wait for the leading bodies in GIScience to arrive at a solution. They must address these issues or become irrelevant. The authors present a "road map" or a 'common sense' plan for the development of GIScience program in any institution regardless of their size. Each individual higher education institution is unique and will have variations to this proposed plan. Ultimately, regardless of the importance of GIScience and it demand for those who are skilled as GIScience experts or practitioners, many institutions will continue to have weak programs if they fail to recognize the key elements represented in this "bare bones" plan. In summary, intuitions for higher education that want to develop GIScience curricula and provide well-qualified professionals for the expanding GI-Science market must: i) follow a rational plan; drawing from the available experience of leading GIScience institutions such as the UCGIS and leading GIScience programs; ii) evaluate the relevancy of their programs to the GI-Science market; iii) involve GIS industry representatives in all phases of the process and iv) be flexible enough to quickly respond to the "shifting sands" of Information Technology.

Notes

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