Spatial science education: an imperative tool for higher level training and research in Nigeria

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Abstract

The world in which we live today is steeped in science and technology, and characterised by tremendous explorations and ever increasing discoveries, inventions and innovation. Spatial information and thinking play formidable roles in this regard and as such there is the demand for spatial science/geospatial information system (GIS) to provide professionals with the requisite tool to perform training, research science and administration in various disciplines. Undoubtedly, spatial analysis and GIS have also revolutionised the manipulation of geospatial information in broader sections of the private and public sector.

Faculty in college-level social science and public policy courses rarely integrate systematic analysis of spatial dimensions of phenomena into their courses or teach students to use GIS software to get answers to social science and public policy questions. Spatial analysis is entirely absent from most social science and public policy research methods courses. But spatial analysis is important to political scientists, economists, urban planners, public administrators and other social scientists and public policy professionals study. Spatially integrated social science seeks to correct this shortcoming by integrating spatial concepts and GIS operations into social science courses. Despite its potential, many higher level education institutions in the country still lack the resources and know-how required to use GIS in education and research.

Spatial science education nowadays is becoming more challenging to be taught at pre-tertiary and tertiary education levels and appropriately applied in tertiary education researches. It is therefore imperative that Nigerian universities and other related institutions play a crucial role in providing spatial education programs or courses in order to promote the growth of the use of spatial science/GIS as a policy influencing tool and as a new descriptive, diagnostic, and analytical tool for higher education research in the country.

This paper describes current efforts to help higher level education faculties integrate spatial analysis into their teaching and research work. Spatial science applications are reviewed, and the need for the related department, users and public to be aware and understand the different positions of spatial science/GIS is highlighted. Also, the current problems of spatial education are analysed.

Keywords

geospatial information science (GIS), spatial science, curriculum and research

Introduction

Geographic information science (GIS) is a set of integrated software programs designed to store, retrieve, manipulate, analyse and display geographical data-information concerning people, places and the environment [1]. This recognition led to the introduction of GIS in higher level education and research curriculums in such diverse programs as geography, science, environmental and social sciences, biology and mathematics, mainly in the USA, Canada and a number of European countries beginning in the 1990s [2, 3, 4, 5, 6]. GIS offers a wide range of services to educators in teaching and learning for different subjects in schools. GIS has been long known and utilised in different disciplines at the university level [7]. Many scientific studies have shown GIS to be a useful educational tool helpful in creating an inquiry-based learning environment [8, 9, 10].

Geographic information science is a new science with vast opportunities for growth and an undetermined potential. GIScience research refers to the advancement of innovative applications for this emerging technology by various disciplines. As the powerful tool of GIS became more cost-effective and user-friendly to an overwhelming audience, GIScience began to emerge as the discipline to understand, focus, and direct this technological revolution. There is currently a focused effort being undertaken in the GIS research community to integrate the science and the systems of GIS to improve the theory and applications of this rapidly evolving new discipline [11]. GIS projects are different in the sense that spatial data enables specialised types of analysis which can be performed with them.

As science becomes increasingly interdisciplinary, the potential for using geographic information by various scientists continues to be recognised, and new technological innovations emerge, there will continue to be a greater need to integrate and advance GIScience research in order for this new discipline to reach its potential. Advances in the field of GIScience have the potential to change the way science is performed, expand scientific capabilities, influence how and
what we teach, and, ultimately, change the way we think. We are living in a technological revolution that is far from over.

Recent innovations in information technologies are beginning to have an important impact on education in GIScience both inside and outside the university. The internet and WWW, for example, are rapidly changing the ways in which GIS educators, researchers, and professionals gather raw data, engage in background research, collaborate and communicate with colleagues, and share the results of their investigations. Multimedia and hypertext capabilities are currently being integrated into GIS [12].

These innovations have led to an outpouring of experiments in using some of these technologies in higher education. Numerous higher education institutions are using ESRI Virtual Campus courses. These courses are being used in several different ways. Some institutions use them as prerequisite courses to their own offerings, the laboratory section for courses, part of a GIS distance education program, and a way for educators to learn the latest technology and keep up to date. In addition, materials for courses in GIS, cartography, and remote sensing have appeared on the internet.

**How is GIS used in higher education?**

More than 70 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. Modules are included in many subject areas that show how GIS is used as an analysis tool in those disciplines. Types of programs range from vocational or workforce programs, which focus on entry-level technology education and training, to traditional academic courses with in-depth mathematical and scientific foundations in GIScience. Courses are also provided in various settings including on-campus and distance education courses of varying lengths including hands-on technology workshops, short courses, certificate programs, and degree programs. GIScience provides researchers in numerous disciplines advanced methods to analyse and display data, develop and test models, and integrate data from multiple fields to solve problems. GIScience programs also allow biologists, geologists, geographers, epidemiologists, hydrologists, meteorologists, archaeologists, computer scientists, and many other scientific researchers to advance the science of GIS.

College and university administrative departments use GIS for a variety of logistical solutions (e.g., marketing and outreach; sponsored programs for fund-raising and endowments; facilities management for location of facilities, buildings, grounds maintenance, allocation and classroom utilisation, and campus growth; student affairs for student distribution and statistics; campus police for campus safety, crime reporting, and other mandated governmental regulations) [11].

**The contribution of GIS to education in schools**

*Inquiry-based learning*

GIS takes the knowledge – such as describing the data, complex tables and maps, and diagrams – at different levels, from easy to difficult [13].

*Visual-spatial comprehension power*

GIS allows the user to visualise and analyse previously hidden relationships, patterns, and trends with a new method [14, 15]. The benefit of GIS stems from its ability to provide maps and information which are physically impossible to get with requested requirements and information.

*To reconcile information in order to define the current relationship*

Students, by making sense of this information, fit it into a specific logic and learn it by establishing relations with the problem because it will be used for GIS application in student-centred lessons that are processed with the help of GIS information. In another way, the student learns the subject himself entering the relevant data, processing and analysing them. In this way, the student learns the knowledge not by memorising a lot of information but, with the role in the context and the frame of its environment and with the awareness of how important is it [16].

*Developing thinking skills*

Basic thinking skills are: information processing skills, reasoning skills, questioning skills, creative thinking, and evaluation skills. GIS application is a process that enhances students’ thinking skills such as processing the information obtained (selecting useful information, meaning, categorisation, classification, comparison, differentiation, and analysing them), their justification, and making appropriate inquiry into the reasons [4, 17]. In the end of this process,
students can use creative thinking skills with mental processes activities such as generalising, hypothesising, and working on alternative solutions. According to Kerski [3], using GIS develops high level analytical and synthetic thinking. GIS supports students’ geographical skills by improving spatial thinking ability. There are three dimensions of spatial thinking: spatial-visual stimulus, spatial orientation, and spatial mutual relations [18].

**Professional learning**

GIS has become a source of employment in the geography profession. Especially in developed countries, no one employs the identity “geographer”, but GIS experts or analysts do exist. For this reason there is an increasing awareness among students that GIS is required as a professional option [19]. As a result of GIS applications in schools, which had not been seen in a professional dimension till now, students’ perceptions are changing [20].

**Motivation**

Motivation is one of the most important factors affecting students’ attitudes towards learning and research. Students’ motivation can be increased by using GIS in courses. This is a common result of many studies [13, 21, 22, 23, 24]. Teaching lessons with a language spoken in everyday life by students (digital inhabitants as they are) increases their motivation towards lessons. On the other hand, not knowing how to use the software and the complexity of using GIS can negatively affect student motivation.

**GIS curriculum and teaching**

The priorities and importance of GIScience research have direct implications to educational pedagogy. Research plays an important supporting role for data, tools, and course content provided to students. In addition, research-based instruction helps to promote learning by introducing students to real-world problems that make information learned in the classroom more relevant. The potential of GIS as a tool to support scientific inquiry in all disciplines and at all educational levels has been described by many researchers [25, 26, 27].

The rapidly growing field of GIS has caused instructors to question "what" and "how" to teach GIS. Some educators are using the inquiry-based learning approach where GIS is used as a tool to solve a problem. For example, a marine science student uses GIS as a tool to determine the effects of red tide on the manatee population. Others are teaching GIS as a discipline or topic in information technology or computer science. There is no pedagogical approach that satisfies every educational need; however, most programs should include the following concepts or topics in some depth depending on the level of instruction [28].

It has been well documented that all students learn differently. Therefore, it is important that instructors incorporate several approaches when teaching GIS to reach the potential of their students include the following: a combination of demonstrations to illustrate a theory or a concept; controlled exercises that are led by the instructor; structured inquiry that requires students to develop their own procedures and interpretations; open inquiry that requires students to identify a problem, formulate procedures, and interpret results; and research projects that are based on a long-term experiment or series of experiments [29].

**Importance of GIS curriculum**

The growing demand for GIS-related courses by students and professionals in the late 1980s prompted the need for the education community to design a GIS core curriculum. The NCGIA developed the first GIS Core Curriculum (GISCC) in 1990, which is an excellent guideline for the fundamental concepts of GIS. However, one of the greatest obstacles that have contributed to the lack of widespread integration of GIS across disciplines is the lack of teacher training and curriculum. The instructor must develop the GIS curriculum, which includes a combination of topics, lecture notes, exercises, delivery methods, and assessment procedures for the specific content area. This is a very time-consuming task but is necessary for the advancement and understanding of the interdisciplinary capabilities of the technology.

**Successful design of a GIS curriculum**

Factors, such as the appropriate level of instruction, GIS background and skills of students, delivery approach, and defined learning outcomes, affect the curriculum design [30]. Consequently, there is no such thing as one ideal curriculum. The GIS education constituencies must recognise that each learning situation has specific needs with respect to educational activities [31]. If a GIS content-specific curriculum is to be successful, a design model that suits local circumstances, resources, and student needs should be incorporated and followed as well as a careful student evaluation to determine the success of the curriculum [32].
Several important questions to consider when designing a curriculum are:

- What is the purpose for teaching this course?
- What new knowledge and skills do I expect from the students?
- How do I assess student achievement?
- What are the available resources?
- How do I assess course progress and success?

Many possible approaches can be used as guides in designing the curriculum. As each instructional situation may vary, it is important for the instructor to know and understand the needs of the student audience prior to deciding on the best curriculum design approach to pursue. These are:

- Designing through aims and objectives
- Designing by subject matter
- Designing for knowledge
- Designing on instructor motivations
- Designing for individual needs

It is also important to be aware of the potential dilemmas that may arise when designing a GIS curriculum. One critical problem is the lack of qualified GIS instructors. The speed of GIS development and technological advances has caused a shortage of faculty and instructors who can teach the most current trends in GIS. Another problem is the conflict between education in GIS versus training in GIS. The industry is pushing the training side to produce more qualified GIS technicians to support the needs of the workforce, leaving a gap in qualified individuals who understand the nuts and bolts of GIS. Other dilemmas that GIS educators must consider when designing a curriculum include whether to use GIS as a subset of a current discipline or as a discipline of its own and whether to teach with or about GIS [30].

Fortunately or unfortunately, there is no single best GIS curriculum design or instructional methodology out there. The best design is the one that considers the needs of each specific educational situation. Student evaluations remain one of the best ways to determine the success of a curriculum design.

How to integrate GIS into the curriculum

As spatial literacy continues to be emphasised as a national education goal, the incorporation of GIS in the classroom as an instructional tool is also likely to increase.

However, modifications in instructional delivery methods must be fostered to observe improvements in student learning. The traditional teaching environment must be modified into a learning environment. Several instructional processes should be considered to encourage a learner-oriented classroom: (i) focus on problem-solving over technology, (ii) incorporate GIS skills and technology as background tools, and (iii) develop an active and bona fide learning environment. [33] describes the differences in learning with GIS versus learning about GIS. Both methods have their role in different learning situations; however, the former is preferred to increase problem-solving skills and geographic reasoning.

Potential problems and pitfalls

Any successful venture will face hurdles along the way. The most qualified and enthusiastic faculty and staff are the ones that see the potential and benefit of a GIS program for the university and the students. These visionary and interested individuals should be made aware of the potential problems and pitfalls that may be encountered as they develop the program and facility. Despite the clear benefits of GIS there are three main challenges to the uptake of GIS within the classroom.

- Hardware issues: the availability of suitable computers presents an important challenge: GIS requires considerable computing power to store, process and interpret data.
- Software and data: dedicated GIS software and data can be costly to purchase and maintain, although free and open source software (FOSS) are available to users and government mapping data are now provided free to schools.
- Teacher skills and competence: these form a crucial challenge in the introduction of GIS in the classroom. The main challenges to the introduction of GIS by teachers relate to their personal competency in GIS, the time available to develop resources, their motivation for using GIS and their appreciation of how GIS links to the curriculum.
Some of the common barriers that GIS training faces in Nigerian universities include:

- Turf wars – "where" does GIS fit into the curriculum?
- Long-term funding of program, lab, and centre
- Academic, vocational, or continuing education
- Undergraduate or graduate
- Single- or multidisciplinary coordination
- Finding and retaining faculty
- Training for full-time faculty
- Adjunct faculty coordination
- Advertising for program, content, timetables
- Hardware and software upgrades
- Lack of accreditation and articulation
- No standards for course or curriculum content
- Importance of GIScience research

Conclusion

It remains a challenge to successfully build, implement, and maintain a GIS program at any educational institution. Inevitably, questions arise concerning the importance of a GIS in applied and basic research, how to successfully develop a curriculum, where to find funding to support the facility, who will teach the courses, what technology is needed to stay at the cutting edge, and many others. While teaching with technology has its challenges, we have found that it is both feasible and worthwhile to integrate GIS-based activities in large introductory-level lecture courses. There is no doubt that the impact and demand for GIS will continue to experience tremendous growth in the educational sector in Nigeria over the next decade. Progress continues to be made toward determining the most effective and efficient pedagogical methods to enhance geographic problem-solving and spatial reasoning skills. GIS as a science has helped to facilitate these skills by providing students with a real-world interface between the technology and the content in a variety of subject areas. Efforts should be made to continue to support the progress of GIS research and education at all levels to increase the discovery and understanding of people, places, and things throughout the world. The more we understand about this planet and its inhabitants, the more educated and appropriate our decisions will become when solving important global and local problems.

References


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