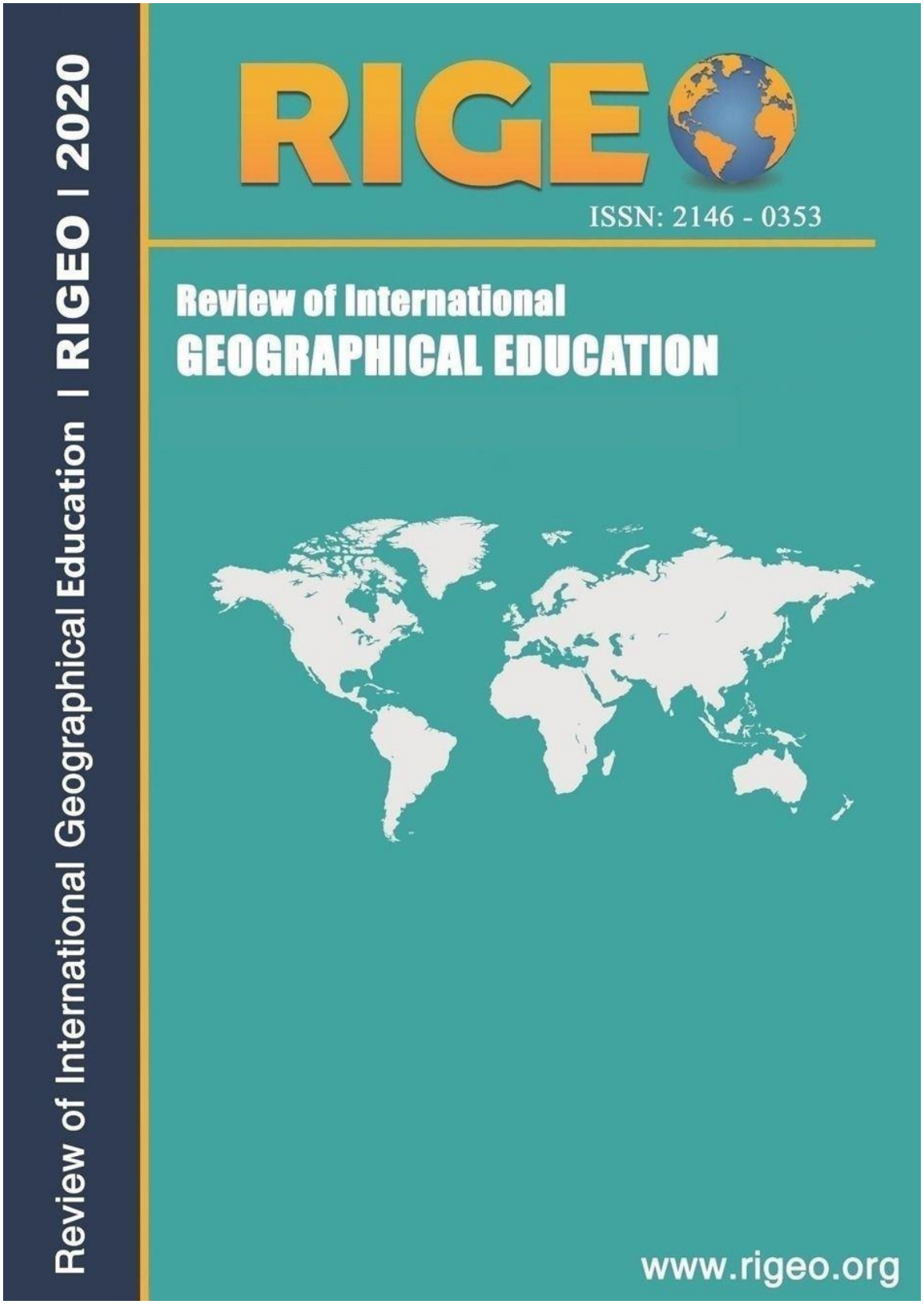
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Problems and Solutions with the Incorporation of Geographical Information Systems (GIS) into Ghanaian Technical University Curriculum

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Abstract

When it comes to helping college grads become better spatial thinkers, geographic information systems (GIS) remain crucial. On the other hand, owing to various implementation issues, GIS education at Ghana's technical university level is severely lacking. This study provides a comprehensive overview of geographic information system (GIS) deployment in Ghanaian higher education institutions, focusing on the technical universities there and the significant obstacles to GIS education and training that have arisen there. Also described is the current state of geographic information system (GIS) courses offered by Ghana's technical colleges. The study that aimed to examine the difficulties associated with teaching and studying GIS at Ghanaian technical institutions used an exploratory and descriptive research strategy. The study's results show that GIS instruction is needed and well accepted at Ghanaian technical university engineering and built environment departments. Finally, the report finishes with a set of suggestions for how higher education institutions in Ghana, and technical universities in particular, may better incorporate GIS technology into their curricula.

Keywords

Problems with GIS Education, Technical Universities, Polytechnics, and Geographic Information Systems

INTRODUCTION:

Since its inception in the early 1990s (Zhou et al., 1999), it has served as an invaluable resource for faculty and students alike in higher education. For students interested in using GIS technology as a major tool in industry, or for those who may indirectly use GIS approaches in decision-making processes, learning and teaching GIS at the tertiary level provides important technical skills (Whyatt et. al., 2011). Thanks to GIS's ability to consolidate geographical information from many reference systems for efficient computer manipulation and analysis, spatial decision-making processes in both academia and industry have been substantially enhanced (Baker et al., 2012). Bednarz (2004) identified several major reasons for introducing GIS in education. "Educational tool that enhances student's spatial thinking skills and as workplace skills where GIS is

needed as a tool for future knowledge in geospatial technologies" is how Bednarz (2004) characterised GIS in the context of education. According to McClurg and Buss (2007), educators have also made use of geospatial technology to improve the learning environment in the classroom. Geographic information systems (GIS) are being more integrated into classroom instruction as a means of preparing students to address global issues (ESRI 2011). The United States of America (Bednarz, 2004), Canada (Kerski 2003), a number of European nations (Broda and Baxter 2003; Wigglesworth 2003), and Bednarz and Van der Schee (2006) are among the countries that have taken GIS out of universities and into elementary classrooms. France, Finland, and Sweden are among the countries that have integrated GIS into their secondary school curricula, but there have been significant difficulties with its implementation (Johansson and Pellikka, 2006). As part of its National Framework for School Education initiative, India included GIS in its secondary school geography curriculum in 2000 (NCFSE, 2000). Geographic information systems (GIS) were first integrated into Ghana's higher education system at the polytechnics, which are now called technical institutions, and subsequently into the universities. There has been little progress towards comprehensive integration of GIS across all levels of the Ghanaian education system, despite the fact that GIS education and development in secondary schools offers promising potential (Oppong and Ofori-Amoah 2012). The skills of surveyors, computer programmers, agricultural technicians, and logistics specialists versed in spatial databases would be in high demand in today's tech-driven global economy, according to workforce studies (Estaville, 2010; Rudibaugh and Ferguson, 2010). On the other hand, geographic information system (GIS) education is severely lacking in Ghana, especially among university students. The majority of Ghanaian college grads do not possess the spatial reasoning abilities and skills necessary to compete in the modern work market. Regardless, teaching GIS at Ghanaian universities has helped students develop better spatial reasoning and better prepared them for the difficulties they'll face in the workforce. Nevertheless, there are several obstacles that have prevented GIS teaching at technical universities from being effectively implemented. To better understand the obstacles to GIS deployment in Ghanaian technical university classrooms, a cross-sectional study was undertaken. Also evaluated were the requirements for and degree of acceptability of GIS technology. It is in this document that the results of the research, and it finishes by offering suggestions on how the country's GIS education system should be improved.

The Current State of GIS Education in Ghana

In 1998, the Department of Geomatic Engineering at Kwame Nkrumah University of Science and Technology (KNUST) was the first institution in Ghana to offer a course in geographic information systems (GIS) to undergraduates. Afterwards, it was expanded to include KNUST's graduate programmes in land economics, civil engineering, and planning. A GIS laboratory was established in the geomatic engineering department of KNUST in 2002 with the support of a grant from the Environmental Systems Research Institute (ESRI), the makers of the ArcGIS software application suite. This laboratory will aid in research, teaching, and learning within the university community and the West African sub-region. The department was able to provide GIS training and short

courses to university staff, students, and faculty after establishing the GIS laboratory. At present, GIS is offered as a core course in other departments at KNUST besides geomatic engineering, including civil engineering (both undergraduate and graduate levels), geography, geophysics, planning, environmental science, land economics, material science engineering, and geologicalengineering.

All of Ghana's state institutions, with the exception of KNUST, provide GIS as a required subject for majors in geography, environmental science, and geomatic engineering. In addition to Catholic and Central Universities, some private schools offer GIS as a required study. You may take a GIS course in five of Ghana's 10 technical universities: Kumasi, Takoradi, Wa, Koforidua, and Sunyani. In 2008, GIS was introduced as a core subject at Kumasi Technical institution, which was formerly known as Kumasi Polytechnic. This made it the first technical institution to do so. It was first offered as a Higher National Diploma-level modular course in the civil engineering department. Students enrolled in the civil engineering and estate management Bachelor of Technology (first degree) programmes were first exposed to it in 2010 and 2012, respectively. In 2012, ESRI made GIS available to everyone in Ghana by distributing ArcGIS instructional packages to selected secondary and higher education institutions throughout the nation via its local agent. This award was used by two more conventional public universities, one more private university college, one more technical university, and six more institutions that provide a second cycle of education.

Topics Covered by GIS at Technical Colleges

Knowing "when," "where," and "what" is the most basic kind of geographic information. In order to map, analyse, and evaluate real-world issues, GIS integrates geographical elements with tabular data (Catlin Dempsey, 2012). Geographic information systems (GIS) are powerful because they can combine geographical data with attribute data about the properties they stand for. Countless companies, as well as governmental, academic, and research institutions, have relied heavily on GIS to aid in decision making over the years. Previously taught only in geography and environmental science, GIS is now taught across a much larger variety of professional disciplines due to its greater uses and advantages (Bearman et. al., 2015). Among Ghana's technical institutions, the departments of building and environmental sciences are the most in need of GIS as a required subject.

field of applied sciences, the natural environment, engineering, and the creative and technological arts. Highway and transportation planning, traffic and road management, water and sanitation, and environmental monitoring are just a few areas where GIS finds widespread use in civil engineering. According to Miller and Shaw (2015), transportation infrastructure management and monitoring have been greatly improved by using GIS as a database platform. It is well-known in the field of electrical and electronic engineering that the use of geographic information systems (GIS) has considerably improved power sector efficiency via automated route selection of new power lines, load forecasting, and optimisation planning for power system substations (Rezaee et al., 2009). Additionally, GIS has tremendous uses in the oil and gas industry, spanning exploration, production, refining, and transportation. In order to make better decisions, GIS is used to gather, store, analyse, and show the geographical

positions of environmental objects like pipelines and wells. A GIS has proven useful in the fields of surveying and estate management for maintaining accurate records of land and properties, which are essential for purposes such as property value and facility management (Dale and McLaren, 1999). Professionals in the field of architecture and building also use GIS for project estimates and quantity takeoff (Cheng and Yang, 2001; Bansal and Pal, 2007). The use of geographic information systems (GIS) is also prevalent in municipal administration, environmental management, and planning for both the built and natural environments (Waddell, 2002). Tourists may using GIS to locate nearby hotels and restaurants, as well as the quickest and most efficient routes to their desired destinations (Gill and Bharath, 2013; Chen, 2007). With GIS, a plethora of tourism data may be shown in an easily digestible searchable map. Additional fields that have made substantial use of GIS include management and business studies, environmental studies, and resource engineering and management (Chinchu and Selvakumar 2012). Despite this, GIS education is still in its infancy at Ghana's prestigious technical colleges, which are renowned for producing industry supervisors with extensive expertise. Approachand procedures Focusing on GIS education at Ghana's technical institutions, this study used an exploratory research approach. The study's aims informed the design of the questionnaires, which included both open-ended and rating-scale items. Of the 102 self-administered surveys that were sent out, 61 (or 59.8% of the total) were actually returned. There were ten (10) technical universities in Ghana, thus the questionnaires were distributed using a purposeful sampling strategy. A total of 35 professors from various schools took the time to fill out the survey. Furthermore, sixteen (16) technicians and ten (10) department heads filled out the survey. Statistical Package for the Social Sciences (SPSS) and Microsoft Excel were used to conduct descriptive statistics analyses on the acquired data. We found and eliminated the survey outliers that could have impacted the findings and the following conversations. For further analysis, the replies were coded in SPSS. Bar and pie charts were used to display the findings. Here is a summary of the teaching staff and their faculties from the sample, as shown in Table 1.

Table 1

Distribution of respondents

ID	FACULTY	PERCENTAGE
1	Built and Natural Environment	26.23%
2	Engineering	63.93%
3	Other faculties	9.84%
Total		**100.00%**

63.93% of the teaching staff came from the faculty of engineering, 26.23% from the built and natural environment and the remaining 9.84% came from mathematics, computer science, agricultural science and industrial arts departments.

Findings

GIS Implementation Challenge

Practical and conceptual difficulties have been identified as obstacles to GIS implementation in classrooms across the world. The conceptual hurdles include the restructuring of courses and the implementation of new pedagogical approaches, while the practical hurdles relate to the acquisition and upkeep of the necessary technological resources (Foote et al., 2012). In 2008, when GIS was first included in technical university curricula in Ghana, these obstacles had to be overcome. There are no regulations for the collecting and exchange of geographical data, and there are no norms regarding the construction of curricula, both of which contribute to the conceptual difficulty in Ghana.

The Availability of GIS Facilities

The availability and the level of adequacy of GIS facilities in the technical universities such as laboratory space, software and hardware availability and geospatial data were surveyed to determine the current state of GIS facilities in the technical universities. Figures 1a, 1b, 1c and 1d graphically show the results of the level of adequacy of existing GIS facilities in the technical universities.

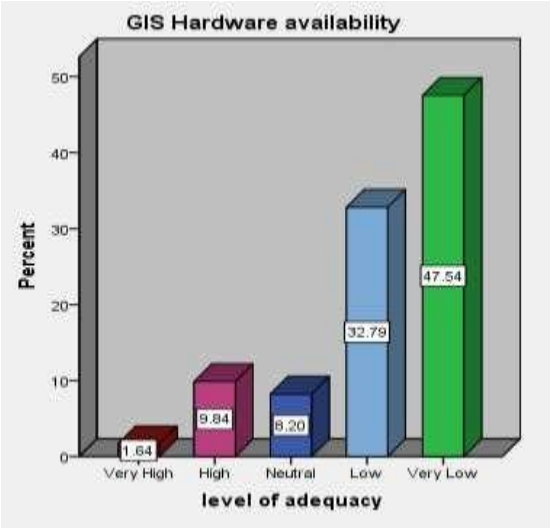

Figure 1a. GIS hardware availability

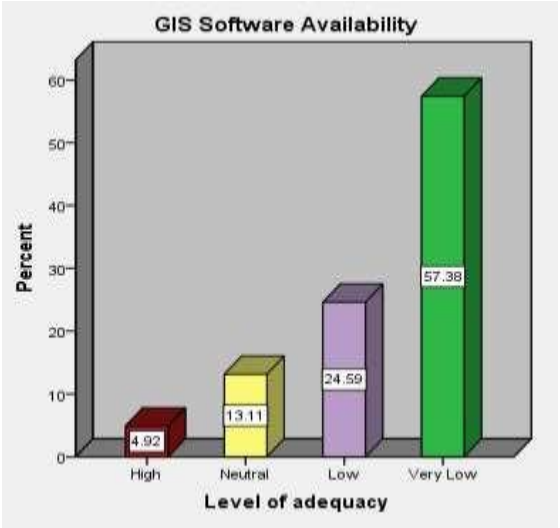

Figure 1b. GIS softwareware availability

More than half of the respondents (57.38%) agreed that the level of adequacy of GIS software is very low in the technical universities. The results clearly depict the poor state of GIS facilities in the technical universities and how they contribute to the current challenges in the teaching and learning of geospatial technologies in Ghana. About 80% of the respondents collectively agreed that the level of adequacy of GIS hardware is either low or very low. 52.46% of the respondents also agreed that access to geospatial data is very low at the universities.

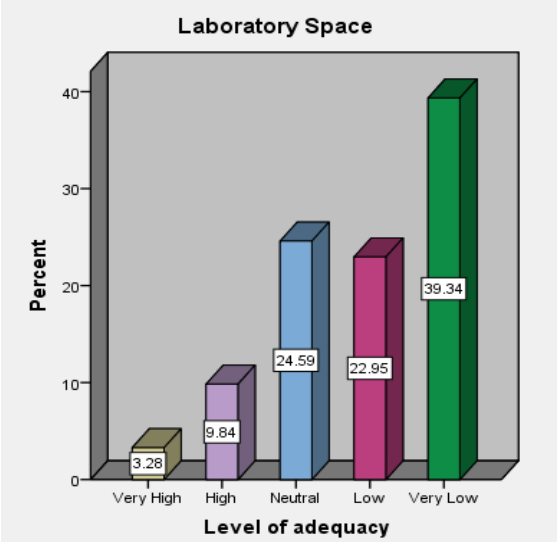

Figure 1c. GIS Laboratory availability

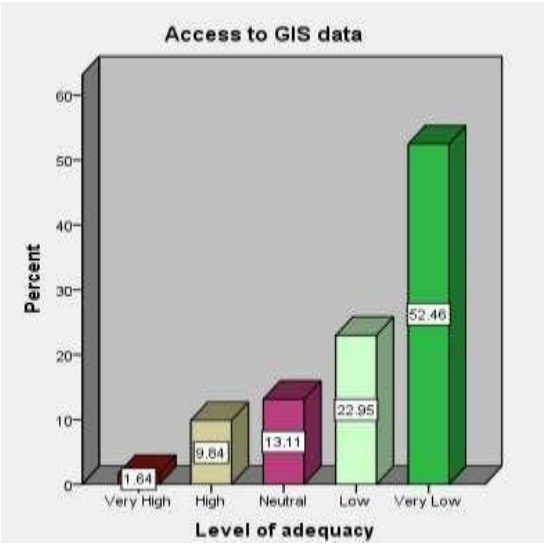

Figure 1d. GIS data availability

The practical challenges such as infrastructural challenges, lack of access to digital spatial data and GIS instructional materials and low level of Information and Communications Technology (ICT) knowledge and skills among students in the technical universities were also surveyed and analysed.

Infrastructural Challenges

Some of the biggest problems that technical colleges have with using GIS have been the cost and difficulty of purchasing and maintaining the necessary software and hardware packages. The reason for this is because government financing for polytechnic education is inadequate (Nyarko, 2011). Purchasing and maintaining GIS software packages often necessitates a substantial financial outlay. One big problem with Ghana's school system, however, is that there isn't enough money to buy educational software and programmes.

Obtaining the necessary hardware for the GIS infrastructure is another significant challenge for technical universities trying to develop GIS curricula. Figure 2 shows that one of the main issues is the high cost of GIS software, which a quarter of respondents (25%) strongly agreed with and 43.33% agreed with. Not only is GIS software expensive, but it also requires powerful computers with plenty of storage space and processing power. There is a significant outlay of funds required to acquire these computers, in addition to the expense of equipping labs with fast and dependable internet connections.

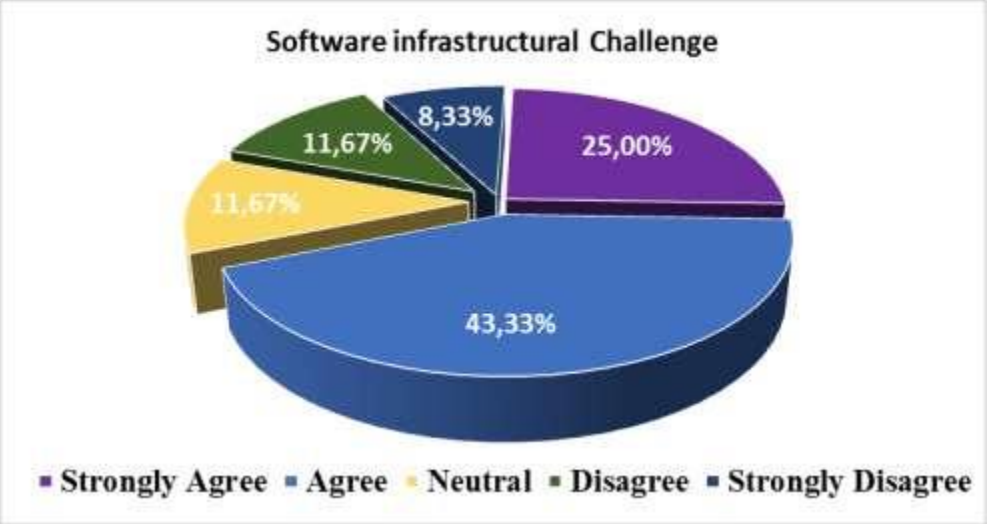

Figure 2. GIS software infrastructure

Digitizers, scanners, and plotters are additional GIS hardware components that may cost a pretty penny to set up and keep running. Challenges with the procurement and maintenance of hardware have a detrimental influence on the implementation of GIS education, according to 68.33% of respondents overall. Thirty percent of those who took the survey strongly agreed, and 36.67 percent agreed, that one of the problems at technical institutions is the absence of enough laboratory space for students and faculty.

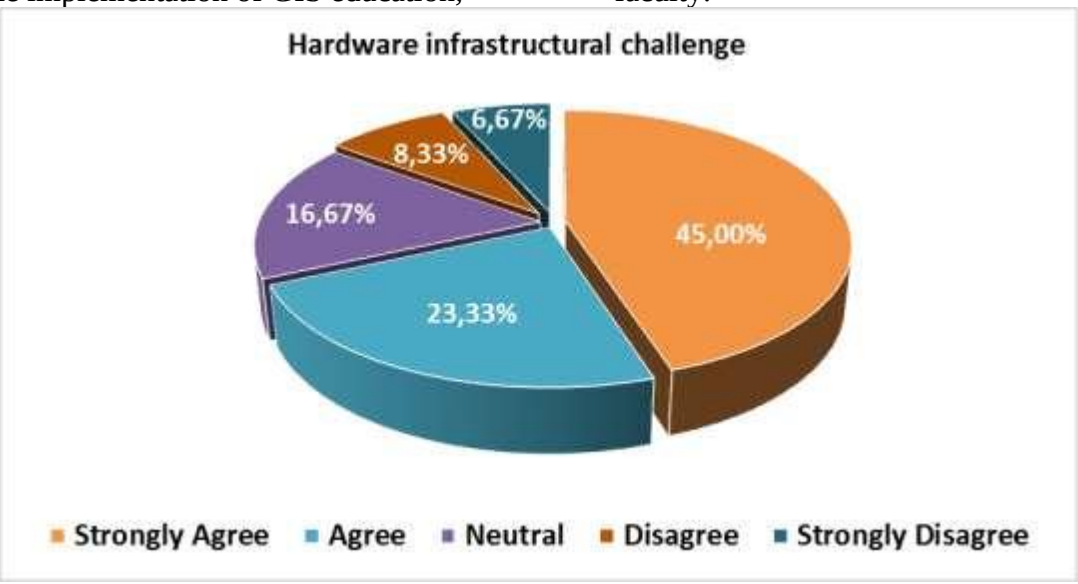

Figure 3. GIS hardware infrastructure

In addition to this, 68.33% of the respondents collectively believe that the poor state of ICT infrastructure in the country also poses a challenge for the adoption of free source GIS packages and other internet-based GIS programs like the Google and Yahoo maps.

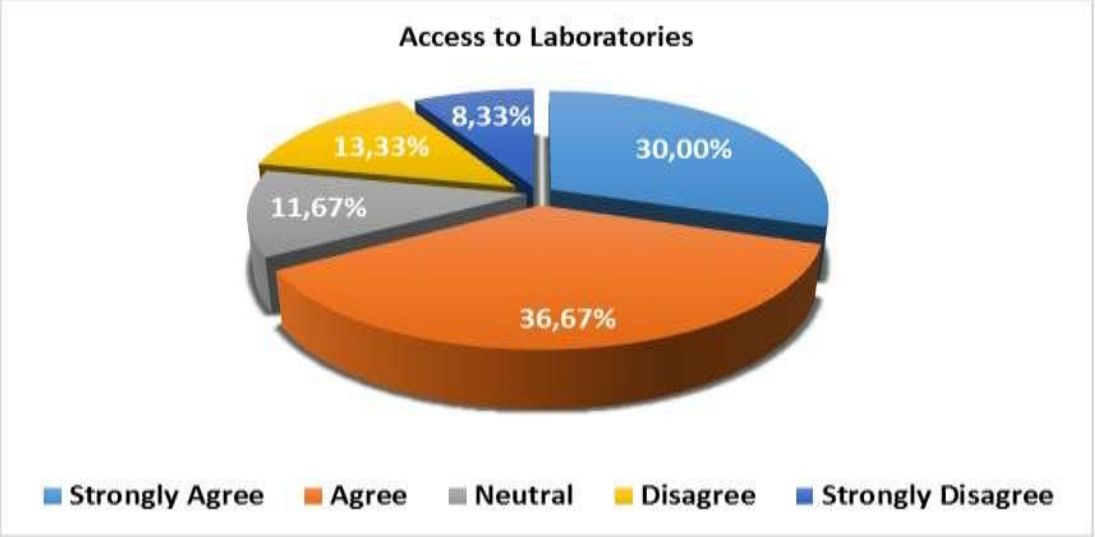

Figure 4. Access to GIS laboratories in the technical universities

Lack of Access to Digital Geographic Data

Besides the infrastructural challenges, 50% of teaching staff collectively agreed that access to digital spatial data and instructional materials for teaching and learning is also a challenge. Acquisition and transfer of digital spatial data for academic purposes in Ghana are extremely difficult and expensive. The digital data and the few hard copy maps available are also not up to date and the facilities and infrastructures such as scanners and digitisers for their conversion into the digital formats are also not readily available. In addition to accuracy and currency of spatial data, many of these data are of different projections system which brings about compatibility issues. In other jurisdictions, there are number of organisations and clearinghouses that provide GIS data either for free or at a very low cost for academic purposes. On the contrary, there is no such centralised database in Ghana where students and educators could easily download data either for free or at a low cost.

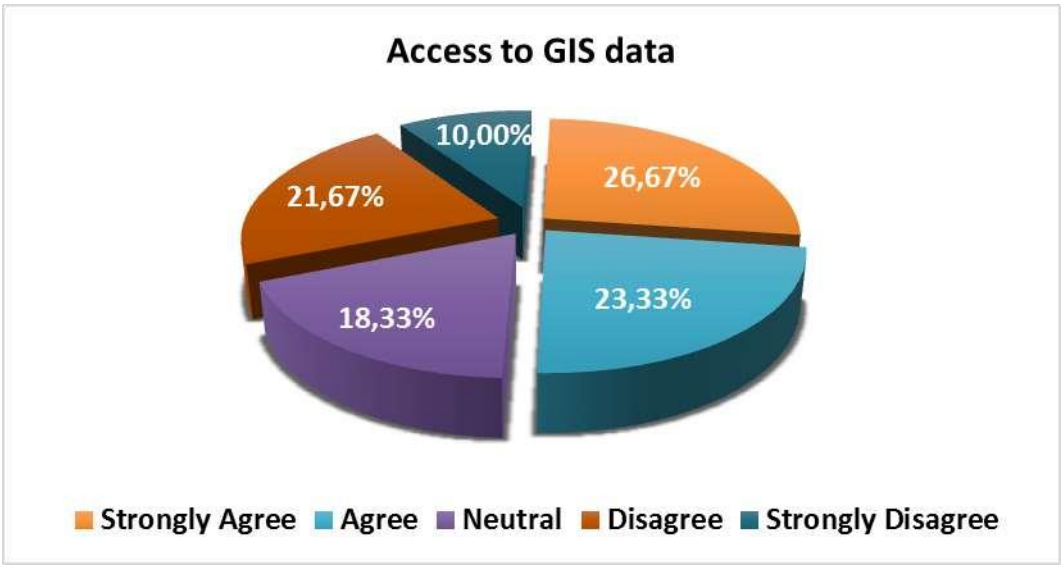

Figure 5. Access to GIS data

Low Level of ICT Knowledge and Skills of Students

Another contributing factor that the researchers considered was the level of ICT knowledge and skills of students in the technical universities. Since GIS is a computer- based application, the basic requirement for effective teaching and learning of GIS is the basics in computer literacy. Experience has shown that students who exhibit a high level of computer literacy tends to understand the concept and the application of GIS better and are able to use the system effectively than their counterparts with low knowledge in computers

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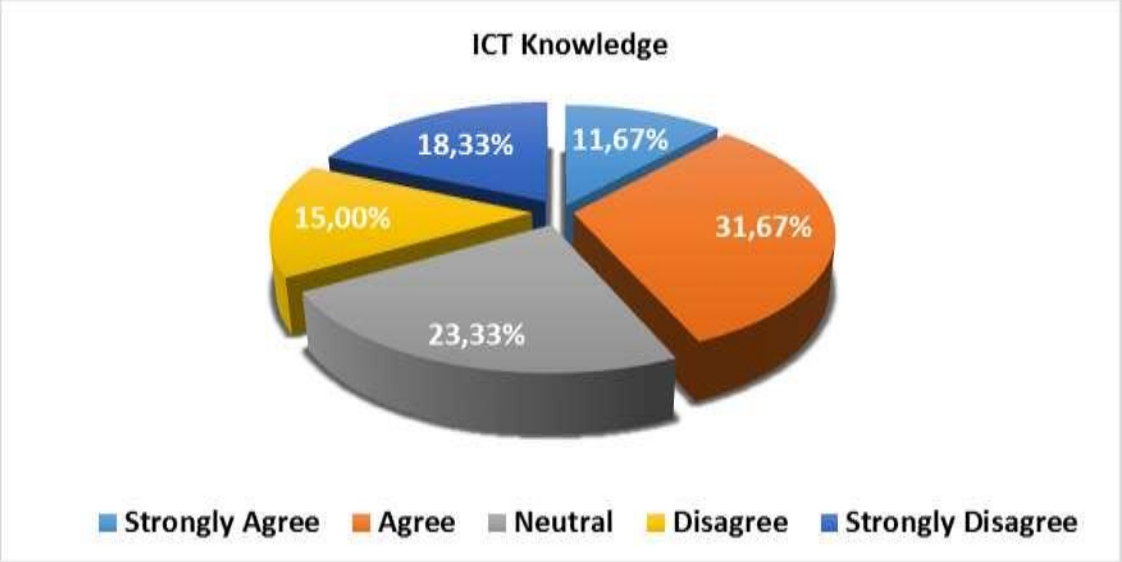

Figure 6. Level of ICT knowledge and skills

With the goal of laying the groundwork for integrating ICTs into the education sector, the Ghanaian government passed the ICT for Accelerated Development (ICT4AD) policy in 2003 and the ICT in education policy in 2008, both of which were reviewed in 2015 with the same objective. Nevertheless, 43.34 percent of respondents feel that students still lack adequate ICT knowledge and skills, which is having a negative effect on technologically based courses in higher education, such as GIS classes.

Recommendations for Improvement

Given the difficulties encountered thus far, GIS instructors, policy implementers, and other interested parties must work together to find lasting solutions to the problems plaguing GIS implementation at Ghana's technical institutions. The following are some suggestions for how higher education in Ghana, and technical institutions in particular, may enhance GIS instruction and student learning. Enhancing Geographic Information System (GIS) Capability at Technical Colleges It will be necessary to upgrade the current GIS infrastructure in order to put greater focus on skill development via the project-based approach to teaching and studying GIS in technical institutions. The technical institutions should have fully-equipped GIS labs with state-of-the-art computers and other necessary

equipment,such
scanners, plotters and digitisers. The use of e-learning, the sharing and transfer of geographical data, and other similar initiatives would greatly benefit GIS education in Ghana's schools if the country's inadequate information and communication technology infrastructure were to be improved. The use of online, shorter courses to supplement traditional classroom instruction will also be encouraged.

Teaching and Learning Approach

Historically, student-centered learning has not been the norm in Ghanaian and developing-world educational institutions. There is a greater focus on teachers delivering facts and figures to their pupils, with less or no attention paid to students actually studying and demonstrating what they've learned. Bednarz (2004) and Favier and Van de Schee (2007) are among the researchers who have stressed the need of integrating the development of both knowledge and skills in geography education. The features of design principles for GIS-supported inquiry-based geography education were also investigated and described by Favier and Van de Schee (2012). Schultz (2012) points out that a method for proficiently using GIS technology may be achieved via active learning in conjunction with inquiry-based and problem-based learning systems. Therefore, the project-oriented approach is the ideal way to teach and study GIS at technical colleges. Since this encourages student participation in the learning process, it follows that additional practical training with the programme is necessary.

Collaboration with Universities and Other Institutions

One thing that sets GIS education apart is the way teachers have collaborated to innovate and enhance practice, frequently across borders and disciplines (DiBiase et al., 2012). Some of the infrastructure issues at these schools may be alleviated by productive partnerships with well-established institutions, such as Ghana's state universities, which have earned a reputation for excellence in GIS teaching throughout the years. Technical colleges also need to network with various GIS software vendors, consultants, and end customers. Efforts to improve GIS instruction at other technical colleges might benefit from existing partnerships in this area. In the early stages of implementing GIS and addressing infrastructure challenges, technical universities can form partnerships with public university departments of geography and geomatic engineering that have the necessary expertise and experience.

Restructuring of Geography and ICT Education in Ghana

Restructuring of ICT education in schools and colleges especially at the second cycle level will help to improve GIS education in Ghana. Experience has shown that, an improvement in ICT training at the secondary school level will produce students with high literacy rate in ICT who can easily appreciate GIS technologies. These students end up in the technical universities and in other tertiary institutions in Ghana. Over the years, government has introduced many ICT policies in education and interventions including the recent ICT for education policy 2015 focusing on the use of ICT as learning and operating tool and also as a career option for students. These efforts must be strengthened in order to improve

ICT education in Ghana. In addition to this, introduction of GIS into the second cycle education as part of geography curriculum as suggested by Oppong and Ofori-Amoah (2012) will also give students entering the higher educational institution in Ghana a brief introduction of GIS and will prepare them adequately for higher education and training in GIS.

Conclusions

Since its incorporation into technical university curricula in Ghana, GIS has shown to be an incredibly valuable professional tool. However, in order to fully use GIS education at the technical university level in Ghana, there are some important implementation issues that need to be addressed immediately, as highlighted in this study. In order to overcome these obstacles, the GIS business, government agencies, and GIS instructors must work together. The potential of GIS in Ghana is still great, notwithstanding the difficulties with implementation that have been covered in this article. The need for a skilled workforce will likely remain strong as more and more industries recognise the value of geographic information systems (GIS) in their work. Therefore, in order to fully use GIS, especially at the technical university level in Ghana, it is crucial that GIS educators and other industry players actively strive to enhance the present infrastructure and people resource.

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Identities and life experiences

At Ghana's Kumasi Technical University, Prince Charles Acquah spends his days lecturing. Upon graduation from Kwame Nkrumah University of Science and Technology (KNUST), Kumasi in 2008, he immediately became a Lecturer in the civil engineering department. Acquah has previously served from 2003 to 2005 as a research and teaching assistant in the Geomatic Engineering department at KNUST. He attended KNUST and earned a Bachelor of Science (BSc.) in Geodetic Engineering and a Master of Philosophy (MPhil.) in Geomatic Engineering. He is an independent surveyor with experience working for consulting organisations specialising in surveying and geographic information systems (GIS). When it comes to environmental monitoring and management, his research interests lie on the use of geospatial technology. He has memberships in two professional organisations: the Ghana Institution of Surveyors and the Ghana Institution of Engineers, both of which he has completed.

Kumasi Technical University's civil engineering department employs Jack Nti Asamoah in the role of lecturer. Beginning his tenure in 2010 as a service member, he was subsequently confirmed as a Senior Technician in 2013. As of January 2016, he is a full-time lecturer in the field. Jack

serves as the department's examination officer at the moment. After attending KNUST, he earned a BSc. in geomatic engineering in 2010. He is also qualified to practise geomatic engineering according to his Master of Science degree from KNUST. He has memberships in two professional organisations: the Ghana Institution of Surveyors and the Ghana Institution of Engineers, both of which he has completed. He has experience in cadastral, engineering, and topographical surveying via his work as a consultant and as a freelancer. His academic interests are in the field of urban planning and management as it pertains to the use of remote sensing methods and associated technology.

Dennis was In his present role as Research Associate at the Engineering Department of Cambridge University, Daniel Konadu is involved with the Whole System Energy Modelling (wholeSEM) Consortium. At the moment, he's using the Foreseer tool to link land and water to the UK's energy networks. Dennis earned a doctorate in environmental science from the University of Lancaster in 2013, the year before he enrolled at Cambridge. In his Opportunity maps for terrestrial carbon sequestration throughout UK landscapes were the primary focus of PhD study. He earned a Bachelor of Science degree in Geodetic Engineering from Kwame Nkrumah University of Science and Technology, Ghana, and a Master of Science degree in Water Science, Policy and Management from Christ Church, Oxford University.