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Bridging Geo technology Competence Gaps among Kenyan Undergraduate Students: An Interdisciplinary GIS Training Model at Chuka University

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Abstract: 21st Century scholars are presented with opportunities to develop careers in emerging technological niche markets. Occupations and industries are also coaching for graduates with technological skills and sectoral market competencies. This situation calls for the utilization of technologies and market oriented models to train graduates on the skills, knowledge and abilities essential for employability. Geospatial niche jobs are fast growing labour markets in the world today and require graduates with interdisciplinary knowledge, Geo technology competences, creativity, problem-solving and computing skills. The objective of this paper is to share on the achievements of an innovative training model used by the author to equip multi disciplinary undergraduate students at Chuka University with relevant geospatial technical competencies. It was found that the use of interdisciplinary Geo technology based training approach cannot only bridge gaps on geo technical competency skills but also enhance interpersonal effectiveness skills and academic competencies as well.

Keywords: Employability, Competency, Creativity, Geospatial Skills, Interdisciplinary

1. Introduction

Today climate change, insecurity and natural hazards are common threats facing humanity and are growing in global importance as well [12]. Therefore the need for geographic knowledge is becoming increasingly important in understanding where these events occur, spatial patterns and even trends of their occurrence. Of importance is that spatial patterns and trends can be analyzed within a geographic information systems (GIS) framework to help better understand variations across the earth's surface.

GIS, Remote sensing, Global Positioning Systems (GPS) and virtual globes have been identified as geospatial technologies in growing demand in the 21st Century labour market [9]. Globally, educational reforms have emphasized on the need to develop creative thinking, data analysis skills, real-world application of knowledge and utilization of technologies in teaching and learning [17], [18] and [19]. Driving these reforms is the increasing need to use replicable methods and empirical data to solve problems. Similarly, emerging educational standards are pushing for an instructional model of teaching based on interdisciplinary learning. Geospatial technologies to be particular; Geographic Information Systems (GIS), Global Positioning Systems (GPS) and Google Earth have become widely applied tools for mapping, visualizing, organizing and analyzing multiple geo-referenced data in business world. It is the time these tools were introduced and fully integrated into our education system.

In classrooms, GIS can be used as an instructional and research tool to enable students understand content, think critically and connect to their communities through field based research projects [4], [16] and [21]. Teaching with GIS has been applauded as a practical way to help students understand their world [8]. On the other hand, Google earth is becoming a common instructional tool for promoting spatial thinking because of their ease to use and dependent on internet data [5]. Basically GIS and Virtual globes are mapping resources representing opportunities for students to open their world of geographic inquiry and for instructors to

teach contents in a visually learning manner. The rationale of advocating for these geospatial tools in education is the fact that they support standard-based and inquiry driven teaching and learning methods [2], [14].

The objective of this paper was to promote constructive teaching and learning using GIS and Virtual globes. These geospatial tools are interdisciplinary in nature, easy and practical to use in class room and are centered on scientific inquiry process.

To achieve this objective the research was guided by the following three questions;

i What impact does using GIS has on the development of university students' skills and competencies?
ii How does the use of virtual globes enhance inquiry-based and visual learning?
iii Which approaches can be used to make Geo technologies based education more effective in Kenya?

Most of the studies in the area of GIS in education have focused on student learning and outcome [1], [3], [10] and [11]. Others have featured on issues of GIS pedagogies especially in teaching spatial contents [13], [15] and [23]. Currently no rigorous studies have been done to examine how internet based geo-technologies like Google Earth can be used in advancing spatial analytical skills and knowledge. The other challenge is that GIS is still perceived as a niche technology rather than an important instructional tool for teaching and learning of essential 21st Century skills like critical and analytical thinking, computing, spatial thinking, problem solving and decision making processes [22]. Based on these gaps there is need for more empirical studies on the application of these tools to advance research in universities and development of location based business solutions.

Furthermore geo technologies are evolving into powerful and efficient tools which call for re-examination of how they can be used seamlessly in teaching and learning of spatial concepts at all levels. For Geo technology to be well received in education there is need for hands-on GIS training to the instructors, administrators and students to expose them to the basic tasks carried out by GIS Software. Locally, there lacks instructional materials that integrate geospatial concepts into existing curricula further impeding the implementation of these tools into Kenyan education system. Participatory learning will give students an opportunity to engage in community projects by working towards addressing a need identified as important to the students and the society.

2. Methods and Pedagogic Approach

Methodological approach adopted in this study was based on geographic inquiry, application of interdisciplinary content knowledge and basic research skills.

2.1. Design of Geo technology Based Learning Activities

Case examples used in this study utilized Google Earth and QGIS geospatial tools in a structured diverse learning approach. The National Geography standards were adopted as guidelines to promote spatial thinking skills and teacher pedagogical content knowledge.

2.2. Curriculum and Instructional Materials Development

Selected topics from geography curricula were used to study concepts of relevance to the modern day students like urbanization, diseases, migration, climate changes and others. Computers, internet connection, Google Earth, Quantum GIS were other technological materials considered essential component for the effective system setting. The content was developed using simple language to understand and procedures for using geospatial learning tools. Google Earth satellite images were used with tools such as place marks, image overlays and polygons used in the exercises. Custom icons of the features being studied were used to help students identify with the phenomena being mapped. The approach adopted for the case projects involved: Selection of a topic, Identification of real world problem, Decision on the products and outcomes, Creation of a suitable work plan, Analysis and presentation of the Findings.

2.3. National Geography Standards

In an education system highly galvanized by quality, standards informs the practices, content knowledge and pedagogic approaches to use in delivering desired learning outcomes. Specifically the national geography standards' objectives are to produce a geographically informed person with spatial thinking skills. For this reason these standards were used as guidelines in the design of all the projects used in this study. Only five out of the eighteen geography standards used were found relevant in this work as developed by the Geography Education Standards Project:

i Geography Standard 1: How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information from a spatial perspective.
ii Geography Standard 3: How to analyze the spatial organization of people, places, and environments on Earth's surface.
iii Geography Standard 12: The processes, patterns, and functions of human settlement.
iv Geography Standard 14: How human actions modify the physical environment
v Geography Standard 18: How to apply geography to interpret the present and plan for the future

2.4. Assessment

In assessing the student's performances; multiple-choice, short-answer and performance-based evaluation criteria with product creation and process-oriented evaluation have been in GIS training [20]. For our projects, students' products and performance incorporating short-answer assessment tools using scoring rubrics were used because of their suitability for beginning trainers. The outcome of these assessment tools was to measure content knowledge, results communication and mastery of GIS Skills.

2.4.1. Case Study A: Teaching Urban Ecologies with Google Earth (Virtual Globe)

In this case, Google Earth was used to promote learning of spatial concepts by analyzing land use and land cover changes within Ndagani conurbation of Chuka town. Google Earth is a virtual globe that integrates remotely sensed images created with satellite and aircraft data at different points in time. Based on these, they are used in visualizing data for better understanding common challenges of the modern world. Google Earth has a relatively good resolution, fully function free version, available for most operating systems, and are easy to learn compared to other geospatial technologies. Because of these reasons they have been adopted in a lot of classroom contexts to inculcate inquiry-based learning [6], [7]. In this design the learning materials used were developed based on the national geography standards.

Project 1. Land Use and Land Cover Change Dynamics around Chuka University

This case study sought to demonstrate skills used in the interpretation of remote sensed data and how to analyze change science using land use and land cover changes. Land use and land cover change is the alteration of the activities and phenomena on the land's surface in a given area. Developments taking place within and around universities in Kenya are driving land use and land cover (LULC) changes through transformation and conversion of the non built environments into built areas. Universities spatial dynamics can be assessed effectively using satellite images due to associated anthropogenic changes resulting to vegetation loss and related impacts.

In Kenya, universities are coming to the people as campuses or constituent colleges and are changing the local social, ecological and economic sets up. Studying the dynamics of land use and land cover around universities help learners understand the processes leading to urbanization and associated problems. Students used Google Earth to analyze and evaluate the major types of land use and land cover in this study area (figure.1). Students were expected to investigate specific features of common land uses around the university from Google Earth images in order to answer question on which areas had more residential land uses around Ndagani the university market? By examining how the land use and land cover changed from 2003 to 2013, students understood implications of man-land interactions and the process of urbanization around universities.

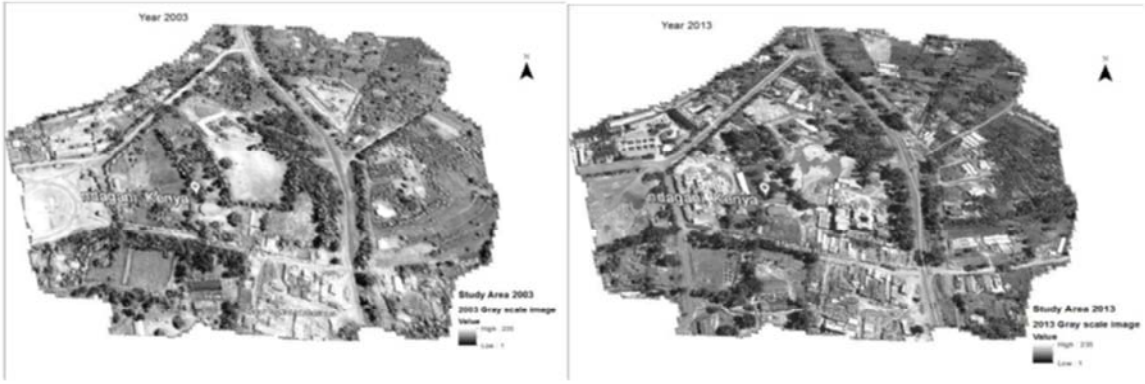

Figure 1. *Google Earth Images displaying Chuka University neighbourhood in 2003 (Left) and 2013 (Right) respectively.*

2.4.2. Case Study B: Teaching Geographic Information Science Concepts

The limitation of using virtual globes is that they focus on visualization while Geographic Information Systems (GIS) support analyses of data, visually exploring relationships among data sets. An approach adopted in this work was that of providing a specific problem that students are familiar with and were expected to learn. This gave students a chance to explore the various geo processing tools available for them to work with on their GIS based projects. By so doing students engaged in some level of inquiry as they went out to collect data they needed for the project. Students were to use the data they collected to answer questions and this depended on creativity and effective communication.

Project # 2: Mapping of Health Care Services Using QGIS

The aim of this project was to familiarize students with basic GIS mapping concepts. Teaching students' skills and techniques used in collecting geographic data and carrying out spatial analysis were considered essential geospatial skills. Students were shown how to down load, install and launch Quantum GIS. Quantum GIS is open source GIS software with geo processing tools and that it supports different spatial data formats makes it easy to use. Learners were oriented to the QGIS software features, functionalities and important spatial analysis skills like queries and proximity analysis. Students were exposed to commonly used geo operations such as interpolation, collection of GPS data and geo referencing

3. Findings and Discussion

3.1. Impact of GIS Training on Students' Skills and Competencies

Training learners to use GIS improves skills related to data collection, communication, knowledge and use of technology. According to the questionnaires and project

assessment portfolios used in the two case projects, there was statistically significant increase in the participants level of skills related to the use of GIS software tools. In this regard, participants were placed into two cohorts as those taking Bachelor of Arts in education and those for Bachelor of Science in environmental studies. Those who participated in project one were second year students in B/ED arts program taking a geography unit on Practical Geography and Fieldwork. They were expected to collect data on variables like; type of LULC, causes of land use and land cover changes as well as terrain characteristics. This group was basically involved in ground data collection and were not trained in GIS but exposed to the use of Google Earth images for field work data verification.

The second group consisting of fourth year students in environmental science was exposed to hands-on GIS training and formed the participants in project two. There were variations between these two groups with participants' in group one showing improved attitudes towards field work studies. The group members were fully involved in the formulation of fieldwork program, designing the questionnaires and in actual field data collection. Most of them reported getting real experiences of carrying out geographic research. The use of Google earth images in the fieldwork for land use and land cover identification, geo referencing and field data verification significantly increased the students' basic research skills as expressed by one of them:

"I'm delighted to learn about Google Earth and the idea of using its images for verifying if the recorded phenomenon is actually the one on that ground. I think this just helped me to be a practical geographer who has been empowered to use technology."

Those learners in group two with hands-on GIS skills were required to use QGIS software to input, analyze and present their work using a pre worked project data. In this case, statistically significant levels of improvement in skills of using GIS software tools was registered given the number of students who were able to complete the tutorial exercises.

These finding were also supported by the responses to the questionnaires administered where some learners mentioned being introduced to geo-spatial technologies, such as GIS or Google Earth, while others said they gained knowledge on how to use QGIS software. The most important was that many learners began experimenting new ways to use technology in their training fields as said by one of the learners:

"I work on the QGIS tutorial exercises given and then try with scenarios related to my Environmental Science course"

3.2. Inquiry-Based and Visual Learning on Knowledge Enhancement

Students clearly recognize the value of technology when they can apply it in addressing issues they know. The use of project approach to teach geographic and scientific concepts within the frame work of GIS exposed students to data visualization and investigation. Students were required to apply knowledge they had acquired in biology, history, geography and business studies in high schools to explain the relationships that different data sets revealed. By analyzing data using attribute query and visual interpretation, learners were able to apply spatial thinking to make decisions. GIS and Virtual globes enabled the learners generate "what-if" scenarios, further prompting them to consider future problems that may occur and the possible management strategies that need to be considered in the future. Findings from the two groups revealed that studying using real data and fieldwork promotes problem based participatory learning and improved interactions. The participants confirmed that by visualizing the data as map increased understanding of location context and distribution of phenomena being investigated as well as implications of the decisions made.

3.3. Making Geo technology Based Education Effective in Kenya

The potential for GIS based learning is good given the number of geospatial related degree programs mounting in Kenyan universities. Similarly, the rapid developments in information technology and increasing use of visualizing and digital image technologies provide exciting opportunities for educators to bring these tools into classrooms. However the value and contributions of geography need to be recognized or understood if Geo technology based education is to be appreciated in the society. Specific challenges on GIS awareness, software usability and lack of knowledge on geographic principles are limiting adaption of GIS education. Despite these impediments, Geo technology based education is establishing a niche in Kenyan universities as tools in teaching and research. Curriculum reforms, geography awareness, integration of geospatial technologies into existing disciplines and short course GIS training seminars are ways of expanding the frontiers of geo literacy in Kenyan education sector. There is a need for collaboration between geo spatial industry and universities to continue growing geospatial competence, infrastructure and skills in the country.

4. Conclusion and Way Forward

Applying geospatial tools in teaching and learning provides students and teachers with skills relevant in today's location oriented service based world. Emerging geospatial landscape in Kenya calls for introduction of teacher professional development programs on use of geospatial tools in teaching and research. More exchange programs should be started to strengthen the existing geospatial education landscape and expose learners to new geospatial technology tools.

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