GIS For Petroleum Course in Geography Curriculum: Case of UAE University

Abstract

Oil revenues represent the main source of national income in UAE and this indicates that large numbers of jobs are available in this sector. Generally, the field of petroleum industry is dominated by geology and engineering graduates. The Department of Geography and Urban Planning at the College of Humanities and Social Sciences, UAE University had renovated its curriculum recently to meet the market demand. Among the vibrant and promising market that had been identified is the field of petroleum industry and based on this a new course entitled “GIS for Petroleum” was introduced. Although the course opens new job opportunities for geography graduates there are some problems related to a suitable textbook that fits the course, heterogeneity of students enroll in the course, language constraint, difficulty in obtaining local petroleum data to train students on, the need for specialized GIS and subsurface 3D software, and harshness of the petroleum environment. Opening job opportunities is ranked at the top of interviews and surveys to graduates from the course. Meetings with customers (where graduates seek employment) helped in reshaping the course to meet the skills needed by the market. This paper shares experience on teaching GIS for petroleum course and how geography educators can update their curriculum to meet the market demand.

Keywords: GIS; Petroleum; UAE; Geography

Introduction

United Arab Emirates (UAE) is founded in 1971 as a federation of seven emirates. Comprising an area of 83,600 square kilometers, the country lies between latitudes 22°–26.5° north and longitudes 51°–56.5° east. According to the 2005 census, the population of UAE is 4,104,695 [1] and the current (2017) population is estimated as 9,402,731 2017 based on the latest United Nations estimates (http://www.worldometers.info/). For population data estimates the reader is referred to the Federal Competitiveness and Statistics Authority (FCSA) (http://fcsa.gov.ae).

The Department of Geography and Urban Planning was founded in 1977 and has produced more than 2000 graduates, with secondary school geography teaching their principal occupation. By late 1990s the market for teachers began to decline, and the Department introduced Geographic Information Systems (GIS) track in 1999 to meet a growing demand in the GIS field. The Department’s goals include adding more UAE nationals to the faculty, improving capabilities for research and publication, and placing more geography and GIS-trained graduates into the national workforce. In 2003, the Department began drafting a revised mission that reflects a growing university-wide commitment to intellectual development in a global context. Greater attention is given to interdisciplinary education, critical thinking, proficiency in English, and students’ connections outside the University and the nation. The latest revision of the Department included developing three general tracks one covered urban planning, the second concentrated on environmental issues, and the third focus on GIS. The Department’s curriculum indicates strong commitments both to the national priorities emphasized in its mission and to the education of well-rounded students of geography.

The Department had started in 2005 a cross-disciplinary thematic application courses in response to the market demand and at the same time a master degree in remote sensing and GIS [2]. One of the thematic application courses is GIS for petroleum. The world will see more high demand for oil due to the increase in the number of population, industrial and commercial activities [3]. The Gulf Cooperation Council (GCC) have the lion share in this market (around 60%). Currently, UAE produces around 3 million barrels of oil per day (b/d). This makes UAE the world’s fifth-largest oil producer. Oil and gas accounted around 40 percent of the UAE’s Gross Domestic Product (GDP). Therefore, it is necessary to introduce courses that qualify geography graduates to compete in this vibrant market. The fact that GIS technology is used in various phases of the petroleum operations such as pipeline construction shows that there is a great demand for college graduates with GIS degrees [4]. GIS/GPS/Remote Sensing help in pipeline operations (selecting a new route, managing existing lines, and studying impact of pipeline on environment). For example, UAE built a pipeline (Habshan to Fujariah Port) with a total length of 360 km and cost of US$ 3.3 billion. The main reasons for building this line are to avoid political tension in the Gulf and the shallow depth of the Gulf (only small ships can go...
inside the Gulf). The line pumps 1.4 to 1.8 million barrel per day (70% of the UAE oil can be exported via this line). Construction and management of the line create business and more job opportunities.

The number of students attending the department is increasing continually. The total number of students at the department during the academic years 2016/2017 reached 300 students (girls and boys). The number of faculty has reached 15, with various scientific ranks and specialties such as physical geography, human geography, GIS/Remote Sensing and urban planning. Other educational facilities available at the Department include two GIS analysts, textbooks and references at the central library, fast speed connection to the internet (fiber optics), local UAE data, hardware and software (ArcGIS, ERDAS Imagine, ENVI licenses). The article starts with setting the objectives of the paper, highlights GIS application for petroleum, discusses GIS for petroleum course, identifies problems related to the introduction of GIS for Petroleum course, and proposes some recommendations.

**Objectives**

The main objectives of this paper are to address issues related to introduction of GIS for Petroleum course in the Geography curriculum, explore suitable model for teaching the course, and share experience with other Universities.

**GIS applications for Petroleum**

GIS provides a natural fit for the petroleum industry. Almost all petroleum operations (exploration, production, and marketing) can be geo-spatially defined then linked to tabular data sets, GPS, aerial photographs, remote sensing, and other real-time and historical information [5]. Beginning with the well prospect and ending at the gas pump, petroleum professionals involved in upstream, midstream, and downstream activities can use GIS for site selection, cross-functional and organizational communications, and economic and market analysis [6]. Virtually all petroleum business operations, from regional geologic exploration, through field appraisal and development, and from product distribution, facilities management and environmental modeling to retailing or commercial and domestic supply, rely on fundamental spatial data components. GIS is not restricted to static maps, but it can be used to track movement of oil ships through Global Positioning System (GPS), generate electronic maps daily, and make these maps available wherever and whenever to petroleum staff through real time web-based GIS [7].

One specific exploration application involves the creation of reconnaissance maps. Such maps are usually performed across large geographic areas, where many data sets or map layers are used in the analysis of hydrocarbon potential. Raster data, such as aerial photos or satellite imagery, can be incorporated with vector data, such as geology, elevation contours, and topographic landmarks or points of interest, can be presented (http://gisgeography.com/gis-in-oil-gas-industry/). Where appropriate, coordinates from land surveys, such as section, township, and range, can be integrated with well data Reconnaissance maps of mature exploration areas can present distinct trends, patterns, and anomalies. GIS is a particularly effective technology that enables exploration team to share information, analyze data in new ways, and integrate the evaluation process (https://www.petroskills.com).

Many conferences related to application of GIS in the petroleum industry are organized during the last few years and this reflects the spread of GIS. For example, ESRI Petroleum GIS Conference 2017, April 12–13, Houston, Texas. The Geospatial Information & Technology Association (GITA) and the American Association of Petroleum Geologists (AAPG) organized also a series of events related GIS application in the petroleum industry.

GIS and related technologies such as remote sensing, Global Navigation Satellite System (GNSS-tracking), Surveying, Unmanned Aerial Vehicle (UAV) are nowadays commonly used in the petroleum industry due to their benefits (save time, money, improve efficiency, better decision making). With the increase in number of satellites and improvement in spatial, temporal, radiometric and spectral resolutions the chances of using remote sensing images for petroleum operations will increase [8]. GIS helps in spatial analysis, better visualization of diverse data and consequently facilitate quick and accurate decisions [9-11].

**GIS for Petroleum Course**

The overall objective from introduction of the GIS for Petroleum course is to open new job opportunities for geography graduates. The course is designed based on literature, input from experts/employers, and survey to job specifications in the field of GIS for petroleum. Most of GIS jobs announced in the field of petroleum need applicants who have skills in data collection, familiarity with GIS software, spatial analysis, DBMS, project management, development of user interface and reporting about petroleum data. The course is opened for Geography students and for other departments such as geology and engineering. It provides a quick introduction to the fundamentals of GIS and Petroleum. It is assumed that those who enrolled in the course have completed introduction to the fundamentals of GIS and Petroleum. It is consequently facilitate quick and accurate decisions [9-11].

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**i.** To develop an understanding of the applications of GIS in the petroleum industry.

**ii.** To expose the students to the applications of remote sensing and GPS in the petroleum operations.

**iii.** To review GIS models and spatial analysis related to the application of GIS in the petroleum field.

Up upon completion of the course (outcomes) a student will be able to:

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a. Integrate different GIS data to solve real petroleum problem (exploration, pipe line sitting, corridor selection, marketing, and environment).

b. Evaluate and critically identify the strength, weakness, and constraints of applying remote sensing, GPS, and GIS in the petroleum industry (SWOT analysis).

c. Demonstrate ability in using GIS software to build petroleum database, perform spatial analysis, and prepare maps, reports, and charts for presentation of results.

d. The assessment of the course is based on quiz and report (15%), midterm exam (25%), course work (lab) (20%), and final exam (40%).

Table 1: Topics covered in GIS for Petroleum course.

<table>
<thead>
<tr>
<th>Week</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Course outline and Introduction to GIS for Petroleum</td>
</tr>
<tr>
<td>2</td>
<td>GIS, Remote Sensing, and GPS for Oil Exploration</td>
</tr>
<tr>
<td>3</td>
<td>GIS for Geophysics</td>
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<tr>
<td>4</td>
<td>Application of GIS for oil production</td>
</tr>
<tr>
<td>5</td>
<td>Use of GIS for pipeline</td>
</tr>
<tr>
<td>6</td>
<td>Application of GIS for Petroleum marketing</td>
</tr>
<tr>
<td>7</td>
<td>GIS for Petrol Stations</td>
</tr>
<tr>
<td>8</td>
<td>Visit to governmental/private departments implementing GIS for Petroleum</td>
</tr>
<tr>
<td>9</td>
<td>GIS as database management systems (DBMS) for the petroleum industry Integration of heterogeneous data and different software</td>
</tr>
<tr>
<td>10</td>
<td>Generation of 3D and sub-surface models to aid in petroleum exploration, management, and monitoring. Visualization, fly-over, animation</td>
</tr>
<tr>
<td>11</td>
<td>Global Mapping of oil</td>
</tr>
<tr>
<td>12</td>
<td>Web-based GIS and Mobile Mapping for the petroleum industry</td>
</tr>
<tr>
<td>13</td>
<td>Presentation of GIS For Petroleum projects</td>
</tr>
</tbody>
</table>

Visit to governmental/private departments implementing GIS for Petroleum

The organization of a visit to governmental/private departments implementing GIS for Petroleum is considered an important element in the course. Examples of these departments include Abu Dhabi Company for Onshore oil operations (ADCO). Students and faculty get to know about the daily operations of the company and how GIS, surveying engineering, GPS, and remote sensing are integrated for providing permissions for oil exploration companies, coordinating between various utilities departments, and managing the petroleum assets. GIS employers delivered talks on their experiences with GIS implementation in petroleum followed by live demonstration on GIS systems and open discussion with students. Through these visits student are able to listen directly to the employers and the skills needed in the market. These skills are incorporated in the body of the course to meet the market demand.

The practical part of the course

The practical part tries to provide students with hands/training on remote sensing and GIS software and at the same time satisfy the 3R (Researched, Relevant, Reactive) approach. Researched focus on setting the objective of the training, relevant means using data that is familiar to the trainees (UAE data), and Reactive ensures that expectations can be satisfied without isolating either fast or slow learners. The practical part of the course is formulated with the following objectives:

i. To develop an understanding of research methodology (problem identification, setting criteria, literature review, data collection, analysis, problems, recommendations, references).

ii. To expose students to the applications of remote sensing and GIS in the petroleum industry and its link to various areas such as physical, environmental, and local planning.

iii. To encourage students, from different fields “inter/multi-disciplinary”, to form some sort of communication and teaming (student-student interaction) to work towards common objectives and goals.

Example of students’ projects

Students were asked to carry out projects related to various operations in the petroleum industry. This includes exploration, pipeline optimum route, and impact of oil on environment. For exploration, students have to use critical thinking to detect any clues for the relationship between the geological formation, land use type and areas of high oil reserved, generate 3-D model (contour-DEM) and overlay with the satellite image and check if there is any relationship between elevation/slope and oil availability. Overlay pipelines on the 3D model and satellite image and check whether the route through which pipelines networks pass is economically feasible (slope, cut, fill, soil stability) and environmentally sound (does it passes near or through population centers, agricultural land, valleys, habitat reserved, etc.). A student may choose a project that focuses on impact of oil fields and refineries and their impact on air, water, land, and human health.

Students gathered various data to solve the above problems. This include, UAE geological map, soil map, main roads, satellite image (land use), topographic maps (DEM, contour), location of oil fields, location of refineries, pollution status near oil fields and refineries, pipelines network for local distribution and ports.

Some of the students were able to generate oil world map with world satellite image as background and identify countries with high production, countries with high consumption, generate flow maps showing import and export of oil routes, factors affecting on marketing (distance, quality of oil), calculate distance and find estimate for transportation (cost of $/ton/per km) and the effect of transportation means (trucks, rails, pipelines, ships, etc.), investigate relationship between oil consumption and population density, industry, and economy.

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Students had proved their capabilities to carry out a GIS project starting from field survey to presentation (outcome). Results of the projects are presented in a form of models, maps, reports, charts and a database with a custom interface that allows for an easy, step-by-step mapping process. Students who were feeling shy at the beginning of the course were able to talk at the end of the course and express their ideas and this is considered one of the educational outcomes (character and confidence building).

The lesson learned from these projects is that students are able to convince their families to participate in collecting of field data. This has a positive advantage that families (community) are becoming part of the educational process and they know what their daughters/sons are doing. After finalizing the projects, students’ families have seen the products of their daughters and they are very pleased with the knowledge and the skills they have gained.

Problems Related to The Introduction of GIS For Petroleum Course

The problems related to the introduction of GIS for petroleum in the Geography curriculum include a suitable textbook that fits the course, heterogeneity of students register for the course, language constraint, and difficulty in obtaining local petroleum data to train students on it, the need for specialized GIS and subsurface 3D software, and harshness of the petroleum environment.

A suitable textbook

While several GIS texts are in circulation, there are only few that truly stand out, balancing analytical techniques with a sufficient comprehensive treatment of the GIS for petroleum subject area. Efforts are being made to rationale a suitable textbook that can be used in the course, and finally the decision landed on Gaddy [6]. The text covers many topics such map projection, coordinate system, GIS, GPS, remote sensing and some real application examples of well site selection, corridor selection, and marketing. However, some topics covered in the textbook such as map projection are covered in separate courses within the Geography Department and this is a repetition for Geography students. Some topics such as oil formation mapping, geophysical exploration, pipeline route selection, Geo-Database Management System (GDBMS) deserve their own chapters. The textbook is intended for both users and managers involve in all aspects of the business, ranging from geologic exploration to oil sales. It assumes that the reader has no previous background about GIS. Therefore, the textbook satisfies the needs for some students outside Geography and as had been said “there is no one size fits all”. Unfortunately, Penwell stopped printing of this book since 2010 and the reference by Timothy & Jeffrey [12] was used. This reference is a collection of edited papers, outdated, not suitable for undergraduates, and it is now also out of print.

Extensive search online in leading publishers’ web sites such as Amazon, Wiley, Taylor and Francis, and CRC Press resulted in finding no textbook that matches the course learning outcomes (CLOs). All available textbooks found are outdated and not fit very well with the CLOs, therefore, a compilation of an up-to-date material had been prepared from various sources. Existing sources are also utilized [13-16], Geospatial Information and Technology Association (GITA) oil and gas conference proceedings [17], ESRI Petroleum GIS Conferences and other additional web sites (Appendix A).

Heterogeneity of students enroll in the course

Students from other departments and other colleges, for instance, Geology, register for the course as elective. Some of these students have no background about GIS and remote sensing as Geography students. On the other hand Geography students have no background about petroleum operations such as geophysical exploration. This situation needs a balance in delivery of the course putting into account the audience diversity. This result in incompletion of the topics set for the course. Short extra slots for those who have no background about GIS and remote sensing are introduced outside the regular course time.

Language constraint

English is becoming a global language because of the extensive impact of the British Empire during the colonial period and the dominance of the American economy, culture, science, technology, and politics in the contemporary world [18, 19]. It is also true that being competitive in global markets requires that one masters English. Within this move, the College of Humanities and Social Sciences started to use English as the medium of instruction. This has created new challenges for instructors who must teach their discipline in English to Arabic-speaking students.

The author uses various techniques to facilitate students’ comprehension of the content-area of GIS for Petroleum Course. Example of these techniques include: speak in short simple sentences, rephrase the concepts, content, and summarize the main ideas. The point is not to simplify the concept taught, but rather the way it is conveyed. Visual aids such as notes written on the board or shown in multimedia format as well as photos, illustrations, charts, graphs, and maps provide context that helps students understand the linguistic/conceptual input [20]. Motivation of students to participate and express their ideas in English (through questions and answers), brainstorming (mind-mapping), presentations, group discussion, and quizzes are found to be useful in developing the students’ speaking, listening, and writing skills.

Difficulty in obtaining local petroleum data

Training students on local data has a great impact on understanding course concepts and contents. Some relevant digital data (vector, raster; aerial photographs, satellite images, attribute) about UAE are compiled. Great efforts had been made to obtain local UAE petroleum data, but without success due sensitivity issue. Although there is petroleum data available for sale from private organization there is no budget allocated for such activities. Data collection (maps, tables) for a GIS project is time-consuming; therefore, students who register for this course are advised to identify their projects as earlier as possible, so they can work on it during summer or winter vacation. The available UAE petroleum data limits the range of research questions, problem-based, and applications to which students are exposed.
Therefore, data from other parts of the world is utilized although students faced difficulties in field checking.

The need for specialized GIS and subsurface 3D software

Following to the agreement between ESRI and Abu Dhabi Systems and Information Centre (ADSOIC) our students are able to get free ArcGIS licenses. This public–private partnership (PPP) helped us to go ahead with our plan of introducing laptops, so that students can perform their geographical analysis wherever and whenever independent on GIS Labs. The lesson learned from this experience is that cooperation with the public and private organizations leads to a win-win situation. That is to say, students of today are leaders of tomorrow and any software they are familiar with during their study is more likely they will order it when they take positions in the industry. So, it is strategic investment for software vendors to provide free software for students. Another benefit is that in the past, GIS Labs close at 9:00 PM local UAE time and in many cases our students (majority females) would like to work after this time. This is only possible if some faculty/lab assistant is present. Therefore, the use of laptops and free software had alleviated this problem. Almost 80% of the students have laptops either bought by their families or through loan from the University. Specialized software such as those dealing with environmental, geological, and sub-surface analysis (e.g. Environmental Visualization System from C Tech, Earth Science software from Rock Ware, 3D for earth from Golden software), and pipeline software are needed and communication are ongoing on how to attract funding to obtain these software.

Harshness of the petroleum environment

Petroleum operations in UAE are in many cases in harsh environments such as among sand dunes (200m high) and offshore. Both situations represent a problem for our students putting into account around 70% of them are females. In addition to this, the high risk from the frequent spread of the Hydrogen Sulphide (H₂S) gas in oil fields makes our students feel reluctant to do their internship or even join the oil field in the future. This gas is colorless, toxic, and flammable. Although of safety precautions (sensors, training in dealing with the gas) and efforts to reduce fatalities from other petroleum hazards, still the petroleum field is considered among high risk fields in comparison to teaching and other office jobs. Discussion with Abu Dhabi Company for Onshore oil operations (ADCO) revealed that there are plans to prepare a suitable working environment for females. This includes arranging shuttle bus between oil fields and offices and assigning office works for females.

Recommendations

From visits to companies that worked in the petroleum industry in UAE such as ADCO and Abu Dhabi Marine Operating Company (ADMA-OPCO), discussion with staff there (user needs/requirements), and the experience of the author, the following recommendations are made:

a. The need for inclusion of a course dealing with surveying engineering and training students on determination of elevation, measurement of angles and distances using levels, theodolites, and total stations.

b. Allocation of more slots within the course or in a separate course to GNSS theories and applications in oil industry.

c. Market demands students with technical background [21] therefore, mathematics and computer science should be integrated with university-based courses. Often, technical competence leads to creative spatial thinking which is essential to succeed at the graduate level and beyond.

d. The current program’s structure requires 120 credit hours for graduation with only 39 of them (32% of the courses) are allocated for geographic courses. Other 68% of the credit hours are for university, college and elective requirements. Although non-geography courses opened and widened students’ understanding, it is recommended to allocate more credit hours to the specialty.

e. It is necessary to provide some sort of monthly meetings that allow undergraduate and graduate students and faculty to mix and mingle to encourage pedagogy and research (e.g. with Master of Remote Sensing and GIS students).

f. Students are encouraged to collect their own data, search on the web for free available data, and explore geo-spatial innovation tools such as Google Earth, Microsoft Virtual Earth, and Geography Network, USGS, and Global Land Cover Facility at the University of Maryland.

g. Include CAD training as part of GIS Lab as many petroleum companies used it extensively.

h. Maximize utilization of available resources in the university, especially, during semester breaks for running “English plus content” courses and encourage more English-medium extra-curricular activities and societies.

Conclusion

The study provides a UAE perspective on teaching GIS for Petroleum course and may be useful and interesting to other departments around the globe. In general, the course provides students with a blend of theoretical and practical background about application of geo-spatial analysis in the petroleum operations. This includes integration of remote sensing, aerial photographs, GNSS, and GIS in the frame of exploration, production, marketing and environmental impact of oil. Key learning objectives such as critical thinking, self-learning, creativity, analysis, and developing IT skills are incorporated in the body of the course. The majority of literature in GIS for petroleum field (references, journals, web sites) and software is in English and this represent a barrier to our students, the process is made easier through extensive illustrations (maps, figures, satellite images, equations, numeric example, video clips) and providing real examples that are familiar to the students, keep in mind “One image expresses thousands of words”. Although there are divergence and convergence in opinions regarding teaching any GIS course or related one [22], the general consensus is that adequate facilities should be available. This includes dedicated human resources, interactive students (brainware), hardware, software, textbook and reference material in the library, fast speed connection to the internet, and local data. The success of the GIS for petroleum course is evident from the number of Geography graduates who joined oil industry in UAE.
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(more than 50) and hence the overall objective of the course is met (new job opportunities for geography graduates).

Appendix A: Examples of GIS for Petroleum Web Sites

iii. ESRI Petroleum: http://www.esri.com/industries/petroleum
v. Federation of American Scientists: http://www.earthsensing.com
vi. Free GIS software: http://www.freegis.org
vii. GIS Café: http://www.giscafe.com
viii. GITA: http://www.gita.org
ix. Global Land Cover Facility at the University of Maryland for satellite data: http://glcf.umd.edu/data/
xi. Oil and Gas Journal-Research Center: http://www.ogj.com
xii. GPO: www.gpo.gov
xiii. Petro skills: https://www.petroskills.com/course/arcgis-essentials-for-petroleum-gise
xiv. Remote sensing aid hyperspectral detection efforts: http://www.pobonline.com
xvi. Software: RockWare- Earth Science software: http://www.rockware.com
xviii. Software: Environmental Visualization System (EVS) from C Tech: www.ctech.com

Acknowledgment

None.

Conflict of Interest

None.

References

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