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Teaching GIS in the College of Computer and Information Science

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Abstract: *Technologies are proliferating and academic disciplines are more transdisciplinary oriented. It is almost unattainable to claim that a technology is solely owned by a discipline or an academic college. Do we bring computers to geography or vise versa? In this paper, the author claims the last. The experience of teaching GIS in the school of computer and information science is reported. Also a brief description of the curriculum used is shared. Moreover, the results of survey conducted over GIS students is discussed. Hurdles in teaching GIS are also addressed. Overall, the feedback (from students and school administrators) has been positive. Although in this school the GIS course is an elective, the demand for it has been always high since it was introduced.*

Keywords—GIS; Information Systems; Computer Science; Technology Curriculum**.**

1. INTRODUCTION

Geographic Information Systems (GIS) are computer programs that handle spatial (data associated with an address or a coordinate) and non-spatial data and enable storing, modifying, processing, visualizing and sharing these data [1]. GIS is mostly acquainted with map design although the technology can do much more than that. Layering data over a map to analyze a situation adds critical problem solving to students such as multidimensional thinking, categorizing, interpreting, inferring and pattern detection [2].

GIS is mostly taught under the geography department in the school of Arts [3]. It is also found heavily on the school of architecture and planning particularly in the departments of architecture, building sciences and urban planning. GIS is found also in the school of engineering particularly in the department of civil and environmental engineering [4]. GIS courses would also be found in the colleges of science, agriculture, medicine and politics [5].

There have been attempts by geography departments worldwide to bring computer programming skills to their educational program [6][7]. There is no denying of the shift from paper (printed maps) to digital records (electronic maps) [8]. It is clear that GIS is used substantially more than just for map creation, thus currently GIS is integrated with other IT systems to bring value. There is no denying of the shift from paper (printed maps) to digital records (electronic maps). This integration means data transfer via APIs, live feed, preprocessing data, hosting and on the fly cloud configuration of possibly virtual machines (to conduct a data intensive analysis), occasionally writing codes for a specifics GIS task and data scraping. These tasks require computer programming skills. This begs the question, do we bring computers to geography or vise versa? Should computer science students take a GIS course in the geography department or in their own school? Or should it be the other way around where geography students take a course or more in the computer science school (assuming there is one in their university)? I will not try to answer the last question as it is outside my specialization but in the remaining part I will try to argue for the benefit of bringing geography to the computer science college.

2. GIS IN CCIS

King Saud University (KSU) is the first public university founded in 1957 at Riyadh city the capital of Saudi Arabia [9]. The university has about 22 colleges that offer various graduate and undergraduate degrees and about 40,000 students are enrolled in it at any given year [9]. The College of Computer and Information Sciences (CCIS) in KSU was established in 1984 [10] and it includes the departments of computer science, information systems, computer engineering, software engineering and information technology which offer undergrade and graduate degrees for male and female students. The experience shared here pertains to only the information systems department. Beyond the preparatory year, the bachelor degree in information systems at CCIS contains almost 14 core courses in computers (programming, IS fundamentals, databases, analysis and design, data structure, modern application development, project management, mathematical modeling, networks, operating systems, electronic commerce, security and ERP) [11]. Students can choose from a wide selection of elective courses that includes semi-structured data, database lab, data warehousing, IS engineering, enterprise architecture, simulation, data mining, decision support systems, data science, e-health, advanced networks, business process management, human computer interaction, ERP lab, cloud computing, selected topics and GIS [11]. Since its inception, CCIS has never taught the GIS course prior to 2019 due to lack of faculty able to teach it. This paper reports the

experience of teaching the GIS course from 2019 to 2022 to information systems students.

The emphasis of the GIS course taught was on the technology rather than the geographic concepts. It was based partially on the geographic information science and systems book [12]. The course learning outcomes were to "1) describe the basic concepts, components, applications and advantages of GIS 2) distinguish between the different data models of GIS 3) load, process, analyze and visualize data on a GIS software 4) learn to think spatially, analytically, and critically about challenging problems 5) discuss and demonstrate fundamental cartographic concepts and principles 6) develop a GIS solution/analysis as a group project". The student learning outcomes were to "1) analyze a complex computing problem and to apply principles of computing and other relevant disciplines to identify solutions 2) design, implement, and evaluate a computing-based solution to meet a given set of computing requirements in the context of the program's discipline 3) function effectively as a member or leader of a team engaged in activities appropriate to the program's discipline". It was a 4 hour credit course, 2 for lectures and two hours for practical training. The final and midterm exam accounted for 65% of the grade, 15% for course project, 10% for lab assignments and 10% for homework (for some semesters it was replaced with obtaining 4 ESRI web courses certificates which are found in https://www.esri.com/training/catalog/search/).

The curriculum of the course begins with an overview of GIS (concepts and definitions, history, data layering, GIS components, GIS capabilities and applications, GIS users and vendors). Then students are introduced to GIS data models (raster and vector) along with some geography concepts (coordinate systems, measurement and projection, topology and scale). Also students are introduced with the first type of spatial analysis which is visual analysis. Later one, vector and raster data analysis methods are introduced which occupies majority of the course work. After that, spatial data quality is discussed. Remote sensing and aerial photogrammetry are later introduced. After that spatial databases are presented. At the end of the course an attempt is made to link GIS with IS through discussing issue of management and that it is not much different than managing other IT systems or projects. The course concludes with a look to the future of GIS where relevant technologies (IOT, dashboards, real time and big data, geospatial artificial intelligence, sports analytics, smart cities, health wearables, indoor navigation, data visualization, VR and AR) are positioned with GIS.

The course project requires students to work in groups mostly on spatial analysis applications. The project is delivered in 3 phase. In the first students are asked to find a problem/need locally where GIS could used to solve it. Next, students are required to gather required data by an means necessary (obtaining it directly from individual or organizations as files, manually recording data using GPS or scrapping it from the internet).Finally students are required to clean the data, conduct the analysis and present the findings in a report or as a poster.

For the practical training or lab, an open source GIS tool was used. Mainly because it is free of cost and secondly it works with windows and mac operating systems. At least half of the lab sessions utilized the tool's training manual which fit perfectly with the course content. For the second half of the lab various functions were practiced such as interpolation, automating workflow, 3D maps, timeseries, hotspot analysis, working with plugins and density mapping.

3. FEEDBACK ABOUT THE COURSE

Student feedback has for the most part been positive. They continue to show interest, register for the course although it is an elective and request it if it is not offered that semester. The course ran 8 times from 2019 to 2022 with a total of 246 student. The number of students in a section increased from just 15 in 2019 to 39 in 2022. Only 2 students have ever failed the course. The average grade is a B+. Table 1 shows the student evaluation of 2019 section performed as a requirement from KSU for every student to fill before receiving his/her grade. If we examine course goals and outcomes section, roughly 80% confirm attaining them.

Table 1. Course satisfaction survey for 2019 section.

Seq.	Assessment Items	Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree	
		Count	%	Count	%	Count	%	Count	%	Count	%
1-1	Course Objectives are stated at the beginning of the term	1	5.0	1	5.0	4	22.5	13	60.0	11	34.4
1-2	Course Objectives are achieved at the end of the term	1	5.0	1	5.0	4	22.5	16	50	10	31.3
1-3	Course Objectives bring about the intended improvements	1	5.0	1	5.0	4	22.5	13	60.0	11	34.4
1-4	Highlight circle number three	0	0	0	0	28	87.5	2	6.3	2	6.3
2-1	The actual learning tasks/assignments meet the Course Objectives	1	5.0	1	5.0	6	18.8	13	40.6	11	34.4
2-2	The amount of work I am expected to do to achieve the Course Objectives	1	5.0	0	0	6	18.8	13	40.6	12	37.5
2-3	The time allocated to complete a learning task/assignment is suitable for the amount of work done	1	5.0	0	0	5	15.6	14	43.8	12	37.5
3-1	I can plan my learning tasks/assignments according to my work pace	1	5.0	1	5.0	5	15.6	13	40.6	12	37.5
3-2	I can solve my problems related to my learning tasks/assignments	1	5.0	0	0	5	15.6	13	40.6	13	34.4
4-1	Learning Environment facilitates in completing learning activities.	1	5.0	2	6.3	4	12.5	13	40.6	10	31.3
4-2	I enjoy learning together with my friends in this course	1	5.0	0	0	7	21.9	13	40.6	11	34.4
4-3	I am satisfied with the overall learning resources (e.g. course materials, books, learning aids) provided to support my learning activities	1	5.0	1	5.0	6	18.8	14	43.8	10	31.3
5-1	Course Instructor has knowledge of the course contents	1	5.0	2	6.3	3	9.4	14	43.8	12	37.5
5-2	Course Instructor has skills in communicating across difficult topics in an easy to understand manner	1	5.0	1	5.0	4	12.5	13	40.6	13	34.4
5-3	Course Instructor uses most recent development in the area in his/her course.	1	5.0	2	6.3	2	6.3	13	40.6	12	37.5
5-4	Course Instructor encourages to explore the content of the course beyond what is required of the text books requirements	1	5.0	1	5.0	2	6.3	14	43.8	12	37.5
5-5	Course Instructor treat students with respect, even when there are differences of opinion	1	5.0	2	6.3	2	6.3	16	50	11	34.4
6-1	Different variety of assessment was employed in the course	1	5.0	1	5.0	5	15.6	13	40.6	12	37.5
6-2	Grades assigned is based on my performance in the course	1	5.0	1	5.0	4	12.5	14	43.8	12	37.5
7-1	Course outcomes are accomplished at the end of the course	1	5.0	1	5.0	4	12.5	14	43.8	12	37.5
7-2	Now I have understanding of basic knowledge required of this course	1	5.0	1	5.0	4	12.5	13	40.6	11	34.4
7-3	I have ability to apply the knowledge gained from the course	1	5.0	1	5.0	5	15.6	13	40.6	12	37.5
7-4	I have ability to formulate solutions to a problem	1	5.0	1	5.0	4	12.5	14	43.8	12	37.5
7-5	The course has developed my analytical skills.	1	5.0	1	5.0	5	15.6	13	40.6	12	37.5
7-6	The course has developed my critical thinking skills	1	5.0	1	5.0	5	15.6	14	43.8	11	34.4
7-7	The course has developed my communications skills	1	5.0	1	5.0	5	15.6	13	40.6	12	37.5
7-8	The course has developed my skill to work in a Team.	1	5.0	2	6.3	6	18.8	12	37.5	11	34.4
7-9	Highlight circle number two	0	0	21	65.6	2	6.3	5	15.6	4	12.5
8-1	I get new knowledge that contributes to my overall development	1	5.0	1	5.0	6	18.8	13	40.6	11	34.4
8-2	I get new skills that contributes to my overall development	2	6.3	1	5.0	5	15.6	13	40.6	11	34.4

It seems information system students are able to grasp and pass the GIS course. Another source of evaluation is the instructor survey performed as an indirect assessment of the 6 course learning outcomes discussed earlier. Responses of the 2022 section is reported in Figure 1.

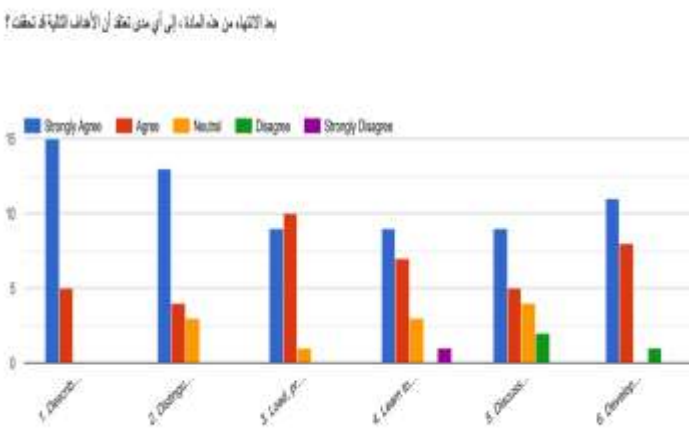

Figure 1. Student responses to CLO survey for 2022 section.

If we combine strongly agree with agree, then roughly 75% (about 15 of 20 students who have filled this survey) of students concur that the course goals have been attained. Students are passing the course and majority of them are satisfied with it which indicates that it is an appropriate addition at least to information system students.

4. Conclusion

Generally in the schools of computer science systems such as ERP,CRM, BPM and DBMS are presented so why not also present GIS to the students? GIS is multipurpose system that could be used by a variety of users but it will be up to the graduates of computer science (whom mostly will end up in the IT department) to maintain such systems. It only makes sense to educate them about the capabilities of such systems early on.

Beyond KSU, the author in [13] reports on a broader survey conducted over GIS students and practitioners in Saudi Arabia. In [13], 50% of students report that they have studied more than 5 GIS courses which speaks to the spread of GIS teaching in Saudi Arabia. In [13] computer programming and business skills are found to be lacking GIS students. About 67% state the difficulty of finding locally qualified GIS graduates to fill open jobs and 55% of respondents classify GIS graduates (or students) as underqualified. Introducing GIS in the computer college seems to be a step towards filling this gap.

Teaching GIS in CCIS hasn't been without hurdles. The open-source GIS package sometimes crashes which require rework by the student or at other times doesn't run a specific function/plug-in which requires debugging. Proprietary software behaves more in a consistent way. A more series problem is lack of local spatial data as students suffer to find suitable data and organizations more often refuse to share their spatial data. In [13] about 68% of respondents also state difficulty in obtaining local GIS data from the public or private sector. This diminishes students enthusiasm as they prefer to work on local data because the context can be explained easily.

It should be noted that student surveys can't be trusted completely as they sometimes reflect their grade more than content, evaluating instructor instead of the course, evaluating too positively as a fear from getting low grades or filling them randomly.

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