Towards a Modern Surveying Engineering Curriculum: Case presented is Surveying Engineering Program at King Saud University

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Key words: Surveying Engineering, Geomatics, Education, Curriculum, Mapping,

ABSTRACT

Surveying or geomatics is the science of measuring and mapping the face of the earth. A surveying engineer is responsible for the collection, representation, analysis, management and modelling of spatial data. The science includes positioning of natural and man-made features, developing control point network, compiling three dimensional digital terrain models, marking property boundaries and relocating them, controlling and monitoring infrastructure: roads, bridges, tunnels, dams and structures and mapping seabed and coastlines.

Advances in technologies (electronics, satellites and laser) have changed the nature of surveying.

To achieve these learning outcomes a curriculum for a baccalaureus degree at King Saud University, Riyadh, Saudi Arabia, has passed several improvements since its first initiation in the late 1980s to serve all gulf countries.

This paper outlines the important aspects of the program history and the latest version that has been accredited by National Saudi Accreditation Association (NSAAA) for the period 2016-2920.

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6.1. INTRODUCTION

Geomatics or Surveying Engineering is the science and technology of measuring, gathering, analyzing, interpreting, distributing, and using geospatial information. It includes the following fields of specialties: land surveying, aerial surveying (photogrammetry), remote sensing (RS), Geographic Information Systems (GIS) and Global Positioning System (GPS).

The term surveying is understood as the science of measurement and mapping of land. It includes property valuation, quantity surveying, construction surveying, minerals surveying, agricultural surveying, hydrographic surveying and cadastral surveying.

Geomatics includes surveying as defined above together with more modern techniques of data collection and processing such as remote sensing, GIS and GPS which have been introduced and developed to enhance both speed and quantity of collected data is a rapidly growing industry worldwide with applications and career opportunities in areas as diverse as business and retail location analysis, conservation and resource management, disaster management and emergency preparedness, and planning and utilities management, (for more discussion about the name see Ipbuker, 2010 and Konecny 2002).

Geomatics Engineering or Surveying Engineering is an applied science and a professional discipline. As an applied science it involves an integrated approach to the measurement, analysis, management, and display of geospatial data. As a professional discipline, geomatics or surveying engineers have specialist skills, knowledge, and understanding in order to provide services that meet the needs of society and which contribute to social and political stability, quality of life and the management of natural heritage and resources.

Advanced computer software and techniques are applied to help in understanding the Earth's physical and natural systems, addressing environmental problems and planning human interventions.

The areas in which the knowledge and technology of Surveying Engineering are today applied include: precise determination of the figure of the Earth and of other planets as well, measurement and determination of the dynamics of earth's crust and earth gravity field, precise positioning on or near earth's surface using both terrestrial, aerial and satellite techniques, measurement and mapping of topography, setting out engineering construction,

monitoring of large engineering structures, design and development of software and data bases for geospatial analysis, production of sea charts, to mention some.

The graduate in the modernized discipline of surveying engineering today finds employment in any area of business dealing with determination of location, and spatial analysis. Numerous papers and reports discussing geomatics or surveying engineering education and experiences in worldwide institutions have been published over the last two decades (Enmark, 2002; Konecny, 2002; Ruther, H. 2003; Watson and Davis, 2003;Duncan, 2004; Semalai and Tahiri, 2005; Qing, 2006; Bhattarai, 2009; Shultz, 2009; Wulf, et al, 2011; Poerbandono et al, 2014; Wegen, 2016). This paper, however, is an attempt to explore the surveying engineering program (SEP) in King Saud University (KSU), Kingdom of Saudi Arabia (KSA), its importance, curriculum development and features.

6.2. HISTORY AND IMPORTANCE OF SEP

King Saud University was established in 1957 in Riyadh, capital of Saudi Arabia, with a campus area of 9 km^2.

The high boom in the Kingdom economy during the last three decades due to the high demand and hence prices of oil led to tremendous infra structure activities. This of course needs the solid ground to be built upon. The main source for this solid ground is the technology of surveying engineering which produce the base maps, help in construction and in monitoring the infra structure in general.

Surveying Engineering has wide practical applications in Saudi Arabia particularly those concerned with engineering projects in all stages. With the advent of satellite and computer technology, the role of the surveying engineer has expanded to encompass use of digital satellite data for a multitude of applications through digital image processing e.g. environmental monitoring, water resources surveys, population studies, image mapping, agricultural, forestation and desertification studies, mapping vegetation cover, urban planning and development, use of artificial intelligence systems, to mention a few.

SEP at KSU was initiated in 1987 under the administration of Civil Engineering Department within the College of Engineering.

It is currently under the chairmanship of the Head of the Civil Engineering Department and the Program Coordinator. The SEP prepares students for careers in geospatial sciences including land, cadastral, and construction surveying, geodesy, satellite positioning and navigation, remote sensing, photogrammetric mapping and land/geographic information systems. The SEP was initiated within the Civil Engineering Department as the unique program of its kind in the GCC universities in response to a request from the High Ministers of Defense of the GCC countries. The purpose was to serve all GCC countries through qualifying surveying engineers with B.Sc. degree.

6.3. SEP MISSION AND OBJECTIVES

The vision of KSU is to maintain the highest standards of academics and research, and to maintain an open, ethical and caring community that promotes honesty, integrity, respect, fairness, trust, civility and diversity. King Saud University values quality and excellence, leadership and teamwork, freedom of inquiry, fairness and integrity transparency and accountability and lifelong learning. King Saud University educational culture emphasizes intellectual vitality, academic freedom and the extension of its services and prosperity to benefit the local, national and global communities.

SE Program Mission is to attain excellence in quality and sustainability of surveying engineering industry, to provide the society with highly qualified engineers to meet the challenges of surveying engineering industry in the 21st century and to serve the society through involvement in knowledge sharing outreach and professional activities that include innovative research, developing new technologies, and continuing education and professional development.

The main objective of the SEP is to offer an integrated and comprehensive B.Sc. (Surveying Engineering) curriculum to meet the demands of development in the Kingdom of Saudi Arabia and other states of the region and to serve the community.

The SEP objectives include the training and production not only of professional Surveying Engineers registerable by the Engineers Council of Kingdom of Saudi Arabia (ECKSA), but also of Geodesists, Hydrographers, Cartographers, as well as Photogrammetrists, Remote Sensing and GIS experts, Database Analysts, Land Managers and Administrators. These professionals are required by numerous local, national and international governmental and non-governmental organizations (NGO) and agencies involved in land, ocean and space administration research including studies on population, transportation, telecommunication, navigation, etc. The SEP twelve "Learning Outcomes" are shown in Table 1 below. Eleven of which satisfy the Accreditation Board for Engineering and Technology *(*ABET) requirements.

Table 1: Program Learning Outcomes

	SEP Learning Outcomes
1	- List and describe various surveying engineering systems and techniques for collecting geospatial data. [SEP Criteria]
2	- Recognize and outline contemporary issues. [ABET j]
3	- Apply knowledge of mathematics, science and engineering in appraising SE concepts and solving SE problems. [ABET a]

4	- Design and conduct experiments using modern SE technology and software skills as well as analyze and interpret data. [ABET b]
5	- Design and plan SE projects to meet desired needs with constraints such as economic, environmental, ethical and safety. [ABET c]
6	Identify, formulate and solve SE problems. [ABET e]
7	- Appraise and show professional ethical responsibilities. [ABET f]
8	- Demonstrate ability to work in teams [ABET d]
9	- Show ability to engage in life-long learning. [ABET i]
10	- Gain broad education to understand the impact of engineering solutions in a global, economic, and social context for serving the society. [ABET h]
11	- Operate modern SE instruments, develop and use software in survey data collection, processing and analysis. [ABET k]
12	- Illustrate professional ideas clearly by writing technical report and giving oral presentation. [ABET g]

[ABET] satisfies ABET requirement

6.4. SEP GRADUATION REQUIREMENTS

To complete the graduation requirements for a B.Sc. in Surveying Engineering, the student is required to successfully pass a total of 165 credit hours. These hours are divided into (Table 2):

32 credit hours of the common first year (Table 3)

8 credit hours of University requirements (Courses on Islamic studies including Islamic Ethics for Engineers).

51 credit hours of College requirements of which 40 credit hours are compulsory courses for all engineering programs (Table 4.a) plus 11 credit hours of complementary courses for SEP including a 2-hours free course (Table 4.b). These include basic science courses: Mathematics, Physics, Chemistry, Statistics, Statistics and computing science.

73 credit hours of program requirements of which 46 credit hours are core courses (Table 4), 4 credit hours of graduation project, 17 credit hours of courses from other programs and 6 credit hours are program electives which can be selected from the list of elective courses in (Table 5). A program research project course without credit hours can be taken by the student to improve his research skills.

Table 2: B.Sc. Degree Requirements in SEP

Requirements	Cr. Hr. (CH)	Description
Common First Year	32	General Chemistry (4) Differential Calculus (3) Statistics (3) English (12) Writing Skills (2) University Skills (3) IT Skills (3) Entrepreneurship (1) Health and Fitness (1)
University	8	Islamic Studies: Compulsory (2) Complementary (6)
College	51	Common (40) Complementary (6) free course (2)
Department	73	Core (49) Projects (4) SE Electives (6) Courses from other Programs (17) Research Project (0, NP)
	1 (NP)	Practical training
Total	165	

Table 3: First University Common Year (32 hours)

Course Code	Course Title	Cr. Hr.
ENGS 100	English language	6
MATH 101	Differential Calculus	3
ENT 101	Entrepreneurship	1
CHEM 101	General Chemistry	4
ARAB 101	Writing Skills	2
Total		16

Course Code	Course Title	Cr. Hr.
ENGS 110	English	6
CI 101	University Skills	3
CT 101	IT skills	3
STAT 101	Introduction to Statistics	3
CHS 101	Health & fitness	1
Total		16

Table 4: College Requirements for SEP (51 hours)

Table 4.a. College Requirements for all Engineering Programs (40 hours)

Course Code	Course Title	Cr. hr. (X,Y,L)	Pre-requisites
MATH 106	Integral Calculus	3 (3,2,0)	MATH 101
MATH 107	Vectors and Matrices	3 (3,2,0)	MATH 101
MATH 203	Calculus for Engineering Students	3 (3,2,0)	MATH 106; MATH 107
MATH 204	Differential Equations	3 (3,2,0)	MATH 203
PHYS 103	General Physics (1)	4 (3,0,2)	
PHYS 104	General Physics (2)	4 (3,0,2)	
ENGL 109	Communication Skills	2 (2,1,0)	
ENGL 110	Technical Writing	2 (2,1,0)	ENGL 109
GE 201	Statics	3 (3,1,0)	MATH 106; MATH 107

GE 104	Basics of Engineering Drawing	3 (2,0,2)	
GE 106	Introduction to Engineering Design	3 (2,1,2)	GE 104
GE 203	Engineering and Environment	2 (2,0,0)	CHEM 101; MATH 101
GE 402	Project Management	3 (3,1,0)	
GE 403	Engineering Economy	2 (2,1,0)	
Total		40	

(X,Y,L) X = Lectures; Y = Tutorials; L = Lab. NP=No grade (Pass or Fail)

Table 4.b. College Complementary Courses for SEP (11 hours)

Course Code	Course Title	Cr. hr. (X,Y,L)	Pre-requisites
GE 209	Computer Programming	3 (2,0,2)	
MATH 254	Numerical Methods	3 (3,2,0)	GE 209, MATH 107
GE 202	Dynamics	3(3,1,0)	GE 201
XXXX	Free Course	2	
Total		11	

6.5. SEP CURRICULUM STRUCTURE

On account of the growing significance of Geomatics technology in different sectors, it is essential for SEP to design appropriate curriculum of B.Sc. Surveying Engineering program as per fast growing technological innovations in engineering sector, national needs, and international standards. Rapid advancement in computer science, information technology and instrumentation has brought about dramatic improvement and change in the methods of surveying and mapping.

As mentioned above SEP requirements are 73 hours, of which 46 hours are core courses given in Table 5.

Table 5: SEP Core Courses

Code & Number	Course Title	Cr. Hr. (X,Y,L)	Pre-requisites
	Land and Geodetic Surveying Group		
SE 212	Spatial Measurements	3(2,1,2)	MATH 107
SE 312	Introduction to Geomatics Engineering.	3(2,1,2)	SE 212
SE 314	Geodesy	4(3,0,2)	SE 212
SE 315	Map Projections	3(2,1,2)	SE 313
SE 413	Satellite Geodesy & Geopositioning	3(2,1,2)	SE 313
	Photogrammetry and Remote Sensing Group		
SE 321	Photogrammetry	3(2,0,2)	SE 212
SE 422	Advanced Photogrammetry	3(2,0,2)	SE 321 SE 331
SE 365	Principles of Remote Sensing & Image Interpretation	3(2,0,2)	SE 321
SE 464	Introduction to Digital Photogrammetry	2(2,1,0)	SE 422
SE 423	Digital Image Processing	3(2,1,2)	SE 365
	Cartography and GIS Group		

SE 453	Cartography and Geographic Information Systems	3(2,0,2)	SE 315
SE 466	Spatial Analysis in Geographic Information Systems	4(3,0,2)	SE 423 SE 453
	Common Courses		
SE 471	Survey Camp	3(2,0,2)	SE 413
SE 473	Professional & Legal Aspects of Surveying	3(2,0,2)	SE 315
SE 331	Adjustment Computations	3(2,0,2)	SE 312 STAT 101
SE 999	Practical Training	1^{NP}	Completion of 110 credit hrs.
Total		46	

SEP core courses can be categorized into three groups with the following credit hours (CH):

Land Surveying and Geodesy (S & G) = 16 CH

Photogrammetry and Remote Sensing (P & RS) = 14 CH

Cartography, Map Projection and GIS (CMGIS) = 7 CH

Common courses (related to the three groups above) = 9 CH

These are shown graphically as in Figure 1.

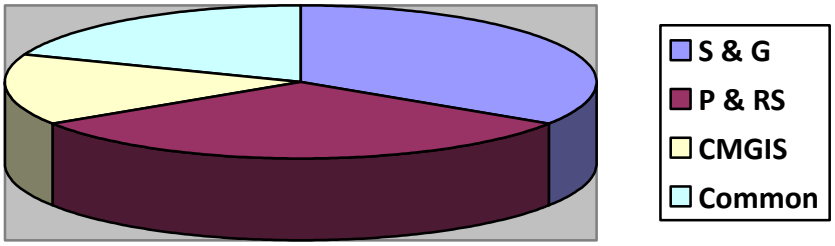

Figure 1: Distribution of Core Courses

This distribution of core courses allows the student to get good background of the different geomatics disciplines and open the way for him to work in different sectors of surveying engineering.

Students should also pass 17 credit hours of helping courses from other engineering programs given in Table 6.

Table 6: Courses from Other Engineering Programs (17 hours)

Code & Number	Course Title	Cr. Hr. (X,Y,L)	Pre-Requisites
CE 302	Mechanics of. Materials	3(3,1,0)	GE 201
GEO 281	Geology for Engineers	2(2,1,0)	
CE 323	Water Engineering for Surveying Students	3(3,1,0)	GE 202
CE 334	Highway Engineering for Surveying Students	3(3,1,0)	SE 312 STA 101

CE 363	Basics of Concrete Structures for Surveying Students	3(3,1,0)	CE 302
EE 329	Signal analysis for Surveying Students	3(3,1,0)	
Total		17	

Students are given opportunity to select 6 credit hours (2 courses) from a list of 10 courses (Table 7), designed and delivered by the program (4 courses) or by other departments (6 courses).

Table 7: Elective Courses

(Each student is required to take 6 cr. hr. from the following list of SE elective courses)

Course Code	Course Title	Cr. Hr. (X,Y,L)	Pre-requisites
	Courses from SEP		
SE 418	Hydrographic Surveying	3(3,1,0)	SE 312
SE 467	Web GIS	3(3,1,0)	SE 453
SE 419	Advanced Geodesy	3(3,1,0)	SE 315
SE 431	Computer Applications in Surveying Engineering	3(2,0,2)	GE 209 SE 331
	Courses from other Departments		
GEO 301	Geomorphology	3(2,0,2)	GEO 101 or GEO 281
PL442	Urban Strategic Planning	3(3,1,0)	-
CE 411	Introduction to Construction Contracts	3(3,1,0)	Successful completion of 110 Cr. Hrs.
CE 412	Estimating Construction Cost	3(3,1,0)	Successful completion of 110 Cr. Hrs..-

6.6. SENIOR DESIGN PROJECT REQUIREMENTS AND EVALUATION

The design project is divided into two parts (2 credit hours each). The student is eligible to register for Graduation Project-1 if he completes successfully at least 129 credit hours including common first year (or 97 credit hours excluding the common first year). Graduation Project -2 can be taken during the first and second semesters only (not during summer semester). The projects are recommended to be team work including data collection either from field observation, running instruments or from governmental departments or private sectors working in a related field, in addition to data processing by developing or using existing computer programs. A panel of two supervisors and an examiner attend a presentation by the students. They evaluate the presentation, answering oral questions and the presented thesis.

6.1. Practical Training Requirements

Students in the program are required to complete 10 weeks of practical training in an area related to Surveying Engineering. Prior to undertaking the practical training program, the student must obtain the approval of the department and he must have completed, successfully, at least 110 credit hours including preparatory year (or 79 credit hours excluding preparatory year). Students enrolling in the practical training program are not allowed to take simultaneously any course or project. Procedure for assisting students for finding a place for practical training and assessment are outlined below:

Local companies are contacted by Vice Dean of the College for academic affairs to enquire about the possibilities of training the department students and the number of students that can be accepted.

Replies from companies are kept in the electronic system of the college.

All available training opportunities are sent to the department, and announced by the department for students.

Student fill-in a form for the practical training and submit it to the department practical-training committee showing his choice of companies.

Vice Dean officially contacts the companies and secures the placement of students.

Student must get the training for the period of 10 weeks and submit weekly reports to the convener of the department committee for practical training.

Company reports a confidential assessment of the student performance to the department.

Department allocates the grade of the training as pass or fail based on the company evaluation and the student’s weekly reports.

Although the practical training is non-credited, it is required to satisfy the undergraduate degrees requirements.

6.2. Human Resources Development

As noted above College of Engineering provides basic common courses (51 hours) for the first year students in all engineering programs. Basic or core Surveying Engineering courses start from second year and specialized technical courses start from third and fourth year.

SEP have capable faculties with high academic qualifications and professional experience as well in fields of land surveying, geodesy, satellite positioning, photogrammetry, remote sensing and GIS.

The university Quality and Development Deanship offers regular seminars and lectures about developing teaching skills and strategies. Although this is intended for new faculty all other faculty can attend and benefit from that.

The program is in short of technicians to help in running and demonstrating surveying instruments and software for the students. The program faculty raised the matter to the university authorities and that would be solved in the very near future.

6.3. Instrumentation and Laboratories

An important tool for running an efficient surveying engineering program is the instrumentation and the laboratory facilities.

SEP has well equipped labs with electronic total stations, GPS, computers hardware and software. Lately a photogrammetric working station has been purchased and installed. All these facilities are now made use of to train students and carry out research.

6.4. Assessment

In KSU semester system was applied along with continuous evaluation of student through number of assignments and quizzes; division of marks were 60% for continuous evaluation including lab work evaluation, home works, mid-term tests and other assignments such as programming or essays and 40% for final exams. Teachers are responsible for all the evaluation system.

6.5. Requirement of Post Graduate Degree in Surveying Engineering

SEP Self Study Report (SSR) (2015) states: “Sustainability of Bachelor Program requires strong faculty, research environment, and infrastructure. All these requirements are available within the SEP. Furthermore, sustainability of the B.Sc. Program is only possible through establishment of higher academic environment with M. Sc. and Ph. D. programs.

SEP faculty group has already set forth a proposal for M. Sc. Degree in Surveying Engineering. This is expected to be approved and started in the very near future".

7. CONCLUSIONS

Following are some comments of NCAAA external reviewers who visited KSU and were in touch with the staff, employers, alumni and students. They have looked through the program academic plan and visited program laboratories. "As to technical and scientific content, the program provides solid theoretical background and practical skills in traditional land surveying and GNSS. Employers and alumni are satisfied with this aspect of the program."

SEP student assessment mechanisms include grading of class attendance and performance in theoretical and practical aspects of regular courses. Assessment methods include home- work, examinations, and lab reports. Grading policies, weights and assignment due schedule are clearly articulated in course specifications, and made available to students at the beginning of each semester. KSU provides workshops for faculty in teaching and learning methods, including student assessments.

Field experience in traditional land surveying appears to be very good. This is evidenced by the survey camp, SE 472, is a "field-to-finish" project and so students consolidate technical skills and knowledge and develop project management and teamwork and interpersonal skills. Students also do two months internship in industry before they graduate. The benefit of the experience is supported by departmental documentation and discussions with current students and alumni.

Since Surveying Engineering, as a discipline involves rapidly growing and changing technologies, the curriculum requires frequent evaluation, restructuring and upgrading. Henceforth, the process of finalization of curriculum will involve organization of workshop encouraging participation of all the users, faculties and professionals.

While designing the courses for Surveying Engineering education, course structure and the contents should be prepared in accordance with Surveying or Geomatics Engineering programs of different universities in order to maintain the international standards.

Introduction of computer programming in all the units of the courses constitutes one of the most important aspects of the Surveying Engineering.

REFERENCES

Bhattarai, N. 2009. Geomatics Engineering Education in Kathmandu University: Issues and Challenges". 7th FIG Regional Conference. Hanoi, Vietnam, 19-22 October 2009.

Duncan, E. E. 2004. "Geomatics Education in Ghana". FIG Working Week 2004. Athens, Greece, May 22-27, 2004.

Enmark, S., 2002. “Innovation in Surveying Education”. Global Journal of Engineering Education, Vol. 8 No. 2.

Ipbuker, C. 2010. “ The Reason of Changing The Name to “Geomatics” , FIG Congress 2010 Facing the Challenges – Building the Capacity Sydney, Australia, 11-16 April 2010.

Joshi, B. K. and M. Joshi, 2015. “Challenges in Sustainable Geomaticcs Engineering Education at Tribhuvan University”. 7th International Forum on Engineering Education (IEEE 2015), 17-19 March 2015 at the University of Sharjah, UAE.

Konecny, G., 2002. “Recent Global Changes in Geomatics Education”. The International Archive of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Vol.XXIV, Part 6 CVI.

Paquette, M. D., 2009. “When do we stop teaching the old methods?”. Professional Surveyor Magazine, January 2009.

Poerbandono P., K. Prijaina and H. Andri, 2014. “Geodesy and Geomatics Engineering Curriculum at the Institute of Technology, Bandung, Indonesia.” FIG Congress 2014. Kuala Lumput, Malaysia 16-21 June 2014.

Qing, Z. 2006. “Photogrammetry education for multidisciplinary geomatics in China”. Geo-spatial Information Science, Vol. 9, Issue 4, pp 273-280

Ruther, H., 2003. “The Situation of Geomatics Education in Africa – An Endangered Profession”. 2nd FIG Regional Conference. Marrakech, Morocco, December 2-5, 2003

Schultz, R. J., 2009. “Education in Surveying: Overview of College and University Geomatics Education”. Professional Surveyor Magazine, January 2009.

Semlali, E. and D. Tahiri, 2005. “Issues and Challenges of the Surveying Engineering Education in Morocco Present and Future”. FIG Working Week, 2005, Cairo, Egypt April 16-21 @005.

SEP Self Study Report (SSR) (2015). Surveying Engineering Program at College of Engineering, King Saud University, Riyadh, Saudi Arabia.

Watson. P., and R. Davis, 2003. “A Practical Approach for Incorporating Integrated Teams into the Survey Curriculum”. 2nd FIG Regional Conference. Marrakech, Morocco, December 2-5, 2033.

Wegen, W. V. 2016. “Geomatics: Education is Key”. GIM International, May 2016.

Wulf, A., T. Nuttens, C. Stal and P. De Mayer, 2011. “Geomatics Education in Belgium: 2011 Program Reformation at Belgian Universities”. FIG Working Week, 2011. Marrakech, Morocco, 18-22 May 2011.

BIOGRAPHICAL NOTES:

Dr. Elhassan is a professor of surveying Engineering at Civil Engineering Department, College of Engineering, King Saud University. His research interest is in digital photogrammetry, remote sensing and engineering surveying. He published 8 books and more than 50 scientific papers in the field of engineering surveying.

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