Chapter 4

Lessons Learned from the Establishments of the First Hydrographic Surveying Program in the Middle East

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Additional information is available at the end of the chapter

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Abstract

The fast pace of technology development and voluntary adoption of international standards requires interdisciplinary and skill-based education. This chapter presents an approach for the development of an interdisciplinary, internationally recognized geomatics program, at King Abdulaziz University (KAU), using a multilevel approach that combined the international guidelines with the local stakeholders' needs being in line with the global demand for professionals in this field. The methodology of this study consisted of interviews with subject matter experts (SMEs), students survey and operational analysis, and observation was used to analyze the program challenges and opportunities. Results obtained showed that the transferability of the approach adopted in this research, along with the commonality of lessons learned from the process, contributes to faster execution for similar programs in various parts of the world. The program was successful to secure to international recognition within 10 years of its inception. The quality of learning outcomes supported by the high employability of graduates was among the key socioeconomic impact of the program.

Keywords: IHO, geomatics, hydrography, curriculum design, learning outcomes, system model, action research, systems thinking

1. Introduction

Geomatics is the new discipline that integrates the tasks of gathering, storing, processing, modeling, analyzing, and delivering spatially referenced data or location information [1]. The spatial technologies represent the core of geomatics and help determine the location and identifying the bathymetry of water bodies. The broad application of geomatics technologies in marine and oceanography applications has allowed geomatics to integrate all the elements of spatial sciences and remote sensing along with measurements in a unique discipline

known as hydrography. Hydrography is defined as the science of mapping and charting the depths of water, whether it is seas, lakes, rivers, or oceans. There are many supporting fields to hydrography including coastal zone management, nautical charting, the safety of navigation, ocean mapping, marine resource exploration, maritime boundary delimitation, protection of the marine environment, marine science, and naval activities of defense. The importance that hydrography gained in the recent years is because of the collective efforts ongoing and the justified need for more additional work on further exploring and exploiting natural resources available in marine environments. The IHO estimates that at least 50% of the world's coastal waters are unsurveyed. The polar regions, the South West Pacific, West Africa and the Caribbean are about 10% surveyed. Moreover, in those areas where studies do exist, many are so old or of such a quality that they cannot support the modern requirements. A direct influence on measurements and observations related to climate and climate change makes hydrography a key enabler to the sustainable development of the seas and the best management and governance of the ocean sustainability and resources.

Until about 20 years ago, the traditional components of geomatics, namely: photogrammetry, cartography, remote sensing, and surveying were all independent, and each had its distinct identity [2]. However, geomatics development is directly attributed to the advances in computer science [3]. To this end, there is a debate about whether geomatics is an evolution of the traditional surveying engineering or natural development in the field of earth science. Regardless of the origin of geomatics, the fundamental fact is that it is not possible for a single person, i.e., surveyor or computer scientist to provide a complete solution at the required knowledge depth necessary [2]. Geomatics provides collaborative solutions have a broad range of applications [4], which makes it a unique discipline. Applications such as spatial database design and management, environmental engineering and climate change modeling, oceanography, forestry, geology, geophysics, civil engineering, and biology have made geomatics as a hub for subspecialties of high professional and economic interest [5, 6]. **Figure 1** show the interdisciplinary science of Marine Geomatics.

The objectives of this chapter address the challenges and highlight the opportunities that arise from developing marine geomatics program in the Kingdom of Saudi Arabia, as an international model of collaboration for similar international efforts. The study was planned to achieve three primary goals, specifically:

1. The utilization of maritime resources is critical to ensuring the economic well-being of many economies. For the Gulf Cooperation Council (GCC) region, the region requires increasing academician awareness with challenges and opportunities as a result of developing a new marine geomatics program with regional specifics of geographic and sociocultural constraints, as well as with international impact and contribution.

2. For local development to occur, it is important to invest in the local establishment of "approach-based engineering education," despite the high costs and other challenges, such as meeting multiple stakeholders' requirements in skill-based education. Such development requires an increased level of the knowledge of the role of the local and international stakeholders' contribution to the development of a new marine geomatics program.

3. Evaluation of the program outcomes and accomplishments in 10 years since its inception is necessary to ensure the establishment of the involved knowledge and its generational transmission.

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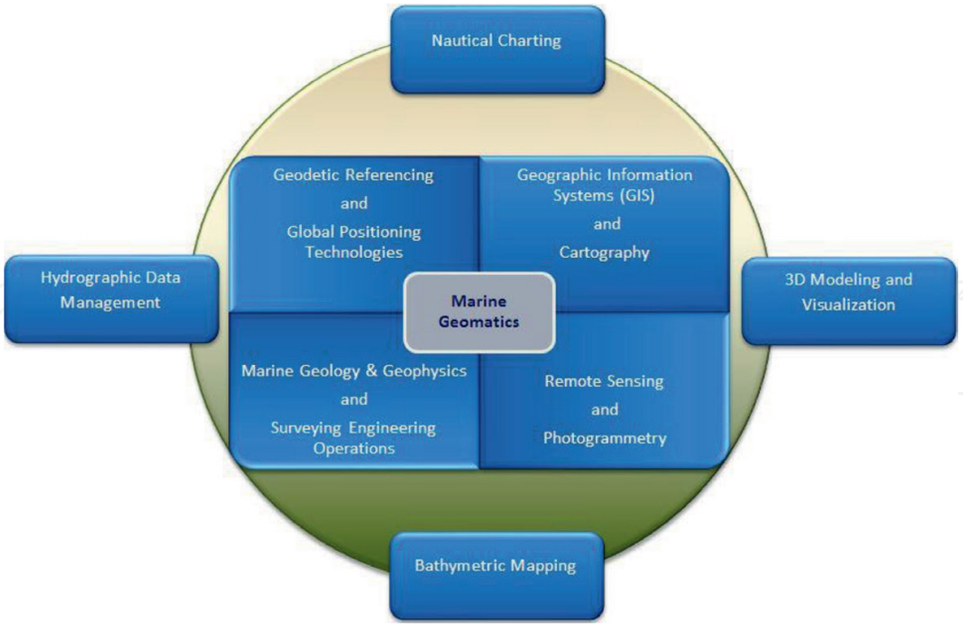

Figure 1. Marine geomatics as interdisciplinary science.

The approach investigated the need and challenges faced to supply the job market with highly trained professionals that are internationally certified to carry out their job, regardless of their regional boundaries. This study discusses issues related to challenges and opportunities for geomatics education and showcases the development of the new hydrographic surveying program at KAU, in the heart of a large metropolitan port city of Jeddah, Saudi Arabia. The study highlights particular issues as a model for geomatics education in similar parts of the world.

In the following sections, the paper sets the foundation for justifying the need for hydrographic surveying program, examines students' performance and satisfaction through survey analysis, and explores current challenges through subject matter experts (SMEs) interviews. It outlines the development of the curricula and introduces the challenges faced by the program and the opportunities that await the new curriculum as it relates to KAU. The last section of the paper draws conclusions within the context of challenges and opportunities associated with the development and evaluation of new specialized geomatics programs.

2. Literature review

2.1. Geomatics education

The significance of approach-based engineering education research has been documented by many researchers, including [7]. Several interdisciplinary subdomain research methods have received substantial attention in education research due to their emergence to form multidisciplinary approach. Case and Light and Cousin [8, 9] indicated that attribution of understanding and implementation of tools as procedures of inquiry in engineering research methods is to the way of their application as tools and context interpreted. The framework formed by the instruments and methods is known as "methodology."

The focus in engineering education research methods that focus on the process was the focus of the work of many researchers including [8, 10]. Today, many advanced economic systems are challenged to rely conclusively on and utilize marine resources. Additional importance linked to having effective marine geomatics programs as a priority for many parts of the world. Agrafiotis and Koumoutsos [11] defined the term education as the process of ensuring the development of knowledge, the formulation, and adaptation of the acquired knowledge to the collective memory and its processing, which contributes to making this process ongoing between generations. Many researchers have discussed the need for geomatics education including [2, 12–14]. Regionally, the need for a specialized geomatics education in the Gulf Cooperation Council (GCC) region comes from the fact that there is a growing population versus natural resources in the area that are underwater, and there are ongoing efforts for exploitation. Another factor is that the GCC countries are in a peninsula surrounded by water, between three of the major water bodies i.e., the red sea, the Indian Ocean, and the Arabian Gulf, which makes safe navigation of increased importance to the region. The fast development of maritime infrastructure and transportation and the large fleet of ships and oil tankers pose a new concern for programs related to marine transportation and safety.

The high cost of establishing efficient maritime education infrastructure, as well as the hard nature of offshore training that students and professionals in maritime industry require, adds more challenge to having enough teaching and training facilities. The outcome of that is a less human resource that can share and transfer the knowledge to the future. It is a global situation faced by a very limited number of specialized marine geomatics programs worldwide. There are many unclear boundaries for the connection between marine geomatics as engineering discipline at its link to many marine sciences including marine geology, marine applied physical oceanography and environmental sciences. The lessons learned from developing technology-based education are attributed to the IT infrastructure itself, as well as to adequately addressing the environmental consideration by the international standards, as discussed by Agrafiotis and Koumoutsos [11]. The need for technologically supported education is on the rise as all educational activities today are helping the process of growing economies, and they depend on technology to a far extent.

The growth of geomatics sector in Saudi Arabia is expanding, along with the process of outgrowing the challenges associated with technology adoption and utilization. This increase makes a golden opportunity for local training of professionals in the field hydrography, according to the international standards of competence laid by the International Hydrographic Organization (IHO). However, despite the observed development in geomatics, it remains limited compared to the western world [15]. Konecny [5] believes that due to the many factors supporting effective adoption of Geomatics Technologies, the need for formal education need is also growing in this advanced technological era. This realization is most pertinent since in an actual sense, development is never achieved nor can it be sustained from outside the developing country [16]. Local professionals play a strategic role in the socioeconomic development of their communities [17]. This provides added value justification for the need of having a state-of-the-art education that combines technology capabilities with local needs. In many developing countries, there is the absence of effective local participation and involvement in strategic planning, formulation, program identification, design, and implementation [16].

Therefore, the spreading of technology-based programs that provides geomatics solutions has to go along with a detailed analysis of the local and regional situation [6, 18].

The scope of skills and expertise required to form the link between higher education institutions of today, whether in form college or university education. The global demand for geomatics professionals and hydrographers worldwide reinforces the importance of having marine geomatics program in the Kingdom of Saudi Arabia, mainly due to the following:

- some of the geomatics-related works in the region are still in the realm of standard (traditional) practice,
- the rapid development in computation and adoption of digital forms of data processing and conversion,
- the clear link between socioeconomically developed communities, sustainability of corporations and government agencies, and the realized need for proper economy drivers that help with wealth data collection and handling,
- the continuing advances in environmental protection, sustainable development, and natural resources conservation through the adoption of advanced Geomatics Technologies that require highly qualified and highly trained personnel.

Marine geomatics is an interdisciplinary applied science that is based on the foundation of Geodesy and Land Surveying. The program is designed on the pillar of four core domains: (1) geodesy and positioning, (2) land surveying and estimation, (3) remote sensing and photogrammetry, (4) GIS and cartography, (5) oceanography and marine environment, and (6) marine geology and geophysics. The components from 1 to 4 are standard in any geomatics or land surveying program. However, five and six are unique in this program and many other hydrography/marine geomatics programs worldwide. The strength of marine geomatics program at King Abdulaziz University is directly attributed to the stakeholders' interest in having professionals in this field supported by a strategic partnership with Saudi Aramco, the largest oil company in the world. Our program is designed to hosting top talented students and to provide a high-quality education according to the international standards of the International Hydrographic Organization (IHO). The international recognition of the program by the IHO has contributed to the excellence and strength of the program.

2.2. Specific needs for the establishment of marine geomatics program

As suggested by Refs. [19, 20], the technology advancement has allowed for developing a new program to cross the interdisciplinary horizon of all sectors of Information Technology. Marine geomatics is one of these interdisciplinary programs that is critically required due to existing gaps in geomatics education in the region and absence of the hydrography-related, skill-based program. This makes the initiative of KAU unique, not only in the Kingdom but also in the region. The fast growing pace of geomatics as interdisciplinary skill-based education in North America has triggered the global need for such education, the relatively rapid pace growing in supporting fields [5, 21].

More specifically, the need for engineering-based multidisciplinary marine geomatics education is increasing day by day. There is an expanding global change in economic dependence in soul natural resources products, such as oil, and the growing concern of utilization diverse financial resources that can deal with an array environmental challenges [22]. All these in addition to the growing technological advancements have maximized the need for skill-based education for professionals, specifically for Saudi Arabia and the GCC region. As indicated by Melezinek [23], skill-based technologically obsessed education became necessary as the application of knowledge became as important as it is a pursuit. This type of education needs to be supported by a contemporary approach to providing advanced professional education. The required efficient and progressive decision-making process has helped with shaping and advancing geomatics education [11]. Today, it is not only the academic community that is concerned with the issues of providing adequate advanced skill-based education, but is also the stakeholders, who are more concerned to have knowledgeable and skilled professionals that can support their communities [24]. The academic education and professional training integration to provide skill-based education have become a need, rather than a complementary resource, more particularly to developing countries with growing economies and depleting resources [25]. It partially addresses the need raised by many researchers including [11] who illustrated the need in keeping up with the rapidly developing technologies through active education systems to provide advanced knowledge and to enhance the contribution to the development of vibrant communities that support stakeholders' objectives and job market trends. This justification is according to the growing need for effective educational systems that are capable of providing advanced training that is keeping with the rapid pace of technology development [12, 14, 26].

3. Methodology

This research is considered as action research, as it summarizes efforts being carried out in the process of developing a new educational program. It introduces a new approach that integrates the environmental socioeconomic considerations with the international requirements for providing advanced skill-based education and training.

It provides direct input to methodologies and mechanisms that are currently embraced globally to improve the process of creating similar programs. The relevance of this approach taken is not limited to the region or country where the development occurred. It can be adopted worldwide with minimal consideration to the socioeconomic factors that might influence successful implementation of such a program. In geomatics, there are many efforts presented by many. The research adopts different levels of analysis and observations, based on the approach proposed by Virkki-Hatakka et al. [27]. **Figure 2** shows a summary of the research approach used in this study. The reason behind this systematic approach was to evaluate challenges and opportunities for marine geomatics programs using local case study.

The research is intended to reach to results and develop conclusions based on critical evaluation of the approach adopted in the development of the academic program. These assessments are important because they provide heuristic evaluation and key observation for the successes and failures of the program. The first stage of the methodology involved SMEs' interviews,

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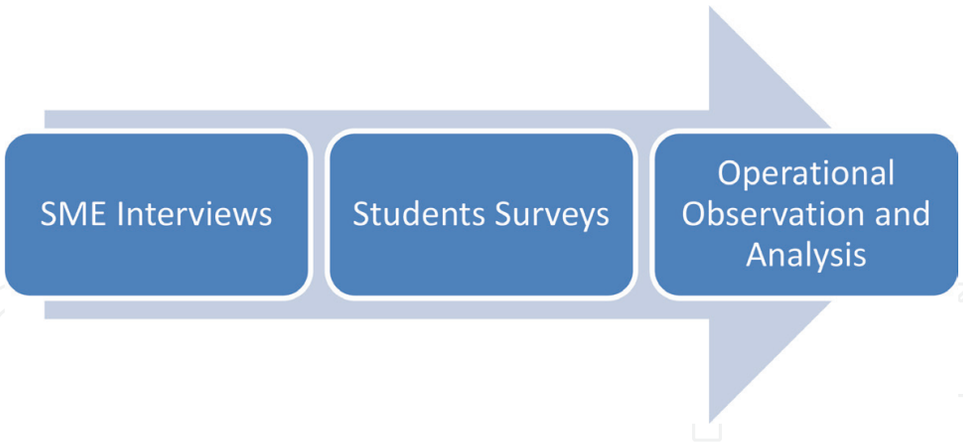

Figure 2. The approach for research.

where two subject matter experts, from those who participated in the evaluation of the program, have analyzed the strides and failures of the program, based on the standard assessment procedure that has focused on determining and listing the challenges and opportunities that are faced by the program. The levels adopted are as follows: (A) critical evaluation of the strategic plan adopted in the developed program, based on qualitative input from different stakeholders and academic administrators; (B) analysis of the policies and procedures used during implementation of the plan while developing the program; (C) observation, evaluation, and self-evaluation of the program performance and development over the study years; and (D) reflection on the outcomes based on the steps from A to C, where they were assessed based on the contribution of the program to addressing the stakeholders' needs for local professionals according to the international standards. The second stage of the research has focused on analyzing the information obtained from the annual students survey completed as part of the quality monitoring assessment, under the University Vice-President Office for development, where students complete the survey. The methodology also included analysis of socioeconomic indicators for the success of the program at a regional level. Critical analysis of the impediment factors for further improvement of local and regional considerations is associated with the establishment of the program.

4. Case of KAU hydrographic surveying program

The hydrographic surveying department aims to provide graduates with basic and advanced knowledge of hydrography, hydrographic data collection, management, and presentation. Also, it provides knowledge of data analysis to determine depths and locations and to create hydrographic/nautical charts, as well as navigational and environmental protection. It has started in 2004 with two full-time faculty members and four collaborating faculties, to reach to eight full-time faculty members, two engineers, and four faculty members under development. The justified need has led KAU to initiate a program that builds the region capability for hydrographic surveying cadre. It also supports the ongoing development and exploitation of maritime resources. Since its inception and for 7 years, the program was under

the Department of Maritime Studies at King Abdulaziz University and was hosted by the Faculty of Marine Science of KAU. In 2011 the announcement of the establishment of a new Faculty of Maritime studies was announced by approval from the higher authorities in Saudi Arabia (Royal Decree). The new Faculty of Maritime Studies hosts four departments, which are the Department of Hydrographic Surveying, the Department of Nautical Science, The Department of Ports and Maritime Transport, and the Department of Marine Engineering. The department graduates are 20 in total, with the first batch graduated in 2008.

The department facilities consist of the state-of-the-art equipment and instruments, including the "University Hydrography" survey vessel. The department services are among the most comprehensive regarding both technical and academic aspects. In April 2008, the construction was completed in the full five-storey maritime studies building, at KAU Campus Al-Morgan, 40 km north of the main campus in Jeddah. This building location is in the creek of Abhor and the Red Sea. A new 16-meter long hydrographic survey vessel was acquired in 2010 to provide hydrographic surveying students with all what they need to practice hydrographic surveying in the field. The vessel utilizes the state-of-the-art hydrographic surveying equipment and processing packages. It allows up to eight students and four crew members to conduct field survey for up to 8 days onshore using onboard data processing and transmission to different receivers.

4.1. Academic requirements

The program is unique in the Gulf Cooperation Council (GCC) states; it is designed to address the gaps in educating professionals in the region, as no other institution offers a similar program or professional certification. The International Maritime Organization (IHO) [28] guidelines provided direct input in the development of the program. The program has focused on addressing far beyond the core competencies needed for hydrographers CAT A certification. The information provided by the local stakeholders [29], including the Saudi Aramco, Ministry of Transportation and National Surveying Authority, provided a regional benchmark for the skills and competencies required. The stakeholders showed a wide range acceptance and support of the idea of providing a professional license (CAT A) along with

Figure 3. KAU "hydrographia1" training vessel.

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B.Sc. in hydrographic surveying. **Figure 3** showing the University Hydrographia 1 survey vessel which is used a field data collection and survey planning training lab.

The B.Sc. in hydrographic surveying program is designed for 131 credit hours, ideally, over 4 years of study [30]. **Table 1** is shows the program structure. The first year of the program covers the university requirements, as the education system in Saudi Arabia requires university students to take a faculty-based previous year, in which students will study 14 credits of common foundation courses in natural sciences as outlined in **Table 2**. As discussed by Rashid

No.	Course name	Course code	Units
1	Mathematics for Maritime Studies	MATH 201	4
2	Linear Algebra I	MATH 241	3
3	Physics 204	PHYS 204	4
4	Physics (practical)	PHYS 281	1
5	Introduction to Computer Science	CPIT 201	3
6	Maritime Communication	MSN 243	2
7	Marine Meteorology	MSN 245	2
8	Fundamentals of Surveying	MSS 220	3
9	Technical Communication	MSS 221	2
10	Fundamentals of Nautical Science	MSS 310	3
11	Underwater Positioning Systems	MSS 311	3
12	Estimation and Uncertainty Management	MSS 312	4
13	Geodesy and Map Projections	MSS 313	4
14	Water Level Measurements and Prediction	MSS 320	3
15	Surface Positioning Systems	MSS 321	3
16	Underwater Imaging and Mapping I	MSS 322	4
17	GIS and Bathymetric Data Management	MSS 323	3
18	Marine Law and Policy	MSS 410	1
19	Underwater Imaging and Mapping II	MSS 411	4
20	Remote Sensing for Marine Applications	MSS 413	3
21	Marine Geology for Hydrographers	MSS 414	3
22	Nautical Charting	MSS 420	3
23	Hydrographic Data Management and Presentation	MSS 421	3
24	Degree Project	MSS 429	3
	Total		71

Table 1. Hydrographic surveying core courses.

1	The program structure (including the knowledge and skills to be acquired) was evident to me
2	The things I had to do to succeed in the program including courses assessment tasks and criteria for assessment were made clear to me
3	Sources of help for me during the program including faculty office hours and reference material were made clear to me
4	The conduct of the courses and the things I was asked to do were consistent with the course outline
5	My instructor(s) were fully committed to the delivery of the courses (e.g., classes started on time, instructor always present, materials well prepared, etc.)
6	My instructor(s) had a thorough knowledge of the content of the courses
7	My instructor(s) were available during office hours to help me
8	My instructor(s) were enthusiastic about what they were teaching
9	My instructor(s) cared about my progress and were helpful to me
10	Courses materials were of up to date and useful (texts, handouts, references, etc.)
11	The resources I needed (textbooks, library, computers, etc.) were available when I needed them
12	In this program, efficient use was made of technology to support my learning
13	I was encouraged to ask questions and develop my ideas
14	I was inspired to do my best work
15	The things I had to do (class activities, assignments, laboratories) were helpful for developing the knowledge and skills
16	The amount of work I had to do was reasonable for the program credit hours allocated
17	Marks for assignments and tests were given to me within a reasonable time
18	Grading of my tests and assignments was fair and reasonable
19	The links between the courses and throughout the program were made clear to me
20	What I learned is important and will be useful to me
21	I had improved my ability to think and solve problems rather than just memorize the information
22	I was able to develop my skills in working as a member of a team
23	I had improved my ability to communicate effectively
24	Overall, I was satisfied with the quality learning experience

Table 2. Students survey questions.

and Tasadduq [31], some programs face the challenge in curriculum design as it relates to the rapid evolution of technology, which was a major consideration in exploring the options for setting this academic program to meet the IHO professional standards.

The advanced curriculum addresses the university requirements, the faculty requirements and the program core courses and elective courses requirements as set by the King Abdulaziz University, Academic Policy. A total of 131 credits covers some 14 credit hours, divided into

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four courses at the preparative preceding year, according to the Saudi higher education system. At this prior year, the students learn mathematics and physics extensively. Another 26 credit hours represent additional courses according to the requirements of KAU. In this, 26 credits of compulsory university requirement courses include Arabic and English languages, Islamic culture, and Humanities. The university requirements are also supported by 10 credits of the faculty requirements, in which the faculty needs students to study mandatory faculty courses, namely marine environment, statistics, and oceanography. A total of 50 credits that constitute the university requirements, as well as the faculty requirements are a must prior to starting the core courses of the Hydorgprahic Surveying specialization. Out of 81 credits, 69 credits represent the mandatory courses and 8 credits represent the elective courses that students can choose from a vast number of classes. The last four credits are for the necessary training as the IHO requires it.

English is the language of study in the program. Students must complete intensive four courses in English during their first 2 years. Ideally, before the start of the specialization courses by the beginning of the third year, students must obtain an equivalent to 200 TOEFL score, to begin their third year. KAU English Language Centre offers these courses.

The core program credits are 81 credit hours and provide students with all the skills needed to become a professional hydrographer; starting at the seventh term, students begin to take specialty courses. Students must mainly go through the process of applying the scientific method in solving particular research issue and report that in a sound acceptable precise way as a graduation project. The core hydrographic curriculum covers four specialty areas, which are: Hydrographic Surveying courses, where students will learn about the methods and procedures of hydrographic surveying, supported by the Science and Engineering behind that. In the core courses students are introduced to to tide measurement, echosounder equipment measuments through singlebeam and multibeam echosounding, sidescan sonar, offshore geophysical surveying. The second specialty area covers positioning and navigation, including terrestrial and satellite positioning and altitude systems. This component will provide the student not only with the basic foundations needed to meet the requirement as Category "A" hydrographer but also to address the academic requirements for getting a B.Sc. degree. The third specialty area covers geodesy and estimation, where students will learn about datum and coordinate systems, map projections, maritime boundary delineation, estimation and filtering, and uncertainty management. This component will provide the student not only with the basic foundations needed to meet the requirement as Category "A" hydrographer but also to address the academic requirements for getting a B.Sc. degree. The fourth specialty area is nautical chart production, where students will learn about Geospatial Information Systems (GIS), data management, remote sensing, and photogrammetry. This component will provide the student not only with the basic foundations needed to meet the requirement as Category "A" hydrographer but also to address the academic requirements for getting a B.Sc. degree. **Table 1** provides an overall view of the components of the hydrographic surveying program and their term distribution, including prerequisite and elective courses.

Students can choose to take 8 credit hours of elective courses to add additional 8 credits in order to graduate. The courses students can choose from are Technical Communications,

Marine Geology for Hydrographers, Offshore Geophysical Surveying and special topics in hydrography.

The field training provides the required field skills as outlined by the International Hydrographic Organization (IHO) guidelines [28]. Over two terms of 6 weeks on the board of a hydrographic survey vessel, students gain the required practical knowledge needed to work with different data acquisition systems. The focus of the core skills that students get while on training covers field calibration of single beam/multibeam echo sounder, multibeam system patch test, and reference systems. The students are also involved in the survey design and planning, hydrographic surveying specifications, and types of hydrographic surveys.

4.2. International certification and local accreditation requirements

The International Hydrographic Organization (IHO) was formed in the year (1921) by some member states, with principal objective to ensure that all the world's seas, oceans, and navigable waters are surveyed and charted, to provide safe navigation for mariners. Its vision is to act as the sole authority worldwide to provide governance and guide for global hydrographic activities. The IHO is a United Nations observer organization. Its mission is "to create a global environment in which States provide adequate and timely hydrographic data, products and services and ensure their widest possible use" [28]. Some 85 coastal states are engaged as members of the IHO and work on promoting and advancing maritime safety, including the protection and sustainability of the marine environment. The international board handles the accreditation process in the IHO on Standards of Competence for Hydrographic Surveyors and Nautical Cartographers (IBSC). It regulates and accredits academic programs and departments that provide certification for professional hydrographers and nautical cartographers. The competency standards are according to Standard 5 revision 11 of the IHO regulations [28].

The Department of Hydrographic Surveying offers a Bachelor of Science degree (B.Sc.) in hydrographic surveying. The program was designed to meet the requirements of the International Hydrographic Organization (IHO) as Category A (CAT-A), according to the latest revised edition of the Standards of Competence for Hydrographers guidelines [28]. The program was recognized in April 2013 as IHO accredited program for (CAT A) professional certification. IHO accreditation provides worldwide recognition for graduates in their level of competence to perform advanced hydrographic surveying skills globally, regardless of their service region. The process of accrediting the Department of Hydrographic Surveying by the IHO was started in 2007 when the Saudi General Commission invited the president of the IHO for survey (GCS). The preparation of the department profile for submission to the IHO involved discussions among the department, the GCS, and the IHO; this has initiated the communication with the IHO. Later, in 2007, the Saudi authorities organized an international workshop in Capacity Building, hosted by local authorities and convened in the City of Jeddah. In December 2012, the Department of Hydrographic Surveying presented its portfolio at the annual meeting of the IBSC in April 2013, where the recognition of the program as Category "A" accredited institution, the highest recognition in the IHO scheme of two categories was granted.

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The international interest expressed by the International Hydrographic Organization (IHO) was evident. The Capacity Building administration of the IHO was working hard to expand the presence of IHO- certified hydrographers in many regions of the world. A high delegation from the IHO has visited Saudi Arabia several times in the past 10 years. A meeting with the president of the IHO was held during his visit to Saudi Arabia to attend activities related to the GCS. A second meeting with the IHO representatives took place during the IBSC visit to attend a regional event in 2014. These two sessions with the administration revealed keen interest for support from the IHO, for the establishment of an international program at King Abdulaziz University.

The hydrographic Surveying Department has maintained a strong international support and collaboration with many organization including the Interdisciplinary Centre for the Development of Ocean Mapping (CIDCO) in Canada in hosting student training programs. CIDCO is a marine geomatics R&D organization that hosts IHO recognized program. ENSTA Bretagne in France has also provided support to the program by delivering training for students in 2012. ENSTA Bretagne is a French national graduate engineering institute with reputed contribution to hydrography. A delegation of the chapter of the UK Hydrographic Society in UAE has visited the program and showed interest in sponsoring professional talk series in UAE, where representatives of the program can participate and share insight with practitioners into the domain of hydrography.

The Saudi Council of Engineers (SCE) has approved the membership of the graduates of hydrographic surveying program. The objectives of SCE are to promote the engineering profession. The council exercises many roles to do whatever may be necessary to develop and upgrade its standards, however, currently the membership of Hydrographic Surveying graduates to the SCE is under review [32]. The mandate of the SCE stipulates that it determines the suitability of the program in terms of accreditation requirements. Till the year 2015, the graduates of the program are recognized as individual members of the SCE according to the SCE regulations.

4.3. Stakeholders' requirements

The support that hydrographic surveying program gets goes far beyond the university top academic administration. The initiation of the program was completely backed up by an advisory board of government and industry. This support secured that the program meets the need of local and regional employers, and provides international standards for training and education. Specific support was evident from the Saudi Aramco, Saudi Ports Authority, Ministry of Transportation, and the Saudi Military Survey Department. Some mutual visits and consultations with the Saudi General Commission for Survey (GCS), Saudi Navy, the Saudi Geological Survey, and the Saudi Coast Guard helped with shaping their operational requirements. The success of the program in securing support from government stakeholders, as well as private stakeholders represented by industry members from Saudi Arabia, provided added value to the program design. Regional support from relevant stakeholders from the United Arab Emirates, who expressed interest in attracting students to work with them on various projects, represented another evidence of the program success. The foundations for collaboration and support have emerged in some mutual agreements and MOUs. All graduates of the program in 2014 were hired by GCS as hydrographers and resumed their duties with positive feedback from their managers.

The program was successful to form industry advisory committee that brings all relevant stakeholders. The committee was successful in providing requirements and considerations for future employees, in the field of hydrographic surveying. Special extra meetings with Saudi Aramco, the leading international oil company and the General Survey Commission (GCS), in addition to leading private sector enterprises, provided some value insights into the program development.

5. Discussion of the findings

The data used for this study came from all three stages of the methodology as outlined in the methods section. Over the past 10 years, the program has granted B.Sc. degree to a total number of 60 students. The majority was graduated before the recognition of the IHO was given. In 2016, the first batch of the program with 10 students has graduated with the IHO recognition as Category "A," which makes this as a milestone in the application development by providing the graduates with international certification along with B.Sc. in Hydrographic Surveying. Out of 50 students, a total number of graduates from the program over the study period, the survey covered 55 students for their feedback on their evaluation of the program and whether the program has met their expectations regarding quality of education needed for the job, or in supporting their future career objective. The interview questions covered the knowledge requirements according to the Saudi National Commission on Academic Accreditation and Assessment (NCAAA) routine assessment for academic programs.

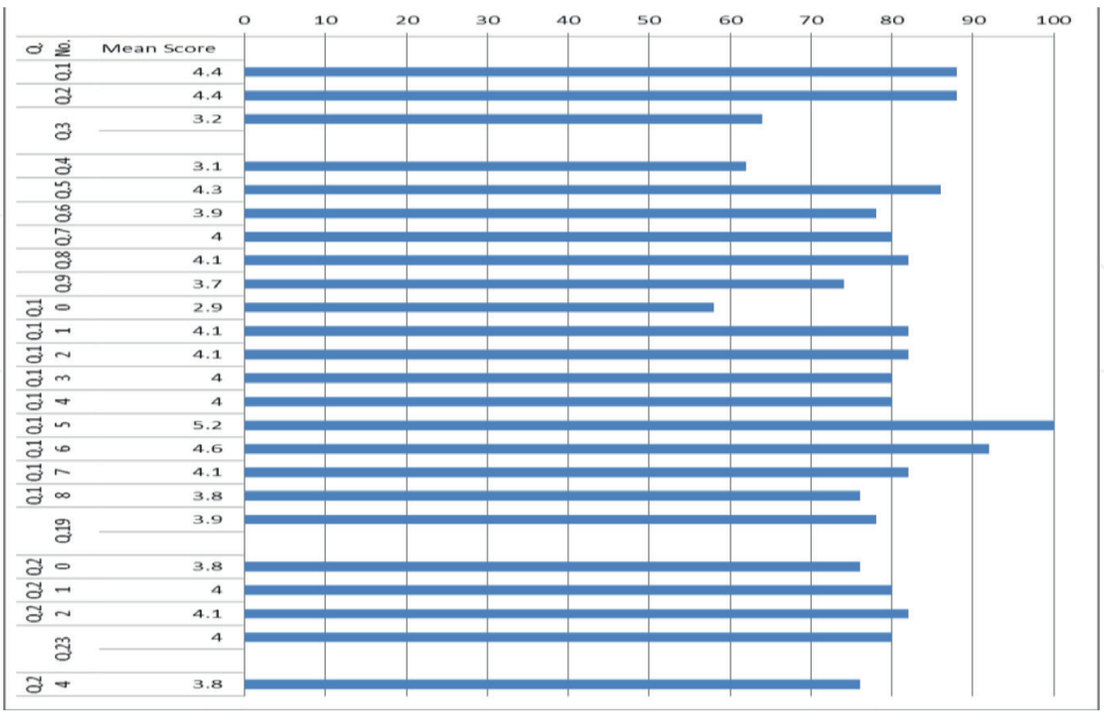

Figure 4. Mean response score % for the survey questions.

The questions of the Interview has focused on different themes, the first topic was general questions, the second theme was focusing on what happened during the program, and the third issue was the overall process evaluation of the program, and the last subject was an assessment of the overall satisfaction with the program. The survey questions are shown in **Table 2**.

The results of the student's survey as shown below have highlighted the level of satisfaction a large number of students have expressed in the program were rated on a scale of 1–5 where five were extremely satisfied, and one is extremely dissatisfied. The results as seen in **Figure 4** have all presented a good level of satisfaction except in 10, where some students have raised a flag on the course reference. This was before securing the IHO recognition, where the course material used was not very well structured. However, the matter has been improved in the following years. These results are cumulative results for the entire period of the study. The (n) is equal to 35 from 10 years time.

The graduate's exit survey has utilized the NCAAA standard forms, and it was used to highlight the themes of help and support for learning, resources available for learners, and the evolution of student and the overall evaluation of the program. The number of students who completed the exit survey was 35 students; they answered some questions dealing with their overall experience in the program, and it was satisfactory and supported 100% employment rate within 6 months of graduation.

5.1. Analysis of challenges

The SMEs interviews have focused on analyzing challenges faced by the program, which falls into four broad challenges, i.e., administrative challenges, academic challenges, operational difficulties, and environmental problems. Each of these challenges requires a very intensive effort to tackle. KAU administration has significantly contributed to providing solutions to all the challenges faced by the program, as a result of the new establishment of the program.

5.1.1. Administrative

The financial procedures have represented one of the biggest challenges regarding allocating budgets, and the spending in the newly established hydrographic surveying program is very generous. However, the financial routines are time consuming and take the time to complete, which delays the program in the beginning. King Abdulaziz University, with support from the Ministry of Higher Education, has contributed to solving this problem by allocating a budget for the new project, that is independent of the budget of the Faculty of Marine Science, the host of the new faculty. In fact, the budget for the new project has in many ways exceeded the budget of the hosting faculty. This has contributed to streamlining the process on spending on facilities as equipment for the new faculty.

Another challenge was characterized by the ambiguity in decision-making, in the form of having a new department with four subspecialties administratively under Marine Science. The department is following the standard decision-making process in the university. This decision-making process for the new department completed under the approval of the Faculty of Marine Science. King Abdulaziz University has supported independent decision-making

process for the newly established department, specifically in financial administration and hiring processes. This decision-making model has provided the flexibility to the organization structure of subdepartments with professional identity located administratively under the Faculty of Marine Science to work more dynamically. However, issues related to students records, registration, and all student affairs were handled under the Faulty of Marine Science, and it was sometimes delaying factor in following the administrative hierarchy. The dual identity of the Department of Maritime Studies, in a sense that the budget of the department is independent, but the organizational hierarchy somewhat falls under the Faculty of Maritime Studies, has created some confusion in the administration in the university. Many contradictions in policies reflected the dual identity related to the Department of Maritime Studies as an individual department, which hold the seeds for new faculty. The higher administration of King Abdulaziz University has exercised every effort to facilitate the transition of the new Faculty of Maritime Studies. In 2011, the Faculty of Maritime Studies was an independent department with a royal decree that announced its existence for the first time.

Another administrative challenge was related to hiring and retention of faculty members in hydrographic surveying. In general, all geomatics specializations are considered rare specialties. This global shortage situation, also, limited spending controlled by outdated policies and procedures as well as the lack of local Saudis faculty members, and staff has made KAU hydrographic surveying program relatively unstable, in the first years. King Abdulaziz University has facilitated this process by activating extra incentive within the pay scheme approved by the Ministry of Higher Education, specifically for attracting faculty members in unique specializations. Also, KAU has provided additional incentive and local grants for research projects that support faculty research activities in small or medium projects.

On the program implementation side, King Abdulaziz University strived to provide world class geomatics education; however, there was some skepticism from students to put their future in the line while applying for a new program. Issues related to field training were among the most significant challenge to this program and for few years in the beginning. Students had to wait for few months for placement in field training. The university administration has realized the importance of providing the students with a perfect academic experience and attempted to support that in two ways. The first way was through allocating generous budgets for facilities and equipment, including the purchase of advanced hydrographic surveying vessel with all equipment needed for training and with onboard lab. The second way was by providing the students with short internship training through several local and international memorandum of understanding (MOUs) with well-reputed professional organizations, including the Saudi Aramco and some of its contractors, who have accepted to train some students in the field over the summer term. Additionally, agreements were signed with international training centers in the Netherlands, France, and Canada. Different batches of students sponsored by KAU to complete their summer training term abroad to get exposed to international operation environments since 2009 groups of students completed their training in the Netherlands, France, and Canada for training. Despite the arrival of the department training vessel in 2010, the administration of King Abdulaziz University has decided to keep the international training program running to maximize the students' international training experience and to provide international collaboration with counterpart institutions in Europe and North America. The training for 2017 is planned to be in the United States.

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5.1.2. Operational

On the operational side, some challenges have faced the newly established hydrographic surveying program. Summary of these difficulties fall in equipment and infrastructure; as the program is new, its facilities and infrastructures are still being developed. Most of lab hardware and software capabilities were developing. As a newly established department, the department was faced with the issue of filling all vacant posts from technical staff to help faculty and administration with different operational issues including communications and archiving. King Abdulaziz University has assisted in this regard by providing some positions for hiring new technical staff, and all posts are now filled, with many specialized hydrographers to support with onboard the vessel training and in the laboratories. Also, additional support staff was hired to take responsibilities for educational affairs and communications.

Historically, students were faced with the challenge of accommodating schedules dispersed over two campuses, 40 km apart. It was a major operational challenge having lectures before noon on the main campus and scheduled labs in the afternoon in the Al Morgan campus. However, King Abdulaziz University and the faculty administration have arranged to bring all classes on the same campus in Al Morgan, saving significant time and effort for students to commute between the two campuses.

5.1.3. Evaluation of learning outcomes

The program is providing new technology-based education in the region. Students were trained to gain competence in sophisticated equipment and hardware. The quality of the program was discussed based on indicators other than the self-reported data from the students. These indicators of the program's success and positive are the employability of the graduates and securing international recognition as a successful professionals, and IHO Cat A certified professionals. These are key indicators of developing high-quality local professionals that are demand for graduates. Reports from international training suggested that our graduates' skills and knowledge are adequate to allow them to gain advanced training skills abroad, specifically in Canada. The students have utilized the program capabilities and facilities efficiently and were able to get jobs easily. Seven of our graduates were employed by the department, and five of them have completed masters in the United States, Canada, the Netherlands, the United Kingdom, and France. Currently, three of our program graduates are pursuing Ph.D. studies in Australia, the United Kingdom, and the United States to take over as faculty members in future.

5.2. Development of sociocultural indicators

The socio-cultural contributions of the program are evident to the geomatics community in Saudi Arabia and the region. The international impact of the program was evident in the input of the program faculty in research projects locally and internationally. **Table 3** is showing the employment rate of the graduates of the program between 2007 and 2016. **Table 4** below is showing the contributions of the program faculty in the last 5 years. The trend is growing as new research projects development is increasing. The department is in active collaboration

Year	Number of graduates	Employment rate	Employer
2007	3	100%	King Abdulaziz University, Saudi Geological Survey, private sector
2008	7	100%	
2009	3	100%	Saudi Aramco, private sector, King Abdulaziz University
2010	5	100%	King Abdulaziz University General Commission for Survey, Armed Forces, Saudi Aramco
2011	7	100%	Private sector
2013	3	100%	Private sector
2014	5	100%	Private sector
2015	8	100%	General Commission for Survey
2016	10	100%	Private sector

Table 3. Students employment history for graduates between 2007 and 2016.

Year	International peer-reviewed journal publications	International conference presentations
2012	4	0
2013	5	2
2014	6	1
2015	6	3
2016	7	1

Table 4. International contributions of the program in the last 5 years.

with York University and Concordia University in Canada in ongoing research projects, and there is an agreement with the Center for Interdisciplinary Development in Ocean Mapping (CIDCO) in Canada for the training of students.

The program has contributed to the economic development of the region by providing highly skilled professionals that are serving in many key employers in the public and private sectors. The program started to familiarize local decision-makers as well as the public with the role and capabilities of geomatics in general and hydrography specifically. The program was visited by a delegation of the Hydrographic Society of the United Kingdom, UAE branch to extend an invitation to the program faculty, and students to contribute to the outreach activities in the region. The program outreach committee has invited some high schools to schedule visits of their final year students to the department and vessel, where students visited the program and learned about the capabilities the program and the requirements for admission. Also, the department has participated in many local conferences and introduced the program at different capacities for professionals as well as for nontechnical extended community members.

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Many high school students showed interest in the program, and some had participated in mini-projects involving hydrographic aspects, where they stayed in contact with the department while working on projects. A delegation of the High School Teachers Conference in the GCC region has visited the department and learned about hydrographic surveying equipment and vessel. The local media, national TV, and other private channels have highlighted several activities by the program, bringing knowledge about the importance of hydrographic surveying.

The program is contributing to the development of a unique community of hydrographers in the Kingdom of Saudi Arabia and the region. It is getting support from KAU administration to extend its role in community service through different educational and awareness activities, as well as through developed short-training courses taught at some institutions in the City of Jeddah.

6. Conclusions

This chapter discussed a collaborative approach in determining the challenges faced by a newly established hydrographic surveying department at King Abdulaziz University, Saudi Arabia. It has presented the opportunities for developing such a program through transfer and modification of the established approach, using KAU program as a model. The newly created program addressed the apparent need for such specialized and targeted higher education that provides international professional certification, especially by looking at the environmental issues in the region, natural resources and maritime transport in the area, and the need for safe navigation. The study has demonstrated the unique inception of a program that meets the international standards, while providing high-quality local education for students in the region has contributed to the socioeconomic well-being of the region and can be seen as a model for similar future programs worldwide.

The establishment challenges faced by the program can be better addressed by proposing a new scheme of collaboration and by exploring new short-term models of recruitment that attract visiting faculty members from well-reputed universities for short-term visiting professorship trips, or by signing partnership agreements with the different universities mainly for faculty exchange and training of students. The support from the international community represented by the IHO and host training institutions was among the key attracting points from various stakeholders in the Saudi Arabia and the GCC region broadly. The program has provided a new, world-class hydrographic surveying education through an effective partnership with the IHO, IHO-IBSC, and the leading training institutions in Canada, the Netherlands, and France. The satisfaction of the program stakeholders and the success of the program to provide employment opportunities to the graduates were a direct measure of the success of the program in meeting the stakeholders' expectations. Over the past 10 years, the graduates' employment rate within 6 months of graduation was 100%. Several meetings with the stakeholders reflected the high satisfaction of the program capabilities

and the graduates' preparation. The Saudi Aramco, the leading oil company in the world, is a strategic partner of the program. The management of the surveying division of Saudi Aramco has expressed interest to hire all graduates in the upcoming through the partnership agreement signed with the Faculty of Maritime Studies. Stakeholders' enthusiasm and KAU higher administration strong support were key factors in the firm inception of the program, backed by generous budgets, resources, and passion for accomplishment. The program has also developed new opportunities for the stakeholders to expand their hydrographic surveying capabilities. GCS has hired all graduates of the 2014 class and started to expand the hydrographic surveying capabilities of the authority.

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References

[1] Natural Resources Canada. Geomatics Sector. 2014. Available from: http://www.nrcan.gc.ca/earth-sciences/geomatics/10776 [Accessed: July 1, 2014]

[2] Bekesi E. GIS education in New Zealand tertiary institutions-information systems perspective. In: Paper Presented at the 8th Colloquium of the Spatial Information Research Center, Otago, Switzerland. 1996

[3] Sifakis J. A vision for computer science—The system perspective. Central European Journal of Computer Science. 2011;**1**(1):108-116

[4] Lilian P-C, Tammy K. The development of geomatics education in Hong Kong, Vol. 10: 4. International Research in Geographical and Environmental Education. 2001;**10**(1):88-91

[5] Konecny G. Recent global challenge in geomatics education. International Archives of the Photogrammetry, Remote Sensing, and Information Sciences. 2002;**XXXV**(6):6

[6] Roche S, Caron C. Geomatics solutions not universal: From a western to a central/eastern European perspective. GIM International. 2001;**15**(6):33-35

[7] Robert W, John H. Spatial Science Education Directions for QUT. In: Les F, Editor. Proceedings Combined 5th Trans Tasman Survey Conference and the 2nd Queensland Spatial Industry Conference, Cairns, Queensland, Australia. 2006. pp. 00037-00037. Accessed from: http://eprints.qut.edu.au

[8] Case JM, Light G. The case. Emerging methodologies in engineering education research. Journal of Engineering Education. 2011;**100**(1):186-210

[9] Cousin G. Researching Learning in Higher Education: An Introduction to Contemporary Methods and Approaches. New York: Routledge; 2009

[10] Johri A, Olds BM. Situated engineering learning: Bridging engineering education research and the learning sciences. Journal of Engineering Education. 2011;**100**(1): 151-185. DOI: 10.1002/j.2168-9830.2011.tb00007.x

[11] Agrafiotis D, Koumoutsos N. Problems of general and technical education. European Journal of Engineering Education. 1981;**6**(1-2):147-158. DOI: 10.1080/03043798108547805

[12] Duncan EE. Geomatics education in Ghana. In: Paper Presented at the FIG Working Week 2004, Athens, Greece, May 22-27, 2004

[13] Young FR. Geomatics education—A modern day. Australian Surveyor. 1992;**37**(4):289-294

[14] Fajemirokun FA, Nwilo PC, Badejo OT. Geomatics education in Nigeria. In: Paper Presented at the FIG XXII international congress, Washington, D.C. USA, April 19-26, 2002. 2002

[15] Aina YA. The need, and development of geomatics education in Saudi Arabia. In: The Second National GIS Symposium in Saudi Arabia, Dharan, April 2007. 2007. www.saudigis.org

[16] Akinyemi FO. Technology transfer: Assessing the impact of desktop cartography course on mapping professionals in Nigeria (1998-2001). In: Paper Presented at The International Archives of the Photogrammetry, Remote Sensing, and Spatial Information Sciences. 2002

[17] Abdalla R. Development of hydrographic surveying database for the Red Sea. In: Paper Presented at The International Hydrographic Organization (IHO) and the Regional Organization for the Conservation of the Red Sea and The Gulf of Aden (PERSGA) Regional Capacity Building Workshop, Jeddah, November 10-23, 2007. 2007

[18] Höhle J. Project-based learning in geomatics. In: International Archives of the Photogrammetry, Remote Sensing and Spatial Information Science, Tokyo, Japan, 2006. Vol. XXXVI. Berlin, Germany: ISPRS; 2005. pp. 1-8

[19] Burkholder EF. Geomatics curriculum design issues. Surveying and Land Information Science. 2005;**65**(3):151-157

[20] Slater F, Graves N, Lambert D. Editorial. International Research in Geographical and Environmental Education. 2016;**25**(3):189-194. DOI: 10.1080/10382046.2016.1155321

[21] Heinz R. The situation of geomatics education in Africa–An endangered profession. International Federation of Surveyors (article of the month). 2003:1-13

[22] Aina YA. Geomatics education in Saudi Arabia: Status, challenges, and prospects. International Research in Geographical and Environmental Education. 2009;**18**(2):111-119. DOI: 10.1080/10382040902861197

[23] Melezinek A. Technology and its education. Some approach and experiences from Austria. European Journal of Engineering Education. 1982;**7**(1):61-66. DOI: 10.1080/03043798208903637

[24] Bingham GA, Southee DJ, Page T. Meeting the expectation of industry: An integrated approach to the teaching of mechanics and electronics to design students. European Journal of Engineering Education. 2015;**40**(4):410-431. DOI: 10.1080/03043797.2014.1001813

[25] Nile G, Wang J, Gau J-T. Challenges in teaching modern manufacturing technologies. European Journal of Engineering Education. 2015;**40**(4):432-449. DOI: 10.1080/03043797.2014.1001814

[26] Venugopal K, Senthil R, Yogendran S. Geomatics education in India—A view point. In: Paper Presented at the 22 Asian Conference on Remote Sensing, Singapore, November 5-9, 2001. 2001

[27] Vikki-Hatakka T, Tuunila R, Nurkka N. Development of chemical engineering course methods using action research: A case study. European Journal of Engineering Education. 2013;**38**(5):469-484. DOI: 10.1080/03043797.2013.811471

[28] International Hydrographic Organization. Standards of competence for hydrographic surveyors. In: IHB, editor. Guidance and Syllabus for Educational and Training Programmes. 11th ed. Monaco: IHO Publication S5; 2011. p. 65

[29] Kufoniyi O, Huurneman G, Horn J. Human and institutional capacity building in geoinformatics through educational networking. In: Paper Presented at the From Pharaohs to Geoinformatics, FIG Working Week, Eight the Global Spatial Data Infrastructure Conference, Cairo, Egypt, April 16-21, 2005. 2005

[30] KAU. Hydrographic Surveying Curriculum. Jeddah, KSA: KAU Press; 2007. p. 192

[31] Rashid M, Tasadduq I. Holistic development of computer engineering curricula using Y-chart methodology. IEEE Transactions on Education. 2014;**57**(3):193-200

[32] Saudi Council of Engineers (SCE). Accreditation Policies. 2006. Available from: http://www.saudieng.sa/English/pages/default.aspx