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THE DEVELOPMENT OF ENVIRONMENTAL ENGINEERING CURRICULUM: A CASE STUDY FROM UNIVERSITY OF DAMMAM

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A B S T R A C T

This study proposes a model curriculum for environmental engineering, based on national research and stakeholder's surveys that meet the needs of the current and recent future of persisting environmental issues. The paper reports on the process of developing a curriculum for this program and the challenges that faced the development of such a program to achieve the government policy and the need of the kingdom. It describes two different approaches to develop the curriculum. One approach takes its starting point from the traditional environmental engineering programs under the civil engineering umbrella. The other framework developmental approach takes its starting point from a particular need of the kingdom. The article suggests that, while curriculum development is a starting point, challenges remain in fine-tuning the programme so that graduates are prepared well to deal with the local environmental issues and sustainable development in the local Saudi environs.

Keyword: Environmental engineering, Dammam.

INTRODUCTION

The Saudi Ministry of Higher Education took considerable steps to ensure that higher education programs fulfil the needs and requirements of the booming economy in the kingdom. To follow the strides of the ministry and to achieve its call, the University of Dammam (UOD) has initiated several non-traditional engineering programs in the kingdom, one of which is the environmental engineering program. Environmental engineering is a relatively new discipline of engineering compared to other classic disciplines (chemical, civil, electrical and mechanical). It is a multidisciplinary department among, civil, chemical, and mechanical engineering as well as biological and geographical sciences. Thus, the environmental engineering department should provide the community, industry and the government with skilled engineers capable of proposing and applying scientific and engineering solutions to the emerging environmental challenges in their own country and the region.

Over the past few years, public and scholarly attention has increasingly focused on the establishment and development of environmental engineering programs in the Kingdom of Saudi Arabia (KSA). However, these attempts were limited to offering few courses at KSA universities especially civil engineering to address these issues. Thus, the need for such a program arises from the booming industrial activities in the KSA as all economic activities are dependent on the fragile environment, and its underlying resource base. For the purpose of restoring of the environment and design innovative solution and management system for the fragile environmental system in the kingdom, the University of Dammam has taken the lead to establish nontraditional engineering departments including environmental engineering to provide graduates and researchers capable of dealing with current and future environmental challenges. The engineering profession has been undergoing significant change at a rapid pace which has been manifested by emerging of new disciplines and curriculum renewal. In the 20th century there was a growth in engineering disciplines at a surprising rate. The fruits of that growth have permeated almost all aspects of people's lives. The key drivers for change include social, economic, technical

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and geopolitical needs (Gomes *et al*., 2006; Molzahn *et al*., 2004; Perkins, 2002 and Turns, 2000).

The key issue that governed in the several engineering disciplines is the development of attitudes of students (SA). For example, in several European countries universities are suffering increasingly from a decline of student applications for chemical engineering as well as for some other engineering and sciences programmers of study (Molzahn *et al*., 2004; Kumar, 2005). This incline and decline in the number of students enrolled in KSA universities has been observed during the past few decades depending on the market needs and the emergence of new disciplines (Desha, 2009). With the broad spectrum of engineering curricula currently available, environmental engineering is trying to compete and collaborate with the other fields. The state of natural environment, combined with a deteriorating of non-renewable natural resources, suggests that the time has come for a new paradigm in engineering that involves environmentally acceptable and sustainable solutions (Byrne, 2009; Perrin, 2006; Mitsch, 2003). Thus, many universities offer degree programs in civil and chemical engineering with varying degrees of emphasis on environmental engineering branches.

Environmental engineering (ENVE) is associated with the design, construction, operation and management of commercial products and industrial processes. These products and processes have chemical, physical, biological or environmental attributes. The degree program typically is focused on a number of main tracks of environmental education. The degree is focused on developing students who are industry oriented as well as competent in many aspects of personal development (Gomes, 2006; Matlock, 2001; Capdevila, 2002; Segovia, 2002). The environmental engineering students are expected to complete a set of undergraduate prerequisites to meet engineering certification requirements while others environmentally related disciplines do not. Some programs do the opposite , they require them to take a little of ecological sciences courses, yet provide no evaluation of the student's competency in the complex field of environmental engineering design (Diemont, 2010; Botchwey, 2009; Abbas, 2007; Lidgren, 2006; Matlock, 2001).

The generic attributes required of engineering graduates in the United States of America through ABET address abilities to apply "knowledge of mathematics, science and engineering; to design and conduct experiments as well as to analyze and interpret data; to use the techniques, skills, and modern engineering toolsz necessary for engineering practice; to identify, formulate and solve engineering problems; to design a system, component, or process to meet desired needs; to communicate effectively; to function on multi-disciplinary teams". This is beside the broad education necessary to understand the impact of engineering solutions in a global/societal context, a knowledge of contemporary issues, an understanding of professional and ethical responsibility, a recognition of the need for and an ability to engage in lifelong learning (ABET, 2009; Mitchell, 2000; Conn, 1993).

The situation of Higher Engineering education in Saudi Arabia is going through a period of transition to the ABET accredited programs which will change the structure of university degrees that necessitates adapting the educational system to the new situation. This process of convergence implies both structural and methodological changes that aim to promote the mobility and employability, paying attention to individual, academic and labor market needs (Lozano, 2009; Lukman, 2009; Harris , 2008; Cloquell-Ballester , 2008; Molzahn, 2004; El-Fadel, 2000). The curriculum design, in the sense of the process of defining and organizing content, teaching and learning strategies, has been a dynamic process since its inception, emerging from the previous experiences and needs of the social context in which it is imparted. But nowadays it implies a challenge to reflect on what should be taught and to redefine new educational paradigms (ABET, 2009; ABET, 2000; Mitchell, 2000).

Developing a curriculum is also challenging, and mostly quite a daunting task. The traditional approach to curriculum development involves developing the curriculum based on the opinion of the available teaching staff. However, more contemporary approaches require collaborative agreements with targeted stakeholders as part of the development process (Davidson, 2010; Felder, 2003).

In this regard, the single most important implication of University of Dammam policy and strategy is the linking of qualifications and academic programmers to societal and economic needs and make a link between the output of higher education and the needs for a modernizing economy. Thus the environmental engineering program should provide learning outcomes that provides learners with the competence and a basis for further learning

(Gattie, 2003; Mitsch, 2003; Doberstein, 2004; NCAAA, 2009). In addition, the program should add significant value to the learner in terms of enrichment of the person provision of status, recognition, enhancement of marketability and employability; opening-up of access routes to additional education and training. And most importantly, the program should provide benefits to society and the national economy. Therefore, and in response to the higher education policy, the NCAAA formulated directives to guide academic planning at the University of Dammam (Kumar, 2006; NCAAA 2008 NCAAA, 2009). However, the challenge was to develop programme that is responsive to specific regional and contextual demands. On the other hand, the program should never become entirely career- or market driven and should consider whether new courses fill an identifiable gap in the provision of skilled and trained graduates.

The starting point of curriculum development: In order to plan a program for the development of curricula for engineering departments at UOD which satisfies the requirements for the NCAAA, the first step was focused on studying the details requested and guidelines suggested by NCAAA. All the necessary forms and required information were collected by conducting several meetings in the specified departments and assigning jobs among the work team. Finally, all the documents and forms were collected and revised by the departments and committee.

Before developing the curriculum, the program developers have made a considerable search to investigate the need for such a program in Saudi Arabia, the existing situation of the environment engineering programs in the Kingdom, career space, and other related issues. These issues are elaborated in the next subsections.

The need for environmental engineering program in Saudi Arabia: The economic growth, social welfare and infrastructure expansion, and the booming local and national development in the kingdom of Saudi Arabia require a wide spectrum of specialized engineers from all specializations. However, the current scarcity of qualified environmental engineers in the kingdom in general and the eastern region in particular necessitates the launching of an environmental engineering program at the newly born university, the University of Dammam.

The aim of this program is to prepare students to become reputable environmental engineers, sanitary engineers, water engineers, site engineers, project managers, program leadesr, consultants, researchers and maybe others in order to deal with the aspects of environmental monitoring, assessing and control organizations in-situ, overcome wastage problems, and lots of other environmental issues. The profession is broad and environmental engineers may work in a variety public and private sectors of industries including chemical, petroleum, minerals, cement, plastics, pharmaceuticals, food as well as other sectors such as research, financial and consulting. Thus, the program must meet and follow the university regulations and its strategic plan in specific and the national sustainable development strategic plan of the Kingdom.

Career space: In order to achieve the required employability, the environmental engineering curriculum design must consider career space in its general framework. In other words, the educational innovation of the program has to satisfy the requirements of local needs. However, it is not the career space intention to set up how to design the curricula, but to provide the university with information about the existing needs and to suggest guidelines to reduce the deficiencies in the professional competences (Botchwey, 2009). Therefore, the environmental engineering graduates need a solid background of technical competences, both in the Engineering, basic sciences and social sciences and humanities as well.

To achieve the above mentioned point, a workshop has been arranged for the purpose that, the environmental engineering program should reflect the needs of the market and be aware of the local environmental issues and priorities. For that reason a list of distinguished scholars and professionals have participated in a workshop with the aim of curriculum development and future of environmental engineers demands explorations. All of the participants have agreed upon that this program is essential for the future of the kingdom and the region as well. Since this is the only separate undergraduate environmental engineering program in the kingdom as well as the gulf countries, it was a challenge to explore the environmental needs and fulfil the international requirements. Therefore, stakeholders have been asked to describe the need and definition of environmental engineers considering the local needs.

Existing situation of the Environment Engineering in the Kingdom: The Environmental engineering discipline is neither offered by government nor private universities of the kingdom as a separate program. Some civil engineering programs offer few courses related to water supply, wastewater drainage, wastewater treatment and disposal, air pollution and control. These courses enable civil engineers to apply the knowledge of engineering to the related fields of environmental issues. In addition, exciting colleges of applied medical sciences address courses related to environmental health and pollution monitoring and measurement of pollutants and contaminants. Thus, due to the limitations of these courses, the University of Dammam has decided to develop a high-quality environmental engineering program that meets the current and future need of the kingdom of Saudi Arabia. The framework of curriculum development is discussed in the next section.

A framework approach to curriculum development:
The framework approach to curriculum development was arisen from the current need and requirement of the environmental engineering program. These needs can be classified into economical, social and institutional aspects.

Economic reasons contain current scarcity of qualified Environmental Engineers in the country in general and in the industrialized eastern region in particular due to local and regional intensive ongoing developmental plans and progress, foreseeable demand due to economic growth, social welfare and infrastructure expansion, availability of environmental monitoring, assessing and control organizations in-situ, most excellent utilization of existing resources to overcome wastage problems and acceptance of new environmental concepts, methods and rules that save both (momentary ?/monetary) aspects and time restrictions.

Social/cultural aspects include assisting national sustainable development and set strategic plans, availing appropriate numbers of experts and specialists in the field, initiating places for more jobs, and presenting superior prospects for Saudis to become environmental engineers and effectively participate in the growth of the country. The program relevance to institution/college mission address networking with other institutions, research centers and relevant academic colleges, departments and schools, enhancement of teamwork capabilities and merits, gaining superlative professional standards, acquiring the finest ethical behavior, leading valuable and quality research and relevance of the program to the mission of the college of engineering, since environmental engineering is one of its core engineering professions. Thus, the vision and the mission of program need to be in harmony with the college of engineering mission and vision which is to provide the community with engineering graduates who acquired an outstanding engineering education, instilled with best professional standards and ethics and who are prepared to lead quality research, contribute to the body of knowledge, serve local community and international market in all majors offered by the college, apply modern information technology and act positively towards sustainable development and lifelong learning. Therefore, based on college mission and vision of the program Mission Statement was set to offer a high quality environmental engineering program that prepares graduates with a sound education in environmental engineering, and develops their skills, and professional preparedness with a sense of environmental ethical values and social responsibilities. In this regard, program mission and vision are towards program curriculum development with emphasis on knowledge (cognitive), interpersonal, responsibility, communication IT, numerical and psychomotor skills. Thus, major goals for the development of the program over a specified period are expected to be achieved by the end of program that lasts for four academic years (See Table 1). Furthermore, the program needs to achieve the development of special student characteristics or attributes. The major special attributes and related strategic student activities to develop these attributes are summarized in Table 2. To achieve the above mentioned goals, the starting point in the curriculum development was making a survey of what is available in the similar ABET accredited programs with an attempt to build a structure for the program from the available courses.

In deciding what should go into a curriculum on environmental engineering, it seemed to the developer that the question that needed most to be addressed was: What knowledge would an environmental engineer needs at present and in the future? Answers to this question suggest that the knowledge base of environmental engineer can be grouped around the three environmental components, water, solid wastes and air pollution and noise control. Furthermore the program needs to fulfil the requirements of the university that the program should be of four years in addition to one preparatory year and, to ensure maximum flexibility whilst still allowing students to specialize in a specific area, a set of elective modules must be added.

Table 1. Main goals and associated strategies of the environmental engineering program.

Goal	Strategies
Develop course program and resources during the preparatory year (during first year of program launching)	State program and course specifications. Build required laboratories, Attract relevant staff and faculty Develop bylaws, regulations and articles in accord with university regulations. Attract and raise required resources and funds for establishing program.
Be proactive in developing and providing high quality undergraduate learning environment in environmental engineering education (by end of four years of program)	Attract top quality candidates into EE program. Continually improve quality of EE curriculum and method of delivery of courses. Maintain required ratio of faculty to student. Align EE program with the needs of local, national and regional market needs.
Develop leadership qualities of students (by end of graduation year of program)	Enhance communication skill of students. Increase awareness to global issues, social responsibilities and the need of lifelong learning.
Enhance students ability to apply knowledge of engineering principles in solving environmental engineering problems (by end of each academic semester)	Introduce a focus on analysis, design and capstone environmental design projects. Increase interaction with local industry through formation of an Advisory and consultancy committees.
Inspire of an international academic standard in the field of EE specialization (by end of program)	Academic linkages and protocols with other prominent engineering institutions and councils. Taking steps for getting accreditation from concerned accrediting bodies
Increase student's ability in research and development (R&D) (by finalization of graduation project)	Enhancing student's research methodologies and capabilities. Addressing local problems with emphasis on practical research and development, R&D.
Develop psychomotor skills (at end of each academic semester)	Ability to handle laboratory and field equipment, machines and instruments. Gaining experiences in quality control and environmental impact assessment
Obtain input from external bodies (a continuum process during program launching phases)	.Acquire recognition from professional societies, councils and firms. Merge resources with concerned local authorities. Conduct joint research with recognized institutions and local municipalities and enterprises.

Table 2. Summary of special attributes and associated strategies and student activities.

Special Attributes	Strategies/Student Activities to Develop these Special Attributes
Ability to find cost-effective and optimal solution	Senior design projects that cover alternative solutions and the design constraints, enabling students to find the optimal solution. Final year graduation project to address R&D existing industrial, municipal or local problem.
Awareness of and commitment to lifelong learning	Through some selected courses, students will be made aware of the need for lifelong learning. Case studies used in courses where relevant to demonstrate the necessity for continued learning in the professional field.
Awareness of contemporary issues, global challenges and impact of EE engineering on society	The design courses, seminars, workshops will provide scope for the student to become familiar with contemporary issues, global challenges. Offered courses will emphasize the impact of EE engineering profession on the society and community environmental awareness. Environmental engineer day to focus on environmental communal issues and to enhance department and community interaction.

Of the available set of elective modules students must complete five elective courses in addition to the compulsory modules. These elective courses are optional with the student having to choose among them under the supervision of the department and fulfilling the specific courses requirements and prerequisite.

APPROACHES TO CURRICULUM DEVELOPMENT

The first draft curriculum: Environmental engineering curriculum was first developed under the umbrella of civil and environmental engineering following the traditional and well known environmental engineering programs offered at most local, regional and international universities. This resulted in a curriculum biased towards civil engineering areas. The proposed program focused on a major skeleton of basic sciences, humanities, and basic engineering and environmental core supported by minors that addressed sets of elective courses on three main domains namely: Minor 1: Waste Engineering and Management (which included electives on: Advanced Wastewater Engineering, Industrial Wastes Treatment, Occupational Health and Hazardous Waste Engineering & Management), Minor 2: Air & Noise Pollution & Control (It included electives on: Air Pollution Fundamentals, Air Pollution Control, and Noise Pollution & Control) and Minor 3: Aquatic Environmental Engineering & Management (which incorporated electives on: Desalination Technology, Wastewater Reclamation & Reuse, Irrigation Engineering, Surface Hydrology, Groundwater Engineering, Groundwater Contamination and Marine Pollution). The offered program overlooked essential environmental aspects needed for the satisfaction of the local governmental and private industrial sectors, such as options on water quality monitoring and operation and control of water and wastewater treatment plants. Besides there was an imbalance and lack of integration between modules related to water, air, and soil aspects. The proposed program concentrated on civil structural design tools, analysis and code of practice in core courses such as: Analysis of Determinate Structures, Foundation Design, Structural Design, Hydraulic Structures, GIS for Environmental Engineers, Environmental Pollution & Control and Project Management. All modules were set in conformity with ABET criteria. The draft was amended and evaluated by external academic reviewers and their comments were incorporated in the program.

The second draft curriculum: As the first program was biased towards the civil engineering and the intended program was purely environmental engineering, the curriculum developer searched for ABET accredited environmental engineering programs and tried to develop a hybrid curriculum between civil and chemical engineering aspects. However, this selection resulted in a rather weak program in all aspects of basic engineering fundamentals. The result produced a program that has neither basis of civil and environmental engineering nor chemical and environmental engineering. This condition might have arisen from the program developers themselves as they belong to different engineering backgrounds and domains with each developer trying to bias the program to his related field and (delete in accord with his point of view), trying to stress on certain areas and its importance to environmental engineer. The minors were established as a pool of electives divided between the junior and senior years of study. The formulated program was sent to external evaluators from different countries with different engineering backgrounds. Comments of assessors were incorporated in the program, yet to complicate tasks of program acceptance. An agreed upon program by the developers was again forwarded to local reviewers. Their comments were addressed to and another curriculum was developed.

At this point of curriculum development, the deanship decided to use a collaborative approach in the curriculum development process, by including the stakeholders such as the potential employers of the graduates. Thus, after implementing the curriculum, the program was evaluated through a well-organized workshop. Focus group discussions were conducted with the stakeholders to determine their experiences.

The need for collaborative partnerships between education institutions and stakeholders was highlighted by Vilela et al. (2004), who stated that universities were created to meet the needs of the communities they served. Collaboration can be seen as a very important aspect of modern education, as it is a process as well as a product of innovation (Lawson, 2004). Lawson (2004) did warn against the idea that ‘‘the professional knows best what clients and students need and must do”. Therefore, the educators should rather view students and their clients as partners who have valuable expertise on their own needs. Lawson (2004) explained the need to engage the ‘‘right mix” of stakeholders when developing the new curriculum. Students and their clients as partners who have valuable expertise on their own needs. Lawson (2004) explained the need to engage the ‘‘right mix” of stakeholders when developing the new curriculum. Therefore, the stakeholders to be included in program developing process was defined and invited to a well-organized workshop. The stakeholders were: Faculty members from UoD; Public & governmental institutions (Municipality of Dammam; Ministry of water and electricity, presidency of Meteorology and environment; saline water desalination center SWCC), Private sector (e.g., ARAMCO, SABIC etc.), Representatives from the educational institutions (e.g., King Fahd University of Petroleum & Minerals KFUPM; King Abdulaziz university KAU) in addition to NGOs (Saudi Geological Engineers Association).

In this workshop, the final version of the program was introduced to be evaluated by the stakeholders who were invited to evaluate such a curriculum from the local need to such a program. The discussion was based on several categories. The categories were basic sciences, social sciences and humanities, mandatory modules, elective modules, reasonability of credit hours, the structure of the program, the coherence of the contents and, so forth. It was clear at the end of the workshop that a curriculum will enable the graduates to meet the needs of the SA. It was also clear that the curriculum development process could be a painful process for all concerned and a feeling of ‘‘collegiality” between stakeholders and teaching staff. In this workshop, the collaborative process was very successful, and the stakeholders actually expressed feelings of ‘‘Ownership” of the curriculum.

The stakeholders had a significant contribution to the program development and their suggestions were highly appreciated. However, changing curricula could also be a traumatic experience for some people. Candela *et al*. (2006) described this phenomenon extensively, and indicated the difficulties project leaders might have deleting content from the previous curricula. There is a think that sometimes people are not ready, or not everyone at the same time sees the thing for change, or in other words, people might be threatened by change, especially people who have been teaching the old curriculum for a long time. The overall impression was one of satisfaction with their role as stakeholders in the process of curriculum development. The few negative comments could not be seen as an expression of discontent with the process, but rather expressing the wish that all the stakeholders utilized all the opportunities offered to them to a maximum. Educational programs need to identify what knowledge and skills will be needed to meet the goal to improve the health of the community at large. This will enable the students to meet their educational needs, and take more responsibility for their own education.

All participants agreed that, this program is essential for the future of kingdom and region as will. Since this is only separate undergraduate of environmental engineering program in kingdom as well as in gulf countries, it was a challenge to explore environmental needs and fulfil international requirement. After elaborate discussions and expressions of opinions the participants agreed to several changes by adding and omitting some modules. Final curriculum, which is a reflection of participant's comments, is shown in Fig 1 that also shows percentages of subjects in the curriculum with humanities and social sciences.

The third draft curriculum: After the curriculum workshop, the final curriculum has been modified and several elective modules have been added. The edited version of the environmental engineering program consists of four years (135 credit hours) plus a preparatory year (30 credit hours). The credits required for the degree of Bachelor of Science in Environmental Engineering are distributed among eight semesters, as illustrated in Fig. 1). This version of the program was believed to fulfil the major program supportive domains discussed previously. This step took about a year and a half of laborious work, intensive efforts and serious work to compile a reasonable curriculum in environmental engineering that will address the current and future needs of environmental protection and safety issues.

Brief description of field experience activity: The program requires a mandatory summer training program that enables the student to experience the real work environment. It also provides an opportunity to participate in group work. The student can work in: Engineering workshops and engineering drawing offices (for a period of at least four weeks), engineering surveying camp (for a minimum period of four weeks), company, a factory, a laboratory, a treatment unit, monitoring sector, an environmental facility, health department, construction site, an incubator. etc (for a period of at least eight weeks). Student training will commence at the end of second and third academic year of the program.

University of Damman – College of Engineering
B.Sc. in Environmental Engineering Curriculum – Program Components
Total Credit Hours 135 Hours

1st Year : Freshman		2nd Year : Sophomore		3rd Year : Junior		4th Year : Senior	
1st semester	2nd semester	1st semester	2nd semester	1st semester	2nd semester	1st semester	2nd semester
Into to Islamic culture (2Crs)	Faith and ethics in Islam (2Crs)	Economic in Islam (2 Crs)	Political system in ISLAM (2 Crs)	Technical writing (2Crs)	Research Methodology (1 Crs)	Professional Practices & Ethics (2Crs)	Environmental Law & Regulations (2Crs)
Libarary Skill (1Crs)	Calculus II (4Crs)	Oral Communication & Public Speaking (1 Cr)	Differential Equations & Numerical Methods (3Crs)	Probability & Statistics (3Crs)	Engineering Economic (2Crs)	Senior Design Project I (2Crs)	Senior Design Project II (2Crs)
English Composition (2rs)	Physics II (4Crs)	Linear Algebra (3Crs)	Environmental Microbiology (3Crs)	Fundamentals of Soil Mechanics (3Crs)	Wastewater Engineering I (3Crs)	Wastewater Engineering II (3Crs)	Technical Elective III (3Crs)
General Chemistry (3Crs)	Computer Programming (2Crs)	Organic Chemistry (2Crs)	Engineering Surveying (3Crs)	Uni operations& Processes I (2Crs)	Uni operations& Processes II (3 Crs)	Design of environmental project 1 (3Crs)	Technical Elective IV (3Crs)
Calculus I (4Crs)	Engineering Drawings (3Crs)	Environmental Engineering Fundamental (3 Crs)	Strength of Mathematic (2Crs)	Air pollution (2Crs)	Air pollution control (3 Crs)	Technical Elective I (3 Crs)	Technical Elective V (3 Crs)
Physics 1 (4 Crs)	Statics (3 Crs)	Fluid Methematic (3 Crs)	Water supply environmental (3 Crs)	Engineering Hydrology (2 Crs)	Introduction to Geooelectrical and Geo environmental Engineering	Technical Elective II (3 Crs)	
Introduction to Engineering (1 Crs)		Environmental chemistry (3 Crs)	Water quality (2 Crs)	Thermodynamic Mass & heat Transfer (3 Crs)	Solid and Hazardous waste management (3 Crs)	Summer Training II (0 Crs)	
				Seminar Training I (0 Crs)			
(17 Crs)	(18 Crs)	(17 Crs)	(18 Crs)	(17 Crs)	(17 Crs)	(16 Crs)	(15 Crs)

Engineering: Credits 81 (59%) Basic Sciences: Credits 36 (27%) Humanities and Social Sciences: Credits 19 (14%)

Figure 1. Final curriculum of B.Sc Engineering.

Upon completion of the set training program, the student are required to submit a brief written report on his work experience, endorsed by the training institution, and present it orally. A grade of pass or fail will be offered to the candidate by the evaluation panel formed by the department of environmental engineering.

Learning outcomes: Main intended learning outcomes include: On-job training, group work experience, team work attitude, psychomotor skills, ability to gain knowledge and acquire skills in practical work environment, class interactive learning and enhancing written and oral communication.

Project or research requirements: The curriculum contains a mandatory 'Graduation senior design Project', a capstone senior-level research program that must be completed under the supervision of, at least, one faculty member. The student and/or group of students is/are required to undertake a graduating project that may have certain selected components of part of the following: data collection, sampling, analysis, synthesis, design, evaluation, alternative solutions, monitoring, cost estimation, laboratory investigation, case study, modeling, etc. A comprehensive dissertation or thesis on the project work is required from the student and/or group of students, who must present his/their work in front of an examining committee or research panel formed by the department of environmental engineering.

The expected learning outcomes of the senior design project or research task are dexterity to suggest and distinguish between environmental research alternatives and techniques, ability to apply knowledge of basic sciences, computational methods and engineering principles, propensity to perform analysis, design and evaluation of selected problem, ability to find optimal solution to concerned problems under a set of constraints and limitations, further enhancement of communication skill, exposure to group and team work, recognition of, professional and societal responsibilities, appreciation of the profession impact on the society.

Provisions for student academic advising and support: Each student will be assigned an academic advisor who will act as a mentor, providing academic and career advice, and general counseling, each student will also be required to meet his advisor at least twice a semester, one at the beginning of his registration and the other one towards the end of the semester, the department will provide support to the students in the form of hosting extracurricular activities, field trips, conferences, general lectures and seminars by inviting guest speakers and keynote representatives from leading institutes, departments, businesses and industrial enterprises, the department entails to provide an interactive learning environment. The chairman of the department will be available to meet the students and listen to their academic problems and concerns. A college of engineering club, society or forum will be formed to help students undertake their academic and research activities.

Description of assessment procedures (including mechanism for verification of standards): Assessment procedures to be followed by the department are in full accord and harmony with directives of the College of Engineering and Dammam University rules. Likewise, it focuses generally on self-assessment of the graduation project to be undertaken at the end of the fourth year. The student assessment will include: 50 % student performance as judged by supervisor, 30 % Exam committee or panel including presentation by student/students and 20 % thesis or dissertation presentation, a national reviewer, with professional experience, will be invited to attend panel, exam committee and discussions and be part and parcel of the assessment process of the graduation project.

The reviewer can be a member of Dammam Environmental Municipality or District Environmental Authority, or Saudi Council for Engineers and any other related responsible units, councils and firms, an external examiner or reviewer is mandatory and shall verify the assessment. The reviewer may be attracted from an environmental engineering department from a reputable university, or an international environmental organization or society such as American Society of Environmental Engineers.

Learning Outcomes in Domains of Learning: The knowledge to be acquired by students are awareness in basic sciences, mathematics, and general engineering principles, knowledge in the fundamentals of environmental engineering ideologies and conceptual facts, understanding and practicing the environmental engineering values in the analysis, design, evaluation, monitoring, execution and management of different engineering tribulations and tasks, an understanding of the professional and ethical responsibilities of the environmental engineering profession and work, understanding of the function, tasks and role of the environmental engineer, assessment of impact of environmental engineering in national, regional and global context.

Cognitive skills: A set of cognitive skills are expected to be highlighted by the program including the ability to understand and apply engineering principles, theories and procedures in analysis, synthesis and solving environmental engineering problems and challenges. Environmental engineering graduates will have the ability to collect data and information and perform analysis, interpretation and draw inferences or conclusions, demonstrate critical reasoning and requisite quantitative skills to identify, formulate, and resolve environmental engineering problems, create designs that reflect economic, environmental, and social sensitivities, formulate and solve environmental engineering problems, use modern tools, techniques, and computation methods necessary for environmental engineering practice, evaluate alternative designs and solutions, with an understanding of the impact of the proposed solution.

Interpersonal skills: The level of interpersonal skills and capacity to carry responsibility to be developed stresses on the several points, for example, the student will have the ability to work in a group, students should be responsible for their own learning that requires using means to find new information data, or techniques of analysis, the students should be aware of ethical and professional issues involving values and moral judgments in ways that are sensitive to others and consisting with underlying values and relevant to professional codes of practice.

Communication, IT and numerical skills to be developed: Students will have the ability to communicate in English both orally and in writing, students also will have sufficient knowledge in information technology that will enable them to gather, interpret, and communicate information and ideas, will have the ability to develop simple programs to solve some numerical problems. Furthermore, students will have sufficient background in statistical or mathematical techniques that will enable them to apply in interpreting and proposing solutions.

The psychomotor skills and the level of performance required: Students will have the ability to handle and testing equipment, machine and instruments, the ability to perform environmental engineering tests in chemistry, physics, microbiology, water, waste, air and noise characteristics, pollutants and related materials, knowledge of equipment monitoring and calibration work, gaining experience in quality control issues, ability to formulate appropriate impact assessment reports, getting acquainted with safety procedures and quality protocols.

Academic accreditation: In accordance with the university regulations and by-laws, academic accreditation will focus on: in each course a 10% sample of tests and assignments are checked, marked by another member of faculty each semester to confirm the standards of assessment. If significant differences are found courses are second marked and differences resolved by the chair of the department. On yearly basis an external examiner from a reputable engineering college will visit the department and offer his scientific comments on overall and specific performance issues and considerations. Every third year an international visiting team visits the faculty and as part of its evaluation the standards of students work and grades allocated are checked against international standards for peer review. Students and graduates views of courses offered, methodology of teaching, learning process etc. is sought on continuous basis. For professional accreditation, the college will seek the recognition of international and national generic bodies and environmental engineering societies (e.g., American Society for Environmental Engineers (ASEE), Saudi Council for Engineers, Saudi ARAMCO ...etc) for professional accreditation for major changes or updating of the program.

Program Planning, Monitoring and Review: The department conducts its affairs through a number of standing committees that shoulder matters such as: examination, registration, consultancy, publishing, meetings and conferences, public relationships, training, research, postgraduate studies, knowledge and technology transfer etc. Each committee is entrusted with some duties and responsibilities. The quality of program is reviewed by the Program Assessment Committee; the Undergraduate Committee looks after the undergraduate curriculum, and makes changes as and when necessary to maintain the currency of the program. All faculty members are distributed in the standing committees, so that all participate in the academic affairs of the department, all decisions of the department are discussed in the Department Council meeting for approval of the department.

Key Performance Indicators: Key performance indicators will be used to monitor and report annually on the quality of the program as follows**:**

1. Average score on an overall program quality item on a student survey on completion of the program (50% response rate required), student's average score for their satisfaction with their experience.
2. Learning and teaching: ratio of students: Faculty and teaching staff, percentage of students who completed successfully first year of the program, proportion of students who complete the full program in minimum time, proportion of students (available for employment) who are employed within six months of graduation, proportion of faculty with verified doctoral degree, proportion of full time faculty who completed training programs in teaching or attended conferences during the year, percentage of graduates undertaking further training or postgraduate studies at the census date, proportion of fresh graduates who proceed directly (within one year) to postgraduate studies.
3. Student administration and support staff: Ratio of students to administrative staff, ratio of students to support staff.
4. Learning resources: Ratio of books and periodicals held in the traditional library to students Proportion to budget used on books and periodicals.
5. Facilities and equipment: Proportion of expenditure on IT to total budget, number of accessible computer terminals per student, proportion of expenditure on equipment and laboratory requirements and materials to total expenditures.
6. Financial planning and management: Total operating and running cost and expenditure per student, proportion of funding raised and derived from different sources (government, postgraduate fees, research income, consultancy and other sources).
7. Employment process for faculty and staff: Proportion of faculty leaving the college in the past year, proportion of faculty and teaching staff participating in professional development in the past year.
8. Research: Number of refereed journal, book or monograph, publications during the year per full time faculty member, percentage research students in the student body, number of research students who graduated in the past year, proportion of funds and expenditure allocated to research, percentage of total number of students engaged in postgraduate research programs.
9. Community relationship: Proportion of faculty participating in community development and capacity building in past year, proportion of community education and development program provided per Department of college.

CONCLUSION

The innovation in this curriculum development approach commenced when collaboration between the Department and a number of stakeholders was encouraged. All indications are that the curriculum in environmental engineering is appropriate and relevant. The challenge now is to deliver the teaching in an integrated manner and develop a research programme to underpin the teaching. The framework approach to curriculum development will ensure that any shortcomings will be identified early and that changes needed effected quickly.

By developing the environmental engineering curriculum, the environmental engineering department shows the capability to embark on innovative processes to ensure that this new degree programme was going to meet the diverse needs of the Kingdom of Saudi Arabia. Furthermore, the methodology presented in curriculum development will enable future curriculum developer to make benefit from the positive and negative experiences and the importance of stakeholders involvement in curriculum development. In this curriculum development process, collaboration has evoked very positive responses from the stakeholders and the lecturing staff involved. One can only encourage other engineering departments to use a similar approach in order to develop curricula that will meet the needs of both the students and their future employers.

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