Industrial Engineering Curriculum Restructuring

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Abstract— Major improvements were introduced to the curriculum of the Bachelor of Science (B.Sc.) degree in Industrial Engineering (IE) offered by the Faculty of Engineering at King Abdulaziz University (KAU). The purpose of this paper is to share improvement experiences after the implementation of a restructured curriculum and also to strive for continuous improvement of the existing syllabus. The proposed curriculum is designed to meet specific and unique needs of employers in various local industries. Two-pronged approaches were executed including a field survey to identify job market requirements in the domestic industry and a benchmarking method of comparison with other high ranked industrial engineering programs from both local and foreign universities. Changes to the existing curriculum and course contents are required in terms of designing new content or modifying the existing courses. Industrial engineers are among the key pioneers in enabling an emerging economy and growing industry, yet their development has barely received attention in scholarly journals. This paper reflects best practices with broader lessons for universities and industries.

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Index Terms— Continuous Improvement, Curriculum Restructure, Industrial Engineering, Syllabus.

1 INTRODUCTION

Recent developments in industrial engineering science and industries have resulted in the enhancement of engineering education quality becoming one of the most important challenges. Thus, improving engineering education has become a matter of national strategic concern for both developing and developed nations. The need is to fulfill the primary aim of industrial engineering education, which is to provide the industry with industrial engineering graduates capable of meeting its professional and research needs.

Industrial Engineering is a discipline known for its breadth of scope and application. It is not only concern with technology, but also with people and operational issues. It combines science and technical knowledge with human sciences to design, plan, and analyze systems that involve people, materials, money, energy, equipment, information and other related resources. The most distinct aspect of industrial engineering is the flexibility it offers. Because of its broad perspective, industrial engineering is applicable in a wide variety of industries, including: manufacturing, healthcare, banking, insurance, transportation, construction, utilities, and government agencies.

Industrial Engineering is a broad based field of engineering. However, to maintain the depth and the focus, any proposed curriculum should be designed to meet the specific and unique needs of employers in surrounding industrial areas.

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Hence, manufacturing systems and engineering related operations will be the application domain of the proposed curriculum. As such the curriculum emphasizes on the analysis and design of manufacturing systems.It prepares students to work in activities such as manufacturing process planning and control, automation, production methods and standards, computer-aided manufacturing, engineering economic analysis, facilities design and optimization of industrial operations. However, for industrial engineering graduates to function effectively within interdisciplinary environment, the new curriculum should also include broad engineering sciences courses.

The structure of the curriculum aims to accommodate the need of awareness of the integration philosophy. Generally, the sequence of the courses could follow the serial or a parallel model as shown in Figure 1. Normally, the lower years are dominated by mathematics, basic sciences, language and humanities courses. In the upper year, courses related to design and syntheses are becoming more prominent.

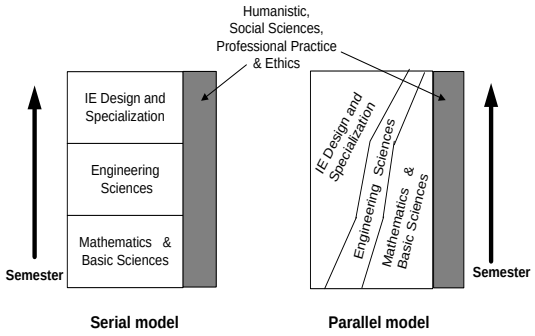

Figure 1: Serial and Parallel Models of Delivering Courses

The ABET guideline (2008) gives the following guideline for Industrial Engineering and similarly named programs:

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"*The program must demonstrate that graduates have the ability to design, develop, implement, and improve integrated systems that include people, materials, information, equipment and energy. The program must include in-depth instruction to accomplish the integration of systems using appropriate analytical, computational, and experimental practices*."

This paper will discuss the redesigning and restructuring of the Bachelor of Science in Industrial Engineering program at King Abdulaziz Univeristy (KAU), Rabigh. In order to cater to the needs of a booming industry and advancement in technology, the IE curriculum at KAU Rabigh, adopted from the main campus in Jeddah upon inception, had to be reviewed and restructured, and will be designed based on the concept, principle and guidelines of the ABET mentioned above. In the proposed curriculum, the parallel model will be implemented whenever possible in sequencing the courses.

The undergraduate program in Industrial Engineering at KAU Rabigh is structured as a full-time program requiring a minimum of 5 years including a preparatory year in the first year. The program structure includes the following key components: total number of credit hours required to complete the program (including lectures, labs and tutorials), distribution of the credit hours as compulsory, elective, and optional, number of credit hours and the percentages of the total number of program hours classified respectively as general education, basic sciences, engineering courses, specialized courses and practical/field training. The program must also satisfy the university, faculty as well as department requirements in order to fulfill the degree requisites.

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This section starts by introducing the vision and mission of the department, the importance of the program, the education objectives and learning outcomes.

2.1 Vision and Mission of the Department

The vision and mission of the Department of Industrial Engineering are as the following:

Vision: A premier center of excellence in the Kingdom of Saudi Arabia for industrial engineering education, training and research.

Mission: Nurturing competent and creative industrial engineering graduates through quality education based on Islamic values and ethics, and serving the society through research, consultancy, and publication.

2.2 Importance of the B.Sc. Industrial Engineering Program

The Kingdom of Saudi Arabia is undergoing rapid changes in various sectors of economy. In particular, manufacturing organization, engineering enterprises and organizations are becoming more complex. To be competitive in the global environment, the Kingdom of Saudi Arabia requires sufficient number of industrial engineers who are well trained to design, install, maintain and manage complex industrial/manufacturing/operation systems.

2.3 Educational Objectives

The Department of Industrial Engineering prepares graduates having ability to design, develop, implement and improve integrated systems comprising of people, equipment, materials, energy and information for serving the community. These graduates should:

1. Be effective in applying contemporary tools of industrial engineering to cater to the needs of upcoming challenges of the changing industrial world.
2. Advance their careers by way of exhibiting their professionalism, leadership qualities and effective oral and written communication skills.
3. Function effectively in diverse teams to handle problems pertaining to different industrial and managerial settings.
4. Demonstrate professional and ethical responsibilities towards their profession, society, and the environment.
5. Apply effectively e-media, computers and software in solving engineering problems.

2.4 Learning Outcomes

Learning outcomes which are related to skills, knowledge and behavior that students are expected to know and be able to do by the time of graduation. The Industrial Engineering program aims to provide the students with a learning experience that permits them to build up the following skills and abilities:

a) An ability to apply knowledge of mathematics, science, and engineering
b) An ability to design and conduct experiments, as well as to analyze and interpret data
c) An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability
d) An ability to function on multi-disciplinary teams
e) An ability to identify, formulate, and solve engineering problems
f) An understanding of professional and ethical responsibility
g) An ability to communicate effectively
h) The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
i) A recognition of the need for, and an ability to engage in life-long learning
j) A knowledge of contemporary issues
k) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

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3 Related Work

A brief overview of changes in the history of engineering education and the curriculum is discussed below.

Mullin and Wilson (2000) examine how the current system and its assumptions influence the goals, processes and outcomes of undergraduate education. Richard K. Lyons (2012) describes in detail the recent curriculum reform at UC Berkeley's Haas School of Business and outlines the process followed to achieve it and lessons learned. Magnoni, D. et al. (2012) discuss the philosophy and development of Olin College and the Olin College Library, and then to address its evolving materials collection. Jain, R and Chandrasekaran (2010) ilustrate the application of business process reengineering (BPR) and benchmarking principles to redesign an undergraduate course on BPR to achieve continuous improvements. Glassey and Hail (2012) describe a concentrated strategy to embed sustainability teaching into a (chemical) engineering undergraduate curriculum throughout the whole programme. Focus groups and diamond ranking have confirmed that students appreciate that sustainable development is a key issue for future engineers to understand and the case study workshops are a realistic, enjoyable and effective teaching method. Cotgrave and Kokkarinen (2010) describe the research and process used to develop a curriculum design guidance model that can be used to develop a sustainability literate construction curriculum in higher education. Thomson a, P. et al. (2012) explore the notion that knowledge is an important resources for vernacular educational reform.

Roxburgh, M. et al. (2008) present the review forms as a part of a larger study evaluating the 'fitness for practice' elements of the nursing curriculum. Systematic review methods were used including the databases. Desha, C.J. et al. (2010) present the method and results of a survey of 27 of the 33 Australian universities teaching engineering education, aimed to ascertain the extent of energy efficiency (EE) education, and to identify preferred methods to assist in increasing the extent to which EE education is embedded in engineering curriculum. Niesche and Jorgensen (2010) report on research into the challenges for leadership in implementation of a new curriculum in a remote region of Queensland, Australia. Gomes V. G. et al. (2006) identified a number of imperatives for curriculum change, and has used this stimulus to embark on the task of curriculum renewal. The curriculum was designed to incorporate an integrated framework for teaching all core concepts, enabling technologies and engineering practice paradigms.

Finally, it is clear from the previous studies that there is a shortage in research on the continuous improvement of industrial engineering curriculum.

4 Methodology

In order to ensure that the new revised curriculum fulfills the requirements of all stakeholders including students, industries as well the governing council, the following steps were taken: updating course syllabi, implementation of generic competencies, adding relevant personal and technical skills as well as conforming to accreditation, ministry of education and FE exam requirements. The newly designed and revamped curriculum is on par with the latest trends in Industrial Engineering and Technology and will help to achieve the requirements of the rapidly developing engineering job market in the region.

The study was conducted using two separate approaches:

a) **Field survey to identify job market requirements**

Student feedback, industry survey, opinions of subject matter expert faculty as well as conformance to both internal quality assurance systems as well as external accreditation (ABET) was the methodology adopted to revise the IE curriculum.

b) **Comparison of industrial engineering curriculums**

Benchmarking by comparison with other high ranked IE programs, both internal (within Saudi Arabia) and external (globally), was also utilized as a highly effective technique to assist in the restructuring process.

Field survey to identify job market requirements

The market survey was conducted from 15 December 2010 to 15 January 2011. A total of 21 companies were sampled for the survey. The questionnaires were sent either through e-mail (E) or direct personal visits (V). Only a total of eight respondents had positively cooperated and returned their responses. Even though the numbers is smaller than expected, but the respondents were key personnel in their respective organization. Among the respondents were practicing industrial engineers, and executives who were aware of the industrial engineering functions. These respondents represent manufacturing companies (3), services (2), and petrochemical industry (1), food industry (1) and telecommunication company (1).

The questionnaires were designed to enquire regarding these items: i) Objective and outcomes of the program and its relevance to the needs of industries and organizations, ii) Learning outcomes, iii) Fulfillment of theory and concepts (engineering science and design), and iv) Required specific knowledge for industrial engineers and career opportunities.

Comparison of industrial engineering curriculums

Comparison of curriculums was made among seven (7) selected universities from the Kingdom of Saudi Arabia, U.S.A, Canada and Malaysia as listed below:

1. King Abdulaziz University, K.S.A
2. King Saud University, K.S.A
3. King Fahd University of Petroleum and Minerals, K.S.A
4. University of Toronto, Canada
5. Rutgers – The State University of New Jersey, U.S.A
6. Purdue University, U.S.A
7. University Technology Malaysia

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5 Results of the Market Survey and the Comparison of Curriculums

5.1 Results of the Market Survey

i) Objectives and Outcomes of the Program and Its Relevance to the Needs of Industries and Organizations

On program educational objective (POE), the respondents scored 62% (substantial) and 38% (partial) for the relevancy of POE to the needs of their organizations. Similar scored was obtained for questions on the ability of PEO to address the integrated aspects of cognitive, technical and skillful performance as expected by the potential employers. This result indicates that the proposed POE should be acceptable.

ii) Learning Outcomes

On Learning Outcomes (LO), the respondents scored 87% (substantial) and and 13% (partial) for the relevancy of LO to meet the expectation of the organizations. Similar scored was obtained for questions on the ability of LO to address the integrated aspects of cognitive, technical and skillful performance as expected by the potential employers. This result indicates that the proposed LO should be acceptable.

The respondents suggested that Change Management and Balanced Scorecard to be included in the syllabus. These suggestions will be considered to be addressed in the course on Industrial Management. The respondents also noted that the students need to be taught on how to practice what they have learned. These suggestions will be addressed by having more industrial visits, emphasized on senior projects with industrial relevance, and implementation of 'capstone course'.

iii) Fulfillment of Theory and Concepts (Engineering Science and Design)

On questions related to fulfillment of theory and concepts of engineering science and design, the respondents supported that the proposed curriculum provide satisfactory coverage of theories and fundamental concept (37% scored fully; 63% scored partially) and they confirmed that the curriculum were relevant to the engineering practice (50% scored fully; 25% scored partially)

Surprisingly, when asked question on whether the program covers all expected courses that an industrial engineers should know, 37% scored "yes" and 67% scored "no". The respondents suggested the following courses/topics to be covered in the curriculum:

- Basic business and accounting
- Change management skills
- English report writing
- Quality management
- Management information system
- Entrepreneurship
- Production planning and control (PPC)
- Business process management and reengineering
- Job analysis and job description
- EXCEL programming

Some of the suggestions have been included in the proposed curriculum, but perhaps the respondents were misunderstood or unaware of the details contents. The curriculum has included courses on English report writing, Entrepreneurship, PPC, Job analysis (Work Study), and Excel Modeling (IER 202). However, the proposed curriculum will appropriately address the above suggestions.

iv) Specific Knowledge Related to Courses

Thermodynamics

A total of 57% of the respondents responded 'strongly agree' and 'agree' to the need of thermodynamic courses to be included in the I.E program. Those who did not agree were from services industry (Saudi Airlines). Respondents from SABIC, strongly agree the need to include thermodynamic into I.E program.

Control Engineering and Industrial Automation

A total of 72% of the respondents responded either 'agree' or 'strongly agree' to the need of Control Engineering and Industrial Automation. Those who disagree (28%) were from services industry (Saudi Airlines and marketing division of P&G).

Material Science

A total of 58% the respondents responded either 'agree' or 'strongly agree' the need to include Material Science in the I.E curriculum. Again those who did not agree were working in services function similar to as noted above.

Manufacturing Processes

A total of 86% the respondents responded either 'agree' or 'strongly agree' the need to include Manufacturing Processes in the I.E curriculum. None of the respondent disagree on the importance of this course for industrial engineering students.

Dynamics

Only 34% of the respondent agreed these courses to be included in the I.E curriculum. A total 33% disagreed and the remaining was 'neural'. This response indicates a course on dynamics relatively less crucial for industrial engineers.

Engineering Mechanics

All the respondents agreed that Engineering Mechanics need to be included in the curriculum.

Design for Manufacture and Assembly (DFMA)

A total of 86% of the respondents scored either 'strongly agree' or 'agree' on the importance of Design for Manufacturing and Assembly course to be included in the curriculum.

Project Management and Maintenance

A total of 86% of the respondents scored either 'strongly agree' or 'agree' on the importance of Project Management course to be included in the curriculum. As expected all respondent (100%) agreed on the importance of Maintenance to be included in the curriculum.

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Industrial Information Systems
All the respondents (100%) agreed that Industrial Information System to be included in the curriculum.

Entrepreneurship
A total of 86% of the respondents scored either 'strongly agree' or 'agree' on the importance of Entrepreneurship course to be included in the curriculum.

Computer Applications
A total of 77% of the respondents scored either 'strongly agree' or 'agree' on the importance of Computer Programming/Application course to be included in the curriculum.

Engineering Economy and Finance
A total of 86% of the respondents scored either 'strongly agree' or 'agree' on the suitability to integrate the traditional Engineering Economy with topics on Islamic Financial/Economy System.

v) Career Opportunities
On questions related to carrier opportunities, the respondents were requested to suggest the possible areas/functions where industrial engineering graduates will fit in their organizations. The following are their responses:

1. Production Planning and Control (PPC), Maintenance Planning, Procurement, and Quality Management.
2. Safety
3. Quality, PPC, Statistics, Productivity, and Management
4. Quality, Marketing Planning, Maintenance, Human Resource, Revenue Management, Work Study, Human Factor Engineering, Management Information System, and Forecasting
5. Quality, Planning, Productivity.

vi) **Limitation and Validity of Survey Findings**
The findings from this survey should be treated as indicative inputs to guide in the design of the proposed IE curriculum. This will complement the findings from benchmarking of industrial engineering programs from various universities, as it will be discussed next.

5.2 Results of the Comparison of Industrial Engineering Curriculums

The findings of the curriculum comparison among the selected universities are presented in this section. Detailed comparison is provided in Table I (Appendix).

i. King Abdulaziz University, Jeddah
King Abdulaziz University (KAU), Jeddah offers B.Sc in Industrial Engineering program which requires 155 credits for graduation (inclusive preparatory year, 27 credits). The year 2 to 5 covers 126 credits. The curriculum sufficiently includes most of the core industrial engineering courses. The program provides wide range of specialized industrial engineering electives courses. However, the program lacks of broad engineering sciences course such as static, manufacturing process, material science and thermodynamic. Lack of such courses may give disadvantage for graduates who will embark their career in multidisciplinary engineering/manufacturing organizations.

ii. King Saud University, Riyadh
King Saud University (KSU) provides a B.Sc. in Industrial Engineering program with manufacturing as its application domain. Students must satisfy a total of 160 credits for graduation. The curriculum includes common courses in engineering sciences such as engineering mechanics, mechanic of materials (customized for non- mechanical students), heat and fluid (customized for IE students) and engineering materials. The manufacturing related courses are manufacturing processes, CAD/CAM, and automated control system.

iii. King Fahd University for Petroleum and Minerals
College of Computer Science and Engineering, King Fahd University for Petroleum and Minerals (KFUPM) offers B.Sc. in Industrial and Systems Engineering which require 132 credits for graduation. It curriculum focuses on the science and technology of industrial systems. In particular the program emphasizes the analysis and design of systems to produce goods and services. The main study areas are; (i) manufacturing systems engineering (ii) operations research (iii) production systems and quality control, and (iii) human factors engineering.

iv. University Technology Malaysia
The University Technology Malaysia (UTM) offers Bachelor of Engineering (Mechanical-Industrial) program through its Faculty of Mechanical Engineering. The curriculum provides strong engineering background with many engineering science courses included, namely, statics, dynamics, mechanic of solid (2 courses), thermodynamics (2 courses), mechanics of fluids (2 courses), electrical technology, electronics, vibration and mechanic of machines, control engineering and instrumentation, manufacturing processes, and engineering design (4 courses). In the upper years, key industrial engineering courses are included. The total credit required for graduation is 134.

v. Purdue University
PurdueUniversity offers B.Sc in Industrial Engineering through its School of Industrial Engineering. The curriculum requires 123 credits for graduation. Purdue is rank number 3 among universities in the USA for its Industrial Engineering program. The curriculum includes engineering science courses, namely, mechanics (3 courses), thermodynamics, electricity and optics, and manufacturing processes. In the upper years, the curriculum provides flexibility where students make their own selection to specialize in any of these options: Human Factors Engineering, Manufacturing Engineering, Operations Research and Systems Engineering, Production and Management Systems Engineering.

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vi. Rutgers-The StateUniversity of New Jersey

The State University of New Jersey- Rutgers offers B.Sc. in Industrial and System Engineering which requires 129 credits for graduation. Its curriculum provides students with a broad engineering education along with specialization in the industrial engineering and manufacturing fields. Specialization is offered in mathematical modeling, quality engineering and statistical techniques, computer-aided design, computer-aided manufacturing, simulation, manufacturing processes, engineering economics, production planning and control, design of engineering systems and information technology. The required engineering science courses are statics, dynamics, mechanic of solids, electrical engineering, manufacturing processes, and mechanical properties of materials.

vii. University of Toronto

B.Sc. in Industrial (Systems) Engineering at University of Toronto provides fours streams of focus in third and fourth year. Students select one of four areas of academic focus, namely, information engineering, human factors, operations research and Bioengineering. In the early years, students study common mathematic and basic science courses. The program also includes engineering science courses such as mechanics, dynamics, material, and fundamentals of electrical engineering.

6 Proposed New Curriculum, Expected Number of Students, and Laboratory Requirements

6.1 Concept and Criteria for the New Curriculum

As noted earlier, the mission of the Department of Industrial Engineering is to nurture competent and creative industrial engineering graduates through quality education based on Islamic values and ethics. The concept and criteria for proposed curriculum are as follows:

a) Graduates from BSIE will have sound knowledge in broad engineering science and engineering design
b) Application domain for Industrial Engineering is manufacturing industries
c) Posses good technical and specialized knowledge in Industrial Engineering, in particular for integration of manufacturing/industrial systems using appropriate analytical, computational, and experimental practices.
d) The graduate should have sound analytical, problem and integration skills.

6.2 The New Curriculum

6.2.1 Proposed Changes to the Existing Curriculum

The basis of reference for the new curriculum is the B.Sc in Industrial Engineering offered in the Faculty of Engineering, KAU Jeddah. To accommodate the job market in the surrounding industrial areas, changes to the curriculum and course contents are needed. Specifically, the changes can be categorized as the following:

a) Introduce six (6) new courses
b) Modify/customize/combine thirteen (13) existing courses to become eight (8) courses
c) Remove two (2) courses
d) Rename one (1) course

Detail description of these changes is summarized in Table II (Appendix).

6.2.2 General Highlights of the Curriculum

The new curriculum provides students with general education, basic sciences, general engineering and specialized courses in industrial engineering. Technical and soft skills such as communication, team working and problem solving are equally emphasized. To widen the students' perspective, the curriculum also includes a ten-week summer training where students will be attached to various industrial and governmental organizations for real practical exposure. The number of credits required for graduation is 155 credits which normally can be completed within five years.

The study plan is divided into 10 semesters where the first two semesters (27 credits) are meant for preparing the students with foundation in mathematics and basic sciences. The total credit hours for year 2 to year 5 are fairly distributed among all the semester, i.e, between 14 to 17 credits per semester. To enforce students understanding, some courses requires tutorials and some are complemented with laboratory experiments. Details of the study plan are provided in Table 1 and the electives are given in Table 2.

6.2.3 Relationship between Learning Outcomes and Courses

The new curriculum is designed to provide the graduates with learning experiences towards achieving the learning outcomes as discussed in Section 4. The general relationship between the Learning Outcomes and the courses is as the following:

- Engineering science courses such as static, thermodynamic, electrical engineering, manufacturing process, workshop, control engineering and automation, and material science prepare graduates necessary knowledge and skills to identify, formulate and solve engineering problems. These also prepare the graduate the ability to function in multi-disciplinary teams as commonly found in the workplace.
- Courses on statistics, design of industrial experiments prepare the graduate the ability to design, conduct, analyze and interpret results.
- The course on introduction to engineering design prepares the graduates the ability for systematic problem system, team work and life-long learning.
- Knowledge of contemporary issues can be gained through Senior Project I where the students are required to write literature review and deliver a seminar on contemporary issues when preparing project proposal. Senior project II will train the students to apply industrial engineering tools and techniques to solve practical problems.
- Issues related to health, safety and environment are

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covered in a course on ergonomics and safety engineering

- Topics on maintenance, design for manufacturing and assembly will expose the student to the issues related to sustainability and manufacturability.
- The understanding of professional and ethical responsibility is to be embedded in courses on Islamic Culture.

6.3 Expected Number of Students

It is projected that the Department of Industrial Engineering will enroll 25% of the students admitted to the Faculty of Engineering. This plan will result in 90 students for the academic year 2012-13(1433-34 H), 120 in 2013-14 (1434-35 H), 150 in 2014-15 (1435-36 H), 170 in 2015-16 (1436-37 H) and finally stabilized at 180 students for the academic session 2016-17 (1437-38 H) onwards. This projection assumes students will be admitted into the department in the 5th semester of their study plan (year 3).

6.4 Requirement for Laboratories

The Faculty of Engineering at Rabigh has embarked on rigorous procurement for modern teaching and research facilities. These include equipment for engineering design, work design, ergonomics, quality engineering, industrial modeling and industrial computing. In addition, common facilities and workshops in mechanical and electrical engineering departments will also be used by industrial engineering students.

7 Conclusion and Future Work

It is the right time for the Kingdom of Saudi Arabia to have a top notch undergraduate program in industrial engineering conforming with the industry needs of the region. The existing three Saudi's universities who are currently offering industrial engineering/industrial systems engineering programs produce insufficient number of industrial engineers compares to the job market requiements. The Kingdom of Saudi Arabia is still relying heavily on foreign engineers to serve in various manufacturing and industrial functions. The proposed new curriculum has its uniqueness as it was designed to match the knowledge and skills arequired by the surrounding industries.

Related to this paper, another study will be conducted that will discuss the transformation of the education process from traditional to applied engineering at the Department of Industrial Engineering, Faculty of Engineering, KAU Rabigh.

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References

[1] Mullin, R.; and Wilson, G. (2000). Quality of undergraduate education examining the current paradigm and system. Journal of Quality Management, 5, 225-246.

[2] Weber J. M. (2011). Enhancing business education through integrated curriculum delivery. Journal of Management Development. 30(6), 558-568.

[3] Lyons R. K. (2012). Curriculum reform: getting more macro, and more micro. Journal of Management Development. 31(4), 412-423.

[4] Magnoni, D. et al. (2012). Creating a materials samples collection to support the engineering curriculum. Journal of Management Development, Library Management. 33(8/9), 511-524.

[5] Jain, R.; and Chandrasekaran, A. (2010). Benchmarking the redesign of "business process reengineering" curriculum. Benchmarking: An International Journal. 17(1), 77-94.

[6] Glassey, J.; and Haile, S. (2012). Sustainability in chemical engineering curriculum. International Journal of Sustainability, 13(4), 354-364.

[7] Cotgrave, A.; and Kokkarinen, N. (2010). Developing a model promoting sustainability literacy through construction curriculum design. Structural Survey, 28(4), 266-280.

[8] Thomson a, P. et al. (2012). Creativity and cross-curriculum strategies in England: Tales of doing, forgetting and not knowing. International Journal of Educational Research, 55, 6–15.

[9] Roxburgh, M. et al. (2008). A review of curriculum evaluation in United Kingdom nursing education. Nurse Education Today, 28, 881–889.

[10] Desha, C.J. et al. (2010). Surveying the state of higher education in energy efficiency, in Australian engineering curriculum. Journal of Cleaner Production, 18, 652–658.

[11] Niesche, R.; and Jorgensen, R., (2010). Curriculum reform in remote areas: the need for productive leadership. Journal of Educational Administration, 48(1), 102-117.

[12] Gomes V. G. et al. (2006). Chemical engineering curriculum renewal. Education for Chemical Engineers, 1, 116–125.

[13] Paramasivam, Sivajothi, and Kanesan Muthusamy. "Study of Critical Success Factors in Engineering Education Curriculum Development Using Six-Sigma Methodology." Procedia - Social and Behavioral Sciences 56 (2012): 652-61. Web

[14] Hassan, Adnan "Report for the Dean", Faculty of Engineering, King Abdulaziz University, 2011.

[15] Sari, Zaki. "A New Curriculum for Manufacturing & Industrial Engineering and Engineering Management for BS and MS Degrees." Procedia - Social and Behavioral Sciences 102 (2013): 560-67. Web

[16] Shafeek.H, Mohammed Aman and Muhammad Marsudi "From Traditional to Applied: A Case Study in Industrial Engineering Curriculum" International Conference on Advanced Information and Communication Technology for Education (ICAICTE 2013)., Hainan, China. September 20-22, pp.461-470,2013

[17] Michael Hill, a Kyle Boone,b Rajib Anwar et al. " presented The Future of Chemical Engineering Design: Impact of Faculty Makeup and Industrial Needs" Proceedings of the 8th International Conference on Foundations of Computer-Aided Process Design – FOCAPD 2014 July 13-17, 2014.

[18] Yusuf Ziya Ünal, Özgür Uysal "A new mixed integer programming model for curriculum balancing: Application to a Turkish university" European Journal of Operational Research 238 -339–347, 2014.

Appendices

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Table I: Comparison of Industrial Engineering Curriculums

Category		KAU Jeddah	UTM	Rutgers University	Purdue University	King Saud University	KFUM	University of Toronto
Total Credits		155 (132)	134	129	123	160	132	
Degree		B.S. Industrial Engineering	B.Eng (Mechanical-Industrial)	B.Sc Industrial and Systems Engineering	B.S. Industrial Engineering	B.S. Industrial Engineering	B.Sc. Industrial and Systems Engineering	B.Sc. Industrial (Systems) Engineering
General Education (Language, Social Science)	Language-English	English Language 1 English Language II	English for Acad Com; Advanced English for Acad Comm; English Elective	Expository Writing; Sci & Tech Writing	English Composition	English Language for Eng. & Comp. St. -1-; English Language for Eng. & Comp. St. -2-	English Language (9 cr)	Engineering Strategies and Practice I
	Language-Arabic	Arabic Language (1) Arabic Language (2)			Fundamentals of Speech Comm	Language Skills	Arab Studies (6 credits)	
	Islamic / Humanities	Islamic Culture (I) Islamic Culture (3) Islamic Culture (4) Islamic Culture (2)	Humanity Elective; Ethnic Relations; Islamic Institutions/ Islamic & Current Issues;	Hum/Soc Elective 1; Hum/Soc Elective 2;	General Education Elective (optional)	-Intro to Islamic Culture; -Islam and Society; -Fundamentals of The Islamic Political System;	Islamic Studies (8 cr) Physical Education (2 cr)	Complementary Studies Elective [2]
	Writing/Comm	Technical Writing Comm. Skills	TITAS; Co-Curriculum I; Co-Curriculum II	Hum/Soc Elective	Freshman Engineering Lectures	Expository Writing		Engineering Strategies and Practice II
Mathematics and Basic Sciences	Chemistry	General Chemistry I General Chemistry Lab		Gen Chem for Eng; Gen Chem for Eng	General Chemistry;	General Chemistry -1-		One science elective [3]
	Math	Calculus I; Calculus II; Calculus III ; Calculus IV; Differential Equations I; Linear Algebra;	Calculus; Engineering Mathematics; Differential Equation	Multivar Calc; Diff Eqns Eng & Ph; Calc Math Phys Sci; Calc Math Phy Sci;	Analytic Geometry and Calculus I; Analytic Geometry and Calculus II; Linear Algebra; Ordinary Differential Equations; Multivariate Calculus	Calculus for Engineering; Differential Equations for Engineering Students; Numerical Methods Differential Calculus; Integral Calculus; Algebra & Analytic Geometry	Mathematics (14 cr) Numerical Methods (3 cr)	Calculus 1; Calculus II; Linear Algebra; Differential Equations; Algorithms and Numerical Methods
	Physics	General Physics I General Physics Lab General Physics II		Analytic Phys IIA; Analytic Physics I; Analystic Physics IIA Analytic Physics IIB; Anal Physics II Lab			Physics (8 cr)	
	Biology	General Biology I						Engineering Biology
	Statistics	General Statistics; Prob. and Eng Statistics; Engineering Statistics;	Data Analysis in Ind. Engirg	Intro to Engr; Eng Probability;	Probability and Statistics I; Probability and Statistics II;	Engineering Probability and Statistics	Engineering Probability & Statistics (3 cr); Engineering Statistics (3 cr)	Probability and Statistics with Engineering Applications;

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Category		KAU Jeddah	UTM	Rutgers University	Purdue University	King Saud University	KFUM	University of Toronto
Computer	Computing	- Computer Skills; - Structured Computer Programming ; -Fund of Computer Sys; -Computer Applications in Industrial Engin I -Computer Applications in Industrial Engineering II	Programming for Engineers	Intro to Computers	Programming Applications for Engineers; Intro to Computer Tools for Engr; Computing in IE	Computer Programming; Computer Application in Engineering; Industrial Information Systems Computer Aided Manufacturing; Computer Integrated Manufacturing	Computer Programming (3 cr) Fundamental of Database Systems ; Computer Control Systems	Computer Programming; Data Modelling Design and Analysis of Information Systems
Engineering Sciences	Intro to Engineering							Introduction to Mechanical and Industrial Engineering;
	Statics		Statics;	Engr Mech Statics;				
	Dynamic		Dynamics	Eng Mech – Dyn;				Dynamics
	Mechanics		Mechanics of Solids I; Mechanics of Solids II;	Mech of Solids;	Basic Mechanics I; Modern Mechanics; Mechanics of Materials;	Engineering Mechanics; Mechanics of Materials for non-ME students		Mechanics;
	Thermo		Thermodynamics I; Thermodynamics II;		Thermodynamics I;	Heat and Fluid for IE Students		
	Fluid		Mechanics of Fluids I; Mechanics of Fluids II;					
	Electrical	Basic Electrical Engineering	Electrical Technology; Electronics;	Elements of EE;	Electricity and Optics; Linear Circuit Analysis I	Electric Circuits and Machines	Electrical Circuits (4 cr)	Electrical Fundamentals
	Vibration		Vibration & Mechanics of Machines;					
	Control Eng		Control Engineering; Instrumentation	Comp Contr Mfg Sys; Comp Contr Lab	Industrial Control Systems	Automatic Control Systems	Linear Control Systems	
	Materials		Materials Science;	Mech Prop Materials		Introduction to Engineering Materials	Material Science (4 cr)	Applied Science: Materials
	Manuf Proc		Manufacturing Processes	Mfg Processes; Mfg Processes Lab	Manufacturing Processes I	Manufacturing Proc 1; Manufacturing Proc 2	Manufacturing Technology (4 cr)	Manufacturing and Production Systems
	Workshop	Basic Workshop	Engineering Workshop			Workshop		
	Laboratories		Laboratory I; Laboratory II; Laboratory III; Laboratory IV	Intro to Experiment;				

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Category		KAU Jeddah	UTM	Rutgers University	Purdue University	King Saud University	KFUM	University of Toronto
Engineering Design		Engineering Drawing; Intro to Eng Design I; Intro to Eng Design II	Component Design ; Engineering Drawing; Introduction to Design; Design for Mfg and Assembly	Eng Graphics; Design of Eng Syst I;	Design I; Industrial Engineering Design	Basics of Engineering Drawing; CAD / CAM; Design of Manufacturing Systems	Industrial Engineering Design Engineering Graphics (2 cr)	
Management		Engrg Management; Industrial Management	Engineering Management; Project Mng& Maintenance			Safety Engineering Management		Organization Design
Specialized IE courses	Eng. Economy & Costing	Engineering Economy	Engineering Economics	Econ Prn & Prob; Eng Economics; Acct for Eng	Engineering Economics;	Enginering Economics; Manufacturing Economics; The Islamic Economic System	Engineering Economics; Principles of Industrial Costing;	Engineering Economics and Accounting
	Operation Research	Operations Research I; Operations Research I	Deterministic Operation Research; Nondet Operation Research	Prob Models in OR; Deter Models in OR;	Oper Res - Optimization Oper Res - Stochastic Models		Opers Resch I (4 cr); Opers Research II (3 cr) ; Stochastic Systems Simulation ; Optimization Methods (3 cr) Introduction to I&SE	Operational Research I;
	Quality	Indust. Quality Control; Design of Industrial Experiments	Productivity and Quality Eng.; Advanced Quality Engineering	Quality Eng & Stat; Quality Eng Lab		Statistical Quality Control; Design of Experiments; Engineering Reliability & Maintenance	Quality Control and Industrial Statistics (3 cr)	Methods of Quality Control and Improvement; Statistics and Design of Experiments
	Integrated Production Sys	Prod. Plan and Control; Facilities Planning; Industrial System Simulation	Production Planning & Control; Facility Design	Simulat Models IE; Production Plan & Control; Facility Layout & MH	Integrated Production Systems I	-Introduction to Planning and Control; -Industrial Operation Analysis -1- -Industrial Operation Analysis -2-; -Industrial Operations Analysis -3- -Inventory Control and Production Planning; -Scheduling of Industrial Operation; -Industrial Systems Simulation -Industrial Facility Design; Operations of Manufacturing Systems	Production Systems (3 cr) ; Facility Layout and Location (3 cr) Modeling and Simulation (3 cr) Stochatics Systems Simulation (3 cr)	Systems Modelling and Simulation Integrated System Design; Resource and Production Systems; One Capstone Course *

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Category		KAU Jeddah	UTM	Rutgers University	Purdue University	King Saud University	KFUM	University of Toronto
Specialized IE courses	Work Study/ Ergonomics	Work Study; Human Factors Engineering	Work Design; Ergonomics and Safety	Work Design & Ergo; Work Des Lab; IE Lab	Work Analysis and Work Analysis and Design II	Work Design and Analysis; Human Factors Engineering	Methods Engineering (3 cr)	Human Centered Systems Design; Industrial Ergonomics and the Workplace;
	Industrial Safety	Industrial Safety Engrg						
Senior Project		Senior Project	Undergraduate Project I; Undergraduate Project II			Project I Project II	Senior Project (3 cr)	Thesis
Electives		Elective 1; Elective II; Elective III	IE Elective	Tech Elect 1; Tech Elect 2	General Elect 1; GE 2; GE 3; GE 4; GE 5; GE 6; Tech Elective 1; Tech Elective 2; Tech Elective 3 IE 470 / IE 484 IE 470 / IE 484 / IE 4xx / IE 5xx			4 course (12 credits) (according to streams)
Summer Training		Summer Training	Industrial Training					
Entrepreneurship			Entrepreneurship					
Seminar /Prof Eng Practice		IE Seminar	Professional Engineering Practice		Industrial Engineering Seminar		Seminar	

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Table II: Proposed Changes to the Existing Curriculum for B.Sc. in Industrial Engineering

No.	Type of Change	Course Name	Justification
1	New Courses	1. Control Engineering and Automation (3 credits)	Automation is becoming common in industrial workplace.
		2.Project Management and Maintenance (3 credits)	Many activities in industries and organization nowadays are treated as project, rather than normal production/operations (routine) management. Maintenance is importance to ensure reliability and sustainability of the equipment, machineries and facilities.
		3.Thermodynamics (3 credits)	Important for industrial engineers to function effectively within multi-disciplinary (team work) industrial environment
		4. Material Science (3 credits)	Important for industrial engineers to have good understanding on materials used in manufacturing processes
		5.Manufacturing Processes (3 credits)	Very important for industrial engineers who work in manufacturing industries.
		6.Design for Manufacture and Assembly (3 credits)	Provide integrated knowledge on design and manufacturing which is required for realization of competitive and quality products into the market
2	Courses to be Combined / Customized/ Modified	1. Intro to Engineering Design I ; (IE 201 ; 3 credits) 2..Intro to Engineering Design II ; (IE 202; 2 credits)	A total of 5 credits on these generic courses is too much. These two course are to be combined/customized into one 3 credit course, and renumbered as IE 203 (Intro to Engineering Design)
		3.Probability and Engrg Statistics (IE 331; 3 credit) 4.Engineering Statistics (IE 332; 3 credits) 5.Industrial Quality Control (IE 431; 3 credits)	Currently, there are three statistics related courses, namely, Probability and Engineering Statistics (IE 331; 3 credit), Engineering Statistics (IE 332; 3 credits) and Industrial Quality Control (IE 431; 3 credits). These courses are to be merged into 2 courses and to be known as Probability and Engineering Statistics (IE 333; 3 credits) and Industrial statistics and Quality Control (IE 432; 3 credits). Overlapping topics will be minimized.
		6.Engineering Management (IE 256; 2 credits) 7.Industrial Management (IE 351; 3 credits)	These two courses have some overlapping topics. As such, topics related and project planning and management can be more effectively covered in newly introduced course on Project Management and Maintenance. Topics on team work and problem solving are also covered in Introduction to Engineering Design. Topics on motivation and leadership are to be covered in Industrial Management and Entrepreneurship (new course).
		8.Engineering Economy (IE 255; 3 credits)	The contents of this course will be improved to include Islamic perspective on financial/economy system.
		9.Work Study (IE341; 3 credits)	Renamed as *Work Design* to show the emphasize of the course is on the design of job and workplace. Jig and fixture design are to be included in the course since they influence the methods of doing works.
		10.Human Factors Engineering (IE 342; 3 credits) 11.Industrial Safety Engineering (IE 441; 3 credits)	These two courses are to be merged and renamed as *Ergonomics and Safety Engineering* (3 credits). The course will focus on workplace ergonomics, manual handlings, environmental ergonomic, and key topics on safety engineering such as OSHA etc.
		12. Senior Project (IE 499; 4 credits)	This course will be implemented in two parts, namely, Senior Project I (1 credit) which focuses on literature review and project proposal, and Senior Project II (3 credits) which will focus on design and development (project implementation)

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		13.Facilities Planning (IE 453, 3 credits)	This course is renamed as Facility Design and to customize it to make the course as a capstone course which integrates various perspectives of integrated manufacturing/ operation system taught in earlier years.
3	**Course to be renamed**	Computer Application in Industrial Engineering II (IE 323; 3 credits)	Renamed as *Industrial Information Systems* to show the focus of the course on design and development of database systems for industrial engineering,
4	**Courses to be Deleted**	Fundamental of Computer System (IE 321; 3credit)	It is suggested that the contents should be covered in other computer related courses such as CPIT 100 (computer skills)
		IE Seminar (IE 393; 1 credit)	Knowledge of contemporary issues can be gained through Senior Project I where the students are required to make literature review and delivering a seminar on contemporary issues when preparing project proposal.