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A Masters Programme in telecommunications management – demand-based curriculum design

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This paper presents a curriculum design approach for a Masters Programme in Telecommunications Management based on demand data obtained from surveying the needs of potential students of the proposed programme. Through online surveys disseminated at telecom companies in Jordan, it was possible to measure the demand for such a programme and to determine the required programme contents and specifications. The curriculum design is based on definition of programme outcomes and on using a house of quality approach (HOQ) to determine the list of courses required in the programme. Surveyed competencies are mapped to a long list of proposed courses in a HOQ in order to determine the importance of each of these courses. A final list of core and elective courses is then developed considering the contribution to programme outcomes and the academic standards.

Keywords: curriculum development; house of quality; quality function deployment; demand analysis; industry-oriented curricula

1. Introduction

It has been realised in many engineering programmes worldwide, that non-engineering skills and disciplines such as soft skills and knowledge in business subjects, are all very important for success in industry (Black 1994; Denton 1998). This means that programmes oriented towards industry must develop in students a wide range of these professional skills, in addition to teaching sufficient knowledge of the engineering concepts - a set of tasks that is usually hard to achieve in a single degree programme.

In addition, the design of higher education programmes that address the needs of stakeholders and at the same time meet the required academic standards is a challenging task. These are often in conflict due to the wide range of inputs that need to be considered such as the academic standards of the university as well as internationally recognised requirements and academic expectations such as those set by international accreditation bodies (Milne 1994; Lang et al.

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1999; Callahan and Pedigo 2002; Brumm, Hanneman, and Mickelson 2006; Engineers Ireland 2007; The IET Handbook 2009; Wilcox and Wilcox 2010, Higher Education Accreditation Commission (HEAC) Guidelines).

Significant research has been performed on the design of industry-oriented engineering programmes (Coll 1994; Brumm, Hanneman, and Mickelson 2006; Teixeira 2006; Loades 2009; Morse and Flanigan 2009; Watson, White and Lyons 2010). Most of these were based on surveys to quantify expectations of industry of the required knowledge, skills and competencies of graduates. One of the most important approaches used to design engineering curricula based on survey data is the house of quality (HOQ) approach, which relates customer requirements (CR) (industry needs) to design requirements (programme courses) in a conceptual matrix (Boonyanuwat et al. 2008; Sohn and Kim 2009). The result of this approach is a list of courses ranked according to the needs of industry and where the interrelationship between these courses is determined.

In this paper, a design methodology for the curriculum of a new Masters Programme in Telecommunications Management at the Department of Telecommunications Engineering-Yarmouk University in Jordan is presented. The methodology is based on optimising the list of courses of the programme taking into account the prioritised industry requirements obtained from a HOQ approach while simultaneously meeting the academic standards and programme development guidelines of the University. Prioritised industry requirements are obtained from a demand survey through an online questionnaire which was disseminated among staff of telecommunications companies. The questionnaire was used to collect data about the importance of a number of skills and competencies to be offered by the programme. In addition, the demand questionnaire was used to determine programme specifications with regard to the duration of study, location of the programme, modes of study, teaching methodologies and other items.

The remainder of this paper is organised as follows: Section 2 gives a general introduction to the HOQ approach and discusses how it may be applied to curriculum design, Section 3 details the curriculum design process followed during this project using demand data and Section 4 provides conclusions.

2. Curriculum design using the HOQ

2.1. *The HOQ*

The HOQ is the most commonly used tool under the heading of Quality Function Deployment (QFD) techniques (Sullivan 1986; Akao 1997; Boonyanuwat et al. 2008; Sohn and Kim 2009; Abyaneh, Nojehdehi, and Alem 2012). QFD techniques are based on relating the needs of customers obtained through surveys to design requirements. The purpose of QFD is to deliver value by quantifying customers' needs and using them in the development of products as well as in manufacturing processes and control systems (Sullivan 1986; Hill 1994).

A HOQ is a conceptual matrix that relates CR (the 'whats' of a design problem) to design requirements (the 'hows' of the problem). Data on CR are usually collected through focus groups or surveys and is used to determine the relative importance of these requirements. The relative importance of CR is calculated using simple methods such as the arithmetic mean or more complex tools like the analytic hierarchy process (Abyaneh et al. 2012, Nojehdehi, and Alem 2012).

Figure 1 shows a conceptual diagram of a HOQ (of general applicability – we shall discuss the particulars of applying HOQ to curriculum design later in this section). The house consists of a *Relationship Matrix field, Prioritised CR* and a *Roof*. The Relationship matrix relates each technical requirement (TR) (top of the matrix) to each CR (left column of the matrix) using scores: 1, 3 and 9, where 1 represents a weak relationship, 3 represents a moderate relationship and 9 represents a strong relationship (Maguad 2009).

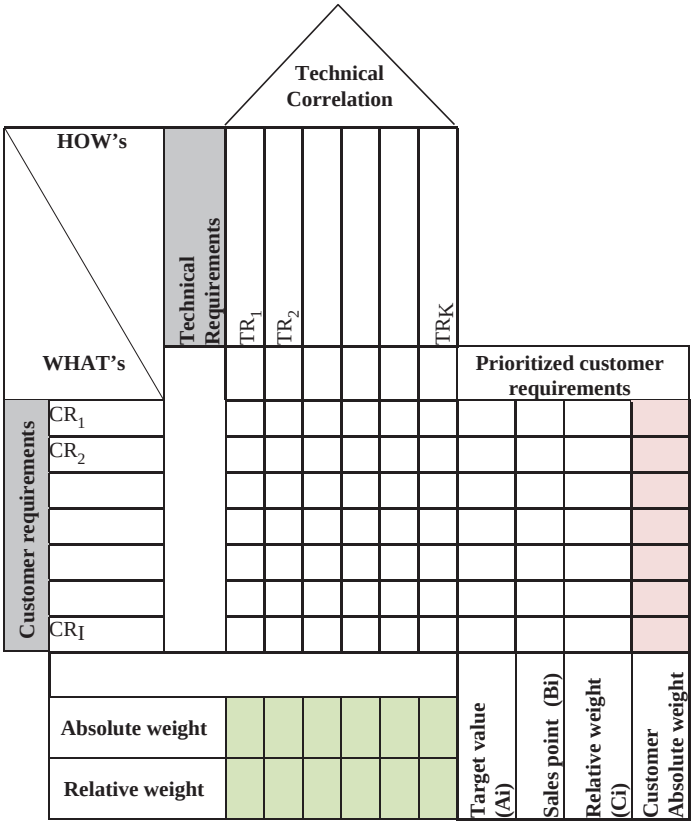

Figure 1. House of quality.

In the *Prioritised CR* field, the absolute weight of CRs is calculated by considering three values; the relative importance, the target value and the sales point. The relative importance is a score on a scale of 1–5 and is obtained from ranking the importance of each CR based on survey data. A target value indicates relevance on a scale 1–5 and is determined from comparison of the product to competitors' products. The sales point indicates the marketing point of the CR on a scale 1–2 (Sullivan 1986).

Each CR can then be assigned a customer absolute weight, denoted CAW_i, which is calculated as (Sohn and Kim 2009):

$$\mathrm{CAW}_i = A_i B_i C_i, \tag{1}$$

where A_i is the target value of CR_i; $B_i$is the sales point value (score of gap value of CR_i) and C_i is the customer importance of CR_i.

The absolute weight of the kth TR, denoted AW_k, is calculated as:

$$\mathrm{AW}_k = \sum_{i=1}^{I} R_{ik} C_i, \tag{2}$$

and the relative weight of the k^{th} TR denoted RW_k is calculated as:

$$\mathrm{RW}_k = \sum_{i=1}^{I} R_{ik} \mathrm{CAW}_i, \tag{3}$$

where RW_k is the Relative Weight of TR_k and R_{ik} is the relationship value between TR_k and CR_i.

The roof of the HOQ describes the interrelationship between the TRs which can be used to make decisions on which, if any, TRs need to be removed or merged. In the context of curriculum design, the roof is usually useful in determining the overlapping and the prerequisite relationships among courses (Sohn and Kim 2009).

2.2. *HOQ for curriculum design*

In the context of design of curricula for academic programmes, the CRs usually refer to preferred competencies or programme outcomes as identified by potential students or employer while the TRs refer to programme courses as identified by relevant academics (Boonyanuwat et al. 2008; Maguad 2009; Sohn and Kim 2009). Therefore, the list of suggested courses can be mapped to the surveyed competencies using a HOQ. The target value (A_i) can be obtained from a gap analysis which can be performed using surveys of competing programmes. The relative importance (C_i) of a given competency (CR) can be obtained by surveys where potential students and/or their employers are asked to rate the importance of each competency while sales point data (B_i) can be obtained from student opinion (Sohn and Kim 2009). The relationship values (R_{ik}) are determined by assessing the contribution of each of the courses to the programme competencies, that is R_{ik} represent the score of the contribution of course k to competency i.

Therefore, using these values, each course can be assigned either an absolute or relative weight, and hence the programme courses can be ranked according to their importance to the overall programme, which allows the design of the curriculum based on the needs of its customers as will be seen in the following sections. In our implementation we did not use target value data (A_i) or sales point data (B_i) and our HOQ is built using relative importance data (C_i) only.

It is important to note that this approach leads to a programme that is solely based on the demand by customers (potential students). In many situations, this must be treated with caution as the opinion of these customers is often based on a relatively short-term desire to familiarise themselves with current prevailing technology (which can change very rapidly). Therefore, it is important to couple the HOQ approach with other inputs to the curriculum design process such as the academic standards of the university and internationally recognised academic standards such as those set by international accreditation bodies (Engineers Ireland 2007; The IET Handbook 2009). These are generally more long-term and fundamental in their intent.

3. Curriculum design process

The design of the curriculum was subject to the constraints and the academic standards set out in the accreditation requirements in Jordan by the HEAC guidelines (2010). These requirements specify that any Masters Programme must have the minimum components given in Table 1. The credit hour system adopted in Jordan specifies the number of contact hours per week for the period of an academic semester which lasts for 16 weeks (including all study and examinations).

Therefore, the design problem was to determine the list of core and elective courses considering these requirements, and at the same time, the relevance of the courses to surveyed competencies and the contribution of courses to standard programme outcomes.

The comprehensive exam relates to an examination that takes place at the end of the programme that assesses the student overall knowledge of the programme. While mandatory, it is not a weekly activity and the credit hour total of zero reflects this.

Table 1. Accreditation minimum requirements.

Curriculum component	Min credit hours
Compulsory courses	21
Elective courses	9
Masters project	3
Comprehensive exam	0
Total credit hours	33

Figure 2 shows a diagram of our curriculum design process which considers all the above constraints simultaneously. The process initiates with the development of a list of academic standards using three inputs throughout the process, (1) the demand questionnaire survey, (2) the accreditation requirements and (3) the programme outcomes. The list of courses is first mapped to the surveyed competencies in a HOQ where a score for each of the courses is obtained and the courses are ranked according to their relative weights. Then, according to the HEAC guidelines and the relative weight of the courses, the list is divided into two subsets; the first is the core courses subset and the second is the elective courses subset (the courses with higher score are assigned as core and those with the lowest score are assigned as elective). The next step is to map the courses to the programme outcomes in order to ensure that these are all fully met. Another HOQ is used to assess this. This process of dividing the list of courses into core and elective ones is repeated until the programme outcomes are met satisfactorily, at which point the final list of courses has been identified.

The following subsections explain how these steps were followed leading to the final design of the curriculum.

It is important to note that the above approach was designed in order to accommodate the potentially conflicting requirements of both academia and industry. The overall methodology of the curriculum design process is based on using the demand data to specify the programme courses and then iteratively manipulating the list based on their contribution to the programme outcomes as well as the accreditation requirements and the university guidelines. This allows the optimisation of the list of courses in order to achieve the overall objective of designing a Masters Programme that meets the industry requirements and at the same time satisfies the academic standards. Therefore, the curriculum design methodology puts equal emphasis on meeting the industry demand and the academic standards which include the accreditation guidelines and the formulated standard programme outcomes of the programme. This facilitates keeping the programme relevant in the future given that the industry demands are changing continuously (especially in the field of telecommunications),

3.1. *Demand analysis*

The Demand analysis of the proposed programme was conducted through an online questionnaire which was disseminated among potential students working at telecom companies in Jordan, as well as their employers.

The questionnaire aimed to capture the market needs by collecting statistical data on the required skills and knowledge of graduates as well as on desirable programme specifications and structure. In this questionnaire, the respondents were asked to evaluate the importance of 20 competencies that may be offered by the proposed programme. These competencies are given in Table 2 and were identified through several brainstorming sessions with telecommunications industry represntatives. The importance of competencies was based on a Likert scale from 1 to 5 (1 = 'totally disagree', 2 = 'disagree', 3 = 'neutral', 4 = 'agree' and 5 = 'totally agree').

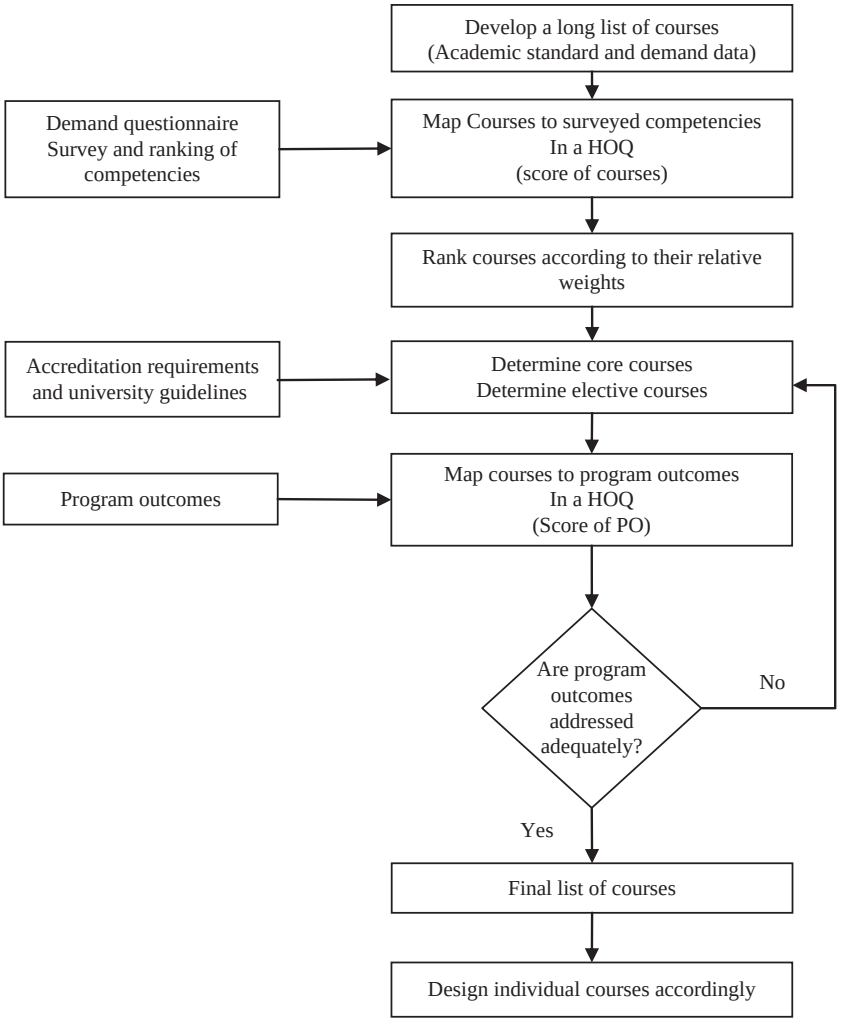

Figure 2. Curriculum design process.

The online questionnaire was developed using an open source tool: Lime Survey 2013 and was disseminated among engineers working across a wide spectrum of telecommunications companies in Jordan by email, phone calls and personal contacts over a span of three months. About 200 respondents accessed the questionnaire and it was completed by 115 of them. Out of these, 19 did not evaluate the proposed competencies and were removed from the analysis. Therefore, the total number of completed responses was 94.

The result of the demand questionnaire regarding the ranking of competencies is given in Table 3 where the arithmetic mean was used to rank the competencies presented in the questionnaire.

3.2. *Programme outcomes*

The next step towards the design of the curriculum of the proposed programme was to formulate a set of programme outcomes in order to guide the curriculum design process. A number of

Table 2. List of competencies that may be offered by the proposed programme.

ID	Competency
A1	Competition in the telecom market
A2	Management of telecom networks
A3	Service flow and logic
A4	Soft skills
A5	Knowledge on future telecom industries
A6	Language skills – English
A7	Management, project management, team management
A8	Regulations and Policies
A9	Financial and admin management
A10	IT and computer skills
A11	Telecom market knowledge
A12	Organisation theory
A13	Planning and optimisation
A14	Research methodology
A15	Human resource management
A16	Total quality management
A17	Accounting, economics, finance
A18	Entrepreneurship
A19	Business technology strategy
A20	Marketing and financial management

Table 3. Ranking of the surveyed competencies using the arithmetic mean.

Rank	ID	Topic	Mean	St. Dev.
1	A2	Management of telecom networks	4.39	1.17
2	A7	Project management	4.32	1.08
3	A5	Knowledge on future telecom industries	4.27	1.09
4	A13	Planning and optimisation	4.24	1.00
5	A4	Soft skills	4.12	0.92
6	A11	Telecom market knowledge	3.99	0.78
7	A12	Organisation theory	3.96	0.78
8	A6	Language skills – English	3.95	0.86
9	A14	Research methodology	3.83	0.69
10	A3	Service flow and logic	3.77	0.69
11	A9	Financial and admin management	3.74	0.63
12	A16	Total quality management	3.74	0.68
13	A8	Regulations and Policies	3.67	0.70
14	A19	Business technology strategy	3.67	0.70
15	A10	IT and computer skills	3.67	0.62
16	A20	Marketing	3.56	0.59
17	A15	Human resource management	3.44	0.53
18	A1	Competition in the telecom market	3.36	0.49
19	A18	Entrepreneurship	3.31	0.43
20	A17	Accounting, economics, finance	3.20	0.43

international sources were considered in the design of these outcomes, such as the standard outcomes of Engineers Ireland (2007) and the Institute of Engineering and Technology (IET) (The IET Handbook 2009). The detailed description of each outcome was formulated considering the demand data regarding the fields of knowledge, competencies and skills of students. Table 4 presents the formulated set of programme outcomes for the proposed programme. These outcomes cover knowledge, skills and competencies intended to be achieved by potential students of the programme.

Table 4. Programme outcomes.

Programme outcome	Outcome description
A	Knowledge and understanding of the basic management sciences including principles of math, statics and management science to solve telecommunication management problems. This will include knowledge and understanding of
Basic management sciences	(1) Accounting and financial issues (2) Organisational behaviour (3) Leadership behaviour (4) Business research methods (5) The structure of the telecommunications network –wired and wireless
B	The ability to identify, formulate and solve telecommunications management problems. The graduate shall be able to
Problem solving	(1) Apply appropriate engineering methods to ill-defined problems in telecommunication network deployment, operation and maintenance (2) Integrate people, knowledge, telecommunications technology, equipment and resources, and formulate judgments with incomplete and limited information (3) Create models for telecommunications network to evaluate performance with proper regard given to the underlying assumptions and limitations (4) Apply practical thinking processes to develop leadership and management skills (5) Apply software tools to solve telecommunications management problems
C	The ability to design processes to meet telecommunications industry needs. The graduate shall display
Design	(1) Knowledge and understanding of telecommunication network design processes and techniques and understanding of how to apply them in unfamiliar situations (2) Ability to apply design methods to unfamiliar ill-defined problems including the choice of technology and possibly involving other disciplines such as IT and civil engineering projects (3) Knowledge and understanding of industry-standard technologies as well as the related codes of practice and standards and the need for their enforcement (4) Ability to integrate systems of people, technologies, information, materials, equipments and energy in a time constrained environment
D	The ability to conduct investigations to provide practical solutions of ill-defined problems within telecommunications engineering management. The graduate shall be able to
Practical aspects	(1) Conduct experiments and collate, analyse, present and interpret telecommunication technology data sets (2) Gather data from codes of practice, databases and other sources and to analyse data using a range of relevant software packages (3) Use up to date analytical, experimental and implementation tools to improve telecommunications services (4) Use research tools including market and technology research in the field of telecommunications management
E	The ability to work effectively as an individual, in teams and in multidisciplinary settings together with the capacity to undertake lifelong learning. The graduate shall be able to
Lifelong learning	(1) Plan and carry through, self-directed continuing Professional Development to improve their own knowledge and competence (2) Understanding group dynamics and exercise leadership (3) Self-evaluate and take responsibility for continuing academic/Professional Development (4) Consult and work with experts in various fields in the realisation of a product or system (5) Identify the need and opportunity for skills development in others

Continued.

Table 4. Continued

Programme outcome	Outcome description
F	An understanding of the need for high ethical standards in the practice of engineering, including the responsibilities of the engineering profession towards people and the environment. The graduate shall display
Ethics, regulation and social issues	(1) Knowledge and understanding of the social, environmental, ethical, economic, financial, institutional and commercial considerations affecting the exercise of telecommunications engineering (2) Knowledge and understanding of the health and safety and legal issues and responsibilities of telecommunications engineering practice and the impact of engineering solutions in a societal and environmental context (3) An ability to reflect on social and ethical responsibilities linked to the application of their knowledge and judgments (4) Knowledge and understanding of telecommunications regulation issues and policies and their business, technological and social implications
G	An ability to communicate effectively with the telecommunications engineering community and with society at large, and to foster appropriate professional and interpersonal skills. The graduate shall be able to
Soft skills	(1) Describe succinctly the relevant advantages and disadvantages of the various technologies to a lay audience (2) Write technical papers and reports and synthesise their own work and that of others in abstracts and executive summaries (3) Communicate effectively in public, national and international contexts. (4) Take significant responsibility for the work of individuals and groups; lead and initiate activity (5) Mentor and coach colleagues (6) Choose the appropriate communication format and tools for a given occasion

3.3. *List of potential courses*

As indicated in Figure 2, the first step was to develop a long list of courses based on staff experience and expertise, and on the international best practices in similar programmes (Aegis University 2013; Morgan State University 2013; North-Eastern University 2013; Stevens Institute of Technology 2013) so that these courses support the achievement of the programme outcomes. Table 5 presents the suggested list of courses.

3.4. *Course ranking using HOQ*

The next step was to map the surveyed competencies in Table 2 to the suggested courses in a HOQ. As stated before, in our implementation we did not use target value data (A_i) or sales point data (B_i) and our HOQ is built using relative importance data (C_i) only. The relative importance of each competency was determined from the ranking in Table 3. Table 6 gives the list of suggested courses mapped to the surveyed competencies in a simplified version of the HOQ where only the relative importance was considered in the prioritised CR. This mapping was performed by the associated academics and based on a consideration of the likely syllabus. Hence, the normalised absolute weight was used to obtain the ranking of these courses which is a normalised version of Equation (2) and was computed as

$$\mathrm{NWC}_k = \frac{\mathrm{WC}_k}{\sum_{k=1}^{K} \mathrm{WC}_k}, \tag{4}$$

Table 5. A long list of potential courses of the programme.

No.	Suggested courses
(1)	Statistics and Data Analysis
(2)	Professional Development (Engineering Profession, ethics, soft skills, etc.)
(3)	Management of Telecommunication Services
(4)	Telecommunication Regulations and Policies
(5)	Telecommunications in the Business Environment I (Strategic Management of Telecom business)
(6)	Telecommunications in the Business Environment II (Financial Management of Telecom business)
(7)	Network Planning and Optimisation
(8)	Telecommunications Networks: Structure and Architecture
(9)	Project Management for Telecommunication
(10)	Operations Management
(11)	Marketing Strategy for Telecom Engineers
(12)	Entrepreneurship in the Telecom Business
(13)	Management and Organisation Behaviour
(14)	Mobile Communications Technology
(15)	Wireless Network Technology
(16)	Core Network-Switching Technologies
(17)	Telecommunication Network: Operations and Implementation
(18)	IP Telephony and Next Generation Networks (NGN)
(19)	Masters Project (Capstone Project)

where the absolute weight is defined as in Equation (2) as

$$\mathrm{WC}_k = \sum_{i=1}^{I} R_{i,k} C_i, \tag{5}$$

where, given our focus on curriculum design, we use the more precise label WC (signifying course weighting) rather than the generic AW of Equation (2). We have

WC_k is the absolute weight of course k; R_{ik} is the score of the contribution of course k to competency I; C_i is the score of the importance of competency i (mean value in Table 3).

In order to determine the core courses, which, according to HEAC guidelines, need to comprise 21 credit hours, the suggested courses were ranked according to their normalised absolute weight obtained from the HOQ in Table 6. The ranking of the courses is given in Table 7. According to the process described in Figure 2, and based on the ranking of the courses, the core courses of the programme would be the courses with the highest rank while the remainder of the courses would be made elective courses with the students choosing three of them (a total of nine credit hours).

The courses ranked 1–6 comprised 9 courses (with a total of 27 credit hours) due to 4 courses tying for sixth place. So, in order to accommodate the university guidelines (24 credit hours for core courses), the course on Professional Development was allocated one credit hour and the course on Telecom Regulations was allocated two credit hours given that these courses contribute to similar programme outcomes.

3.5. *Contribution to programme outcomes*

The next step was to determine the contribution of courses to programme outcomes. The contribution of the core courses to the programme outcomes was calculated using a similar HOQ method of mapping to that in Table 7.

In this HOQ, the CRs are the courses selected based on the needs of industry while the TRs are the programme outcomes. The scores in the Relationship Matrix were decided by academic staff and were based on a consideration of the potential contents of such courses. The absolute

Table 6. Relationship matrix of competencies and suggested courses of the programme.

	Suggested courses	Statistics and data analysis	Professional Development	Management of Telecommunication Services	Telecommunication Regulations and Policies	Telecommunications in the Business Environment I	Telecommunications in the Business Environment II	Network Planning and Optimisation	Telecommunications Networks: Structure and Architecture	Project Management for Telecommunication	Operations Management	Marketing Strategy for Telecom Engineers	Entrepreneurship in the Telecom Business	Management and Organisation Behaviour	Mobile Communications Technology	Wireless Network Technology	Core Network-Switching Technologies	Telecommunication Network: Operations and Implementation	IP Telephony and Next Generation Networks (NGN)	Masters Project	
Topics	Management of telecom network	1		3				3	9		1			1	1	1	1	1	1	9	4.39
	Project management									9	1									9	4.32
	Knowledge on future telecom industries			3	3				3						9	9	9	9	9	9	4.27
	Planning and optimisation	9						9	1	3	1				1	1	1	1	1	9	4.24
	Soft skills		9	1																9	4.12
	Telecom market knowledge			3	3	1			1			9	1		1	1	1	1	1	9	3.99
	Organisation theory													9						1	3.96
	Language skills – English		9																	1	3.95
	Research methodology		9		1						1									9	3.83
	Service flow and logic	1		9							9									1	3.77

Continued.

Table 6. Continued.

Suggested courses	Statistics and data analysis	Professional Development	Management of Telecommunication Services	Telecommunication Regulations and Policies	Telecommunications in the Business Environment I	Telecommunications in the Business Environment II	Network Planning and Optimisation	Telecommunications Networks: Structure and Architecture	Project Management for Telecommunication	Operations Management	Marketing Strategy for Telecom Engineers	Entrepreneurship in the Telecom Business	Management and Organisation Behaviour	Mobile Communications Technology	Wireless Network Technology	Core Network-Switching Technologies	Telecommunication Network: Operations and Implementation	IP Telephony and Next Generation Networks (NGN)	Masters Project	
Financial and admin management			3			9			3										1	3.74
Total quality management			3																1	3.74
Regulations and Policies			1	9	3		3	3						1	1	1	1	1	3	3.67
Business technology Strategy					9														1	3.67
IT and computer skills	3	3					3												3	3.67
Marketing			3		3					1	9								1	3.56
Human resource management									3				9						1	3.44
Competition and telecom market issues	1		3	9	3			3		1	9	1		1	1	1	1	1	1	3.36
Entrepreneurship												9							3	3.31
Accounting, Economics, Finance					3	9	3		3										1	3.2
																				Importance C_i
Absolute weight	60.7	118.1	122.9	91.9	78.4	62.5	83.0	81.6	82.7	57.6	98.2	37.1	71.0	58.1	58.1	58.1	58.1	58.1	330.8	
Normalised weight	0.05	0.11	0.12	0.09	0.07	0.06	0.08	0.08	0.08	0.06	0.09	0.04	0.07	0.06	0.06	0.06	0.06	0.06	0.32	

Table 7. Ranking of courses based on the HOQ in Table 6.

Rank	Course	NWC_k
1	Masters Project	0.33
2	Management of Telecommunication Services	0.12
3	Professional Development	0.12
4	Marketing Strategy for Telecom Engineers	0.10
5	Telecommunication Regulations and Policies	0.09
6	Project Management for Telecommunication	0.08
6	Telecommunications Networks: Structure and Architecture	0.08
6	Telecommunications in the Business Environment I	0.08
6	Network Planning and Optimisation	0.08
7	Management and Organisation Behaviour	0.07
8	Telecommunications in the Business Environment II	0.06
8	Mobile Communications Technology	0.06
8	Wireless Network Technology	0.06
8	Core Network-Switching Technologies	0.06
8	Telecommunication Network: Operations and Implementation	0.06
8	IP Telephony and Next Generation Networks (NGN)	0.06
8	Operations Management	0.06
10	Statistics and Data Analysis	0.04
10	Entrepreneurship in the Telecom Business	0.04

Table 8. Target contribution of courses to programme outcomes.

Programme outcomes / Core courses	POA	POB	POC	POD	POE	POF	POG	
Professional Development					9	9	9	1
Management of Telecommunication Services		9				3		3
Telecommunication Regulations and Policies		3				9		2
Telecommunications in the Business Environment I		9			3			3
Network Planning and Optimisation		3	9	3				3
Telecommunications Networks: Structure and Architecture		3	9	9				3
Project Management for Telecommunication		3	9	9				3
Masters Project	3	9	9	9	9	9	9	3
Absolute weight	9.0	114.0	108.0	90.0	45.0	63.0	36.0	Credit hours C_i
Normalised weight	0.02	0.27	0.25	0.21	0.10	0.15	0.08	

and normalised weight of each outcome was computed as

$$WO_k = \sum_{i=1}^{I} R_{i,k} C_i, \tag{6}$$

$$NWO_k = \frac{WO_k}{\sum_{k=1}^{K} WO_k}, \tag{7}$$

where (adopting the more descriptive label WO to describe the absolute weight in this context)

WO_k is the weight of outcome k; R_{ik} is the score of the contribution of course i to outcome k; C_i is the credit hours of course I; NWC_k is the normalised absolute weight of outcome k.

Table 8 gives the contribution of the courses to programme outcomes.

Table 9. Final list of core courses of the programme.

No.	Course title	Credit hours	Contribution to POs
1.	Statistics and Data Analysis	3	(A)
2.	Professional Development	1	(E,F,G)
3.	Management of Telecommunication Services	3	(B,C,F)
4.	Telecommunication Regulations and Policies	2	(B,C,F)
5.	Telecommunications in the Business Environment I	3	(B,C,E,F)
6.	Network Planning and Optimisation	3	(B,C)
7.	Telecommunications Networks: Structure and Architecture	3	(B,C)
8.	Project Management for Telecommunication	3	(B,C,F)
9.	Masters Project	3	(B,C,D,E,F,G)

3.6. *Final list of courses*

By looking at the contribution of the core courses to the programme outcomes in Table 8, we see that these courses make little contribution (2%) to programme outcome A (Basic Sciences). Therefore, it was decided to move the course on Statistics to the list of core courses and to move the course on Marketing to the list of elective courses in order to accommodate a stronger contribution to programme outcome A. This decision was reached through discussions among the academic staff of the programme and was also based on a consideration of a number of similar international programmes, from which it was concluded that the course on Marketing could be moved to the list of elective courses. The final list of courses is given in Table 9, where the contribution of each course to programme outcomes is specified.

The elective courses (nine credit hours) were selected from the remainder of the list (courses with scores below 0.08). Since different courses contribute differently to programme outcomes, these courses were divided into two groups: the first group are management courses which mainly contribute to programme outcomes B, E and F and the second group are technical courses which mainly contribute to outcomes C and D. Since the programme aims at enhancing management skills of engineers, it was decided that the programme should include the choice of two courses (six credit hours) from the first group, and that it should include the choice of one course from the second group (three credit hours) in order to enhance the contribution to outcomes B, E and F.

In order to complement the contribution of elective courses to the programme outcomes, two more courses were added to the list:

- Special topics on Telecommunications Management
- Independent studies in Telecommunications Management

These courses act as complementary courses where students choose the topic which they feel important to them in coordination with the instructor and the Department. Tables 10 and 11 show the final list of elective courses in the two groups and Table 12 shows the contribution of all the courses to programme outcomes after adjustment. The contribution of each course to the programme outcomes was used to design the individual courses, where course outcomes were developed to support these scores.

In summary, the score of each course is obtained from the HOQ in Table 6. This score indicates the importance of the course to the customers through its relationship to the surveyed competencies. Equations (6) and (7) describe the HOQ parameters used to rank the programme outcomes. The HOQ in Tables 8 and 12 is used to check that POs are covered by all programme courses where a score is given for each PO. This score can be altered by changing the list of core and elective courses until the desired score for the PO is reached.

Table 10. List of elective courses – Group 1.

No.	Course title	Credit hours	Contribution to POs
1.	Telecommunications in the Business Environment II	3	(B,E,F)
2.	Management and Organisation Behaviour	3	(B,E,F)
3.	Operations Management	3	(B,E,F)
4.	Marketing Strategy for Telecom Engineers	3	(B,E,F)
5.	Entrepreneurship in the Telecom Business	3	(B,E,F)
6.	Special Topics on Telecommunications Management	3	(B,E,F)
7.	Independent Studies in Telecommunications Management	3	(B,E,F)

Table 11. List of elective courses – Group 2.

No.	Course title	Credit hours	Contribution to POs
1.	Mobile Communications Technology	3	(C,D)
2.	Wireless Network Technology	3	(C,D)
3.	Core network-Switching Technologies	3	(C,D)
4.	Telecommunication Network: Operations and Implementation	3	(C,D)
5.	IP Telephony and Next Generation Networks (NGN)	3	(C,D)

Table 12. Target contribution of courses to programme outcomes.

Programme Outcomes / Courses	POA	POB	POC	POD	POE	POF	POG	
Statistics and Data Analysis	9			3				3
Professional Development					9	9	9	1
Management of Telecommunication Services		9				3		3
Telecommunication Regulations and Policies		3				9		2
Telecommunications in the Business Environment I		9			3			3
Network Planning and Optimisation		3	9	3				3
Telecommunications Networks: Structure and Architecture		3	9	9				3
Project Management for Telecommunication		3	9	9				3
Masters Project	3	9	9	9	9	9	9	3
Elective Course from Group 1		3			9	3		3
Elective Course from Group 1		3			9	3		3
Elective Course from Group 2			9	9				3
Absolute Weight	36.0	132.0	135.0	126.0	99.0	117.0	36.0	Credit hoursC_i
Normalised weight	0.05	0.19	0.20	0.19	0.15	0.17	0.05	

4. Conclusions

A curriculum development process of an industry oriented Masters Programme in Telecom Management based on demand data and clear definition of programme outcomes has been presented. Demand data collected from a questionnaire completed by engineers who work at telecom companies in Jordan through an online tool enabled the contents of the proposed programmes and other programme specifications to be identified.

The proposed programme has been designed by studying the needs of industry and at the same time meeting the academic standards and the guidelines that govern programme development in Jordan. A HOQ was used to map the surveyed competencies to a long list of courses

chosen to deliver the programme and partly based on the academic interests and expertise of the Department. The HOQ enabled the list of courses to be ranked based on their correlation to the surveyed competencies. The curriculum was designed considering this ranking and also the curriculum guidelines and the local aaccreditation requirements and university guidelines. A list of programme outcomes was then developed for the proposed programme based on international standards and also on feedback obtained from representatives of local telecom industry. The list of courses was then modified based on their contribution to the programme outcomes using another HOQ in order to ensure that the programme courses provide the intended contribution to the programme outcomes where the final list of courses was developed.

It is important to note that there is a slight tension between the industry demand and the need to satisfy the academic standards which are based on the contribution of courses to programme outcome. Through their expertise and the awareness of international practice in similar programmes, the academic staff of the programme tried to reduce this tension by making subjective decisions to modify the list of courses in order to compromise the conflict among the academic standard, the achievement of defined programme outcomes and the prioritised needs of industry. The individual courses of the programme were designed in a way to support the contributions to programme outcomes specified in the HOQ with regard to contents and assessment.

The programme will be taught by the academic staff of both the Telecommunications Engineering Department and the Business School at Yarmouk University. These staff members have gone through training on outcome-based education and course development at a number of EU institutions who are partners in the Tempus project.

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