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A Curricula Assessment And Improvement Quantitative Model For Higher Education: A Design For Six Sigma Methodology

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A CURRICULA ASSESSMENT AND IMPROVEMENT QUANTITATIVE MODEL FOR HIGHER EDUCATION
A DESIGN FOR SIX SIGMA METHODOLOGY

by

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ABSTRACT

Curricula assessment is an integrated process to assist higher education institutions in addressing the challenges in a designated field of study and in exploring the opportunities to better educate and prepare their students for an increasingly complex world.

Although assessment as a topic has been researched extensively, there has been a lack of quantitative tools that address the requirements of many of the stakeholders that may be critical to the curriculum design and assessment processes.

This research proposes the utilization of Design for Six Sigma (DFSS) to develop a quantitative model for curriculum assessment and improvement for higher education institutions. A review of the literature indicates that there is a lack of quantitative tools that enhance the reliability and efficiency of gathering customer requirements for curriculum in higher education environment. In addition, there is a lack of tools to translate these requirements into actual characteristics that can be used for curriculum design and assessment purposes. The literature also indicates that curriculum assessment is one of several educational processes that affect the quality of education.

This research proposes a quantitative model for curriculum assessment and improvement in higher education institutions, utilizing design for six sigma methodology. The proposed model explores the use of the Kano model concept to translate needed requirements into desirable curriculum attributes and the general concept of establishing transfer function to determine the level at which those requirements have been satisfied. The use of the developed model can help

improve student learning and provide curriculum stakeholders with timely feedback about the curriculum and identify areas in need of improvement.

To validate the capability of the proposed model, an ABET accredited department of Industrial Engineering in a US university was used a case study.

To the memory of my father Jameel

To my mother Jawaher

To my lovely wife Duaa

To my children

To my brothers and sisters

To all my spiritual fathers and mothers

I dedicate this effort.

Without you all, it would could not have been achievable.

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LIST OF ACRONYMS/ABBREVIATIONS

4D	Define, Design, Develop, Demonstrate
ABET	Accreditation Board of Engineering and Technology
ACSI	The American Customer Satisfaction Index
AFIA	Academic, Faculty, and International Affairs
BSIE	Bachelor of Science in Industrial Engineering
BSC	Balanced Scorecard
CSL	Customer Satisfaction Level
CTQ	Critical-to-Quality
DCCDI	Define, Customer, Concept, Design, Implementation
DCOV	Design, Characterize, Optimize, Verify
DFSS	Design for Six Sigma
DMADV	Define, Measure, Analyze, Design, Verify
DMAIC	Define, Measure, Analyze, Improve, Control
HoQ	House of Quality
ICOV	Identify, Characterize, Optimize, Validate

IDOV	Identify, Design, Optimize, Validate
IEU	Industrial Engineering and Management System Department
OEAS	Operational Excellence and Assessment Support
NSD	New Service Development
TQM	Total Quality Management
VOC	Voice of Customer
VOB	Voice of Business

CHAPTER 1 INTRODUCTION

1.1 Introduction

Higher education is considered the main pillar for the development process of all nations. Therefore, governments, scientists, industries, societies, and even media give a high level of attention to higher education. That attention mainly aims to ensure that higher education outcomes are of high quality. However, over the years many researchers have continued to focus on the components of higher education (students, teaching techniques, evaluation process, etc.). One of the components that has received a good amount of studying, developing, and evaluating is the curriculum.

“Curriculum” sometimes refers to the process of education for a degree; also, it is sometimes a listing of included courses (Levander & Mikkola, 2009). This listing of courses by their names generally states the content of a course of study, but may also contain the working methods or learning objectives (Levander & Mikkola, 2009). Yet, curriculum plays very important role in holding a competitive advantage in the higher education field. Therefore, the curriculum assessment and development processes should receive a high amount of attention, especially with the rapid changes in the science and technology. To ensure a high quality curriculum that will enable an institution to maintain its competitive advantage, higher education curriculum designers need to have up-to-date tools, techniques, and methodologies.

Universities, like private enterprises, must stress excellent quality, low costs, and high efficiency in order to compete within the education sector especially with the rapid changes in the science and globalization of education (Bullinger, Fahnrich, & Meiren, 2003) (Yang, Chen, &

Shiau, 2006). In addition, it is necessary for higher education institutions to use modern management methods such as total quality management (TQM), balanced scorecard (BSC), and Six Sigma in order to enhance efficiency and effectiveness and sustain the growth and financial health of the institutions. In addition, the results of using these methods would help in increase the reputation of the institution in the community (Yang, Chen, & Shiau, 2006).

Lately, many service organizations have begun to implement quality assurance methodologies; the most recent are higher education organizations (Ziyadeh & White, 2009). Design for Six Sigma (DFSS) is one quality assurance methodology focusing on "design it right the first time" (Yang & El-Haik, 2003, p. 50). In other words, DFSS aims to prevent defects by boosting the ability to turn customers' needs into a final product/service (Ferryanto, 2007).

The assessment process is defined as the procedure of evaluating product or service characteristics in order to determine overall quality and need for improvement (Secolsky & Denison, 2011, p. 461). The curriculum/program assessment process includes the examination of curriculum quality against design requirements to help in benchmarking curriculum with competitors (Wholey, Hatry, & Newcomer, 2010). In addition, the curriculum/program assessment process must provide information to decision makers about if there is a need for improvement (Secolsky & Denison, 2011, p. 462). However, the main goal of curriculum assessment is enhanced student learning (Rodgers, Grays, Fulcher, & Jurich, 2013). Therefore, the curriculum assessment process must provide information about areas in the curriculum where improvement is needed (Suskie, 2009).The purpose of this study is to utilize the benefits of DFSS methodology to develop a quantitative model for curricula assessment and improvement in higher education institutions.

1.2 Document Outline

The rest of this chapter presents the research problem statement and the research objectives, scope, and contribution. Chapter 2 will provide an overview of the literature in related major areas. Chapter 3 presents the research methodology. Chapter 4 offer results after implementing the proposed model in case study. Chapter 5 includes the research conclusions and future research recommendations.

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1.3 Research Problem Statement

Yet, Owlia & Aspinwall, (1998) and Yang, Chen, and Shiau, (2006) found that curriculum planning, designing, and evaluating are some of several educational processes that affect the quality of education service. Therefore, program/curriculum designers, developers, and evaluators need to have up-to-date tools, techniques, and methodologies to assure the high quality of their program/curriculum. A high quality program/curriculum increases customer satisfaction and outcome quality, allowing a program to maintain a competitive advantage (Aytac & Deniz, 2005) (Diamond, 2008).

A review of the literature (Gonzalez, Quesada, Gourdin, & Hartley, 2008) (Diamond, 2008) (Blackmore & Kandiko, 2012) indicates that there is a lack of quantitative tools that enhance the reliability and efficiency of gathering customer requirements for curriculum in higher education environment. In addition, there is a lack of tools to translate these requirements into actual characteristics that can be used for curriculum design and assessment purposes. The literature also indicates that curriculum assessment is one of several educational processes that affect the quality of education.

Furthermore, since curriculum assessment is one of several educational processes that affect the quality in the education service, higher education institutions need new methodologies and techniques for curriculum design and assessment due to the rapid changes in the science and globalization of education (Bullinger, Fahnrich, & Meiren, 2003). The new methodologies and techniques have to aim to enable higher education curriculum designers and evaluators to achieve their ultimate objective, which is improved student learning, through provide timely feedback about the curriculum and spot areas in need of improvement (Rodgers, Grays, Fulcher, & Jurich, 2013).

1.4 Objectives of this Research

This research aims to enable higher education institutions to use the latest quality assurance tools, DFSS, in assessing the relevancy of their curricula in meeting customers' requirements. The specific objectives of this research are:

- To develop a quantitative model for curricula assessment and improvement in higher education institutions using DFSS methodology.
- To develop a methodology to measure the relevancy of higher education curricula in meeting customers' requirements.

1.5 Scope of this Research

1.5.1 DFSS Methodology Scope:

The DFSS deployment process has three stages: Pre-deployment, Deployment, and Post-deployment and emphasizes estimating development costs, and total savings. However, this study's focus is limited to applying DFSS project phases in order to develop the proposed framework (El-Haik & Roy, 2005, p. 69) (Yang & El-Haik, 2003, p. 46).

1.5.2 Case Study Scope:

An ABET accredited Industrial Engineering department in a US University was used, as a case study, to validate the capability of the proposed model to be used as a comparison tool between similar curricula and as a curriculum improvement tool.

1.6 Contributions of this Research

The rapid scientific innovations and globalization of higher education require new tools for curricula quality and relevancy assessment for timely feedback, and for identifying the topics in need of improvements to achieve the ultimate objective of improved student learning (Rodgers, Grays, Fulcher, & Jurich, 2013). Curriculum is considered the core of the education process and its assessment is one of several educational processes that affect the quality in the education service (Alkin, 2011) (Blackmore & Kandiko, 2012). For these reasons, higher education institutions need new methodologies and techniques for curriculum design and assessment. (Gonzalez, Quesada, Gourdin, & Hartley, 2008).

Kukreja, Ricks, & Meyer (2009, p. 11) said “To date, we have not found any articles in the literature that employ Six Sigma methodology to address curriculum evaluation and improvement issues.” However, the literature review process does not show that DFSS methodology has been employed to address program/curriculum assessment. As such, the research propose the use of DFSS as a tool to assess higher education academic curriculum. This novel model introduces the use of DFSS as a methodology to assess academic curriculum/program for colleges and universities.

CHAPTER 2 LITERATURE REVIEW

2.1 Introduction

This literature review was conducted to identify how the DFSS can enhance the design of universities' academic curricula. An extensive literature review was performed on multiple references that addressed issues related to this area of research. However, many scholars have tackled the subject of using quality tools in curriculum design from multiple points of view. Thus, in order to understand the possible correlation between areas related to higher education's curriculum design process, the most relevant areas of available literature are:

- Service Industry and New Service Development (NSD)
- The Higher Education Sector and its Stakeholders
- Curriculum / Curriculum Assessment
- Design for Six Sigma (DFSS)
- Customer Satisfaction / Voice of Customer (VOC)
- Quality Function Deployment

2.2 Service Industry and New Service Development

Since the competition in educational services has become stronger, many countries are investing strongly in university education in order to strengthen their international attractiveness (Yang, Chen, & Shiau, 2006).

Education is considered a part of the service sector with a high degree of interpersonal contact. Generally, services are defined as actions and can be tangible or intangible. The approach to service reviewing, which is the way service providers design how the service will be delivered, has been termed the “service concept”. There could be either incremental or radical changes in what the customer receives. In either case, a transformation of some elements of the service concept will be required (Stevens & Dimitriadis, 2004).

The process of new service development (NSD) is an important competitive issue in all service industries (Fitzsimmons & Fitzsimmons, 2001). “Until recently, the generally accepted principle behind NSD was that ‘new services happen’ rather than occurring through formal development processes” (Menor, Tatikonda, & Sampson, 2002). In this era of global competition, designing of new services that meet with the needs of the customers is crucial to ensure a competitive, advantageous position in any market (Campanerut & Nicoletti, 2010).

Menor et al. (2002) states that modifications to the service concept, which will require new skills from the existing operations, should be looked at it as a new service. In other words, both, the novelty of service offering and service is providing, should be describe as new service that was not previously available to the customers of an organization (Campanerut & Nicoletti, 2010).

NSD includes reevaluating organizational issues, which may require organization transformation through or by the end of an NSD process. The NSD process is built on multifunctional teams specifically formed for a project. Studies have shown that the level of personal contact between the product manager, the commitment of the senior managers, the crossfunctional team, and the interaction process established during NSD affect the speed and effectiveness of the NSD (Stevens & Dimitriadis, 2004).

The global competition in service sectors is increasing rapidly. Therefore, it is vital to find methodologies and techniques to support the development of new services in a structured and systematic way (Menor, Tatikonda, & Sampson, 2002). However, despite the importance of the service sector, there is little empirical research on NSD (Bullinger, Fahnrich, & Meiren, 2003); moreover, the studies that have been conducted on NSD "have largely neglected its application in the educational sector" (Alam & Perry, 2002). This absence of attention to the NSD should be investigated in a way that shows the importance of NSD when it comes to determining educational curricula quality (Oplatka, 2004). However, in the case of establishing and designing new departments in a university, there are few proper models available for reference in designing integrated models that are suitable to practical requirements (Bullinger, Fahnrich, & Meiren, 2003).

2.3 Higher Education Institutions

Several researchers have conducted surveys with professionals, students (graduate and undergraduate) and potential employers in order to evaluate higher education programs. These surveys show that there are several problems in the higher education programs. First, these programs used to stress theoretical models that are hard for students to apply in real life decision-making situations. Second, higher education institutes do not often take real-life problems and integrate them into their curricula. Finally, oral and written communication skills are not sufficiently presented in the programs (Jiang, Shiu, & Tu, 2007).

However, total quality management provides the idea of the integration of functional areas in the organization for a common goal: customer satisfaction (Johansson, Burns, Evans, Barrett, & Karlsson, 2000). Organizations have applied this idea by considering their suppliers as strategic partners; they began connecting them to the strategic planning process. Without doubt, higher education institutions are considered a supplier for employers, which are the organization in this case. However, a paradigm shift must be reinforced by the academic institutions which will provide those future employees (Jiang, Shiu, & Tu, 2007) (Smith & & Angeli, 1995).

This paradigm shift has provoked new challenges for higher education institutions . These challenges define the role of higher education institutions as follows (Nygaard, Hojlt, & Hermansen, 2008):

1. Higher education institutions have to facilitate students' competence building within a certain academic field.
2. Higher education institutions have to facilitate the development of competencies that can be used outside the learning context of higher education institutions.

Owlia, & Aspinwall (1998) and Yang, Chen, and Shiau (2006) found that there are several educational processes which affected quality in the education service. They could be summarized as follows:

- Design of programs of study/design of curriculum planning;

- Delivery and management of programs of study;
- Assessment of students;
- Service support of programs of study/design of teaching/service process
- Guidance and support of students;
- Admissions/design of student recruitment;
- Recruitment, appraisal and development of staff/design of teacher employment;
- Design of financial planning;
- Design of marketability planning; and
- Design of physical/technical facilities/design of space planning

Institutions of higher education have to design academic programs that will solve problems could be associated with processes mentioned above. However, the new academic programs/curricula have to (Nygaard, Hojlt, & Hermansen, 2008):

- Help students gain knowledge that will allow them to advance skills for using this knowledge in real situations.
- Qualify students to advance competencies that are transferable to environments other than the academic field studied

2.4 Stakeholders in Higher Education Institutions

The literature takes different perspectives when looking at stakeholders in education. In some studies, the principal stakeholders are the potential employer and the academic staff (Aytac & Deniz, 2005). In these studies, the authors do not categorize the students as stakeholders (Aytac

& Deniz, 2005). They claim that the students use the curriculum, but they do not have enough information about the competencies required in their occupations, and so they are incapable of evaluating the curriculum from a customer's point of view (Aytac & Deniz, 2005). Other groups of researchers define the most important customers of educational organizations as students and academic staff (Ermer, 1995) (Yang, Chen, & Shiau, 2006). However, in this case, the school faculty should have the capability to evaluate the occupational and technical courses to be taught to students (Aytac & Deniz, 2005). The risk here arises if academic staff suffer from a shortage of industrial experience (Aytac & Deniz, 2005).

On the other hand, the literature review shows that most studies which promote the idea of implementing new quality tools in order to enhance the performance of the higher education institutions include three customer groups for education: students, academic staff and employers (Owlia & Aspinwall, 1998) (Jiang, Shiu, & Tu, 2007) (Nygaard, Hojlt, & Hermansen, 2008). These above-mentioned groups were chosen because that they have direct contact with the education service more than any other groups of customers. Employers could be the private sector or the government (Jiang, Shiu, & Tu, 2007) (Nygaard, Hojlt, & Hermansen, 2008).

2.5 Curriculum

Blight (1995) states that curriculum is about why, how, when, where and what kind of education is offered. Curriculum also includes the content and how it is planned within a degree program (Levander & Mikkola, 2009) Curriculum sometimes refers to the process of education for a degree. Also, it sometimes includes listing courses required for a certain field of study. This listing of courses by their names generally states the content, but may also contain the working method or learning objectives (Levander & Mikkola, 2009). The common understanding is that university curricula have to reflect societal objectives and transmit updated disciplinary understanding and competencies. The objectives and curriculum content are usually an assembly of structured knowledge that is passed on and changes over time (Levander & Mikkola, 2009). Generally, the disciplines and courses include historical effects and cultural deviations as well as institutional traditions and teacher-specific orientation (Levander & Mikkola, 2009). In practice, academic staff base their teaching on their own education, experience, and research. Because the body of knowledge of a discipline is extensive, the teacher, as an expert, decides on structures of topics in each course and simplifies knowledge in order to help the student to understand it (Levander & Mikkola, 2009).

In order design a degree program, it is critical for the program supervisor and academic staff to master the curriculum as unified courses along the learning route (Harden & Davis, 1995). At the degree program level, the curriculum becomes more complex because of the mix of disciplines and the number of academic staff working for the program (Harden & Davis, 1995). The complexity of the curriculum at this level also makes it difficult for program supervisors and the academic staff to maintain links between the courses of the program. In addition, both the content and the number of courses are large within a degree program, which increases students workload (Harden & Davis, 1995).

Furthermore, a curriculum is not fixed; it has to be evaluated on a regular basis (Harden & Davis, 1995)

2.6 Curriculum Assessment

The assessment process is defined as the procedure of evaluating product or service characteristics in order to determine overall quality and need for improvement (Secolsky & Denison, 2011, p. 461). The curriculum/program assessment process in particular includes the examination of curriculum quality against design requirements to help in benchmarking a curriculum with competitors (Wholey, Hatry, & Newcomer, 2010). While the curriculum/program assessment process has to provide information to decision makers about if there is a need for improvement (Secolsky & Denison, 2011, p. 462), the main goal of curriculum assessment is enhanced student learning (Rodgers, Grays, Fulcher, & Jurich, 2013) (Suskie, 2009).

2.6.1 Types of Curriculum Assessment

There are three types of curriculum/program assessment: formative, summative, and developmental curriculum/program evaluation (Alkin, 2011) (Blackmore & Kandiko, 2012). These three types differ based on their point of view about the importance of program assessment (Secolsky & Denison, 2011).

Formative curriculum/program assessment aims to deliver feedback about curriculum construction and delivery processes to help in improving any of these processes (Blackmore & Kandiko, 2012). Moreover, the objective of formative evaluation is to help new and mature program owners by informing them about methods to improve program quality (Wholey, Hatry, & Newcomer, 2010). Formative assessment investigates how would the curriculum meets its customers' requirements and outcomes in comparison with competitors' curriculum (Davidson, 2005).

Summative curriculum/program assessment evaluates curriculum performance in terms of learning outcomes at the end of a semester, course, or program (Blackmore & Kandiko, 2012). Summative assessment aims to measure if the planned objectives and outcomes of a course or a program where achieved or not (Secolsky & Denison, 2011). However, the main objective of a summative assessment is to notify stakeholders if the current curriculum/program could achieve its designed objectives to help them to make decisions about continuing or discontinuing the program (Alkin, 2011).

Developmental curriculum/program assessment aims to find ways for continuous gathering of required information and providing timely feedback for curriculum/program development process (Secolsky & Denison, 2011, p. 464). Developmental assessment encourages the evaluators to play role in the curriculum/program design team (Patton, 2011). Such involvement should include the roles of suggesting evaluative questions, data and logic, and supporting decision making throughout the developmental steps (Secolsky & Denison, 2011). Yet, developmental assessment could be helpful when there is a complex dynamic development environment (Guijt, Kusters, Lont, & Visser, 2012).

2.7 Design for Six Sigma

Some authors claim that DFSS has its origins in system engineering; others have said it is a development of the Six Sigma DMAIC (Design, Measure, Analyze, Improve, and Control) approach (Huber & Launsby, 2002) (Mast, Diepstraten, & Does, 2011). However, DFSS utilizes knowledge from different areas like process engineering, quality engineering, axiomatic design, and probability and statistic science (El-Haik & Roy, 2005) (Yang & El-Haik, 2003).

DFSS is a customer-oriented methodology; it is a quality assurance methodology, which is about "design it right the first time" (Yang & El-Haik, 2003). In other words, DFSS aims to prevent defects by boosting the turning of customers' needs into a final product/service (Ferryanto, 2007). Therefore, DFSS methodology emphasizes understanding the market and defining the customers and their needs as a starting points for any DFSS project (Huber & Launsby, 2002) (Treichler, Carmichael, Kusmanoff, Lewis, & Berthiez, 2002).

In comparison with Six Sigma DMAIC methodology, which is mainly a problem solving approach, DFSS is a prevention approach (Huber & Launsby, 2002). That because DFSS is a proactive approach and focuses on improving the performance in the early stage of the product or service design (Long, Kovach, & Ding, 2011). In addition, when a process achieves its six-sigma level of performance, there will not be more room for improvement and Six Sigma methodology cannot add new value (Hasenkamp, 2010). DFSS, on the other hand, provides new techniques to design/redesign the process, product, or service in order to meet and exceed the customers' needs (Usman, Chakraborty, & Chuan, 2006).

Like the well-known Six Sigma methodology DMAIC (Define, Measure, Analyze, Improve, Control), DFSS has various names for its phases. For example, 4D (Define, Design, Develop, Demonstrate), DCOV (Design, Characterize, Optimize, Verify), DMADV (Define, Measure, Analyze, Design, Verify), IDOV (Identify, Design, Optimize, Validate), ICOV (Identify, Characterize, Optimize, Validate), DCCDI (Define, Customer, Concept, Design, Implementation), etc. (Antony, 2002) (Yang & El-Haik, 2003, p. 42) (Ferryanto, 2007). However, with all these differences in the names of the phases, they all consist of the same concepts and almost all use the same tools (El-Haik & Roy, 2005, p. 43) (Ferryanto, 2007). For the purpose of this research, the ICOV phases will be used because of the availability of a good amount of references.

Each of the four ICOV phases consists of seven development stages and seven tollgates within those. Each development stage has its own tasks; each task is carried out before moving to the next stage. Tollgates are considered as milestones in the life of the project (Yang & El-Haik, 2003, p. 93). Each tollgate has its own entrance and exit criteria; the project team checks and evaluates these criteria to assure the completion of each stage's requirements before proceeding to the next stage. (El-Haik & Roy, 2005, p. 81). Table 2-1 offers a brief description of the DFSS ICOV phases, stages, and tollgates' major entrance and exit criteria (El-Haik & Roy, 2005) (Ferryanto, 2007) (Huber & Launsby, 2002) (Yang & El-Haik, 2003) (Ferryanto, 2007).

Table 2-1 Brief DFSS ICOV Tollgates Major Criteria

	Stages	Tollgates*	
		Major Entrance Criteria	Major Exit Criteria
Identify Phase	Stage 1: Idea Creation	- Target customers - Risk assessment	- Availability of resources to define customer needs - Identification of the tollgate keepers
Identify Phase	Stage 2: Customer and Business Requirements Study	- Project charter - Determine customer needs (VOC/VOB) - Risk assessment	- Availability of resources to develop the conceptual design - Flow-down of CTQs to functional requirements
Characterize Phase	Stage 3: Concept Development	- Transfer Function - Select a service conceptual design - Trade off alternatives? - Risk assessment	- Availability of resources to perform preliminary design - Action plan to continue flow-down of the design functional requirements
Characterize Phase	Stage 4: Preliminary Design	- Flow-down to sub-processes and steps - Perform design, performance, and operating transfer functions - Risk assessment	- Design is likely to satisfy all design requirements - Action plan to finish the flow-down of the design functional requirements to design parameters and process variables
Optimize Phase	Stage 5: Design Optimization	- Design documentation defined - Risk assessment	- Meets customers/ business requirements - Meets or exceeds functional, performance, and operating requirements - Optimize transfer functions
Validate	Stage 6: Verification	- Risk assessment	- Pilot test and refining - Validation and process control
Validate	Stage 7: launch Readiness	- Risk assessment - Control plans are in place	- Handover to new process owner

*Obtaining of tollgate keeper approval is required in all entrance and exit criteria

The DFSS methodology can be used in the design of a new product, service, or process, or the redesign of one of them (Ferryanto, 2007) (Usman, Chakraborty, & Chuan, 2006). However, in both cases, DFSS methodology, through its phase's tasks, stresses the following components (El-Haik & Roy, 2005) (Hasenkamp, 2010):

- Defining customers' needs and wants, Voice of the Customer (VOC) and Voice of Business (VOB) through market research.
- Translate VOC and VOB into Critical-to-Quality (CTQ) then to functional requirements.
- Develop a transfer function that identifies the relationship between the design factors and the functional requirements.
- Project management through adopting a project charter and communication plan.
- The project charter is considered an agreement between the project team and the process/product/service owners and outlines the why, what, how, who, and when of the project.

Changes in the scope of any of these components will likely lead to changes in other components. For example, increasing the numbers of CTQs will increase the numbers of functional requirements (Pyzdek & Keller, 2010, p. 165).

Table 2-2 shows the main tasks and the most common tools for each stage of ICOV (El-Haik & Roy, 2005) (Ferryanto, 2007) (Huber & Launsby, 2002) (Yang & El-Haik, 2003) (Ferryanto, 2007).

Table 2-2 DFSS ICOV Main Tasks and Common Used Tools

	Stages	Main Tasks*	Common Used Tools
Identify Phase	Stage 1: Idea Creation	- Describe the high-level concept (The Idea Definition) - Project scope - Define the targeted customers - Create management plan	- Market/Customer Research - QFD - Kano Analysis - Growth/Innovation Strategy
	Stage 2: Customer and Business Requirements Study	- Identify and validate methods of collecting customers' needs and wants - Gather and transform customers' needs and wants into VOC/VOB - Translate the VOC/VOB to Critical-to-Quality (CTQ) - Quantify CTQ	
Characterize Phase	Stage 3: Concept Development	- CTQ metrics - flow-down of CTQ - Translate CTQ into Functional Req. - Transfer Function - Select a service conceptual design - Trade off alternate	- QFD - TRIZ/Axiomatic design - MSA (Measurement System Analysis) - Design scorecard - Robust design - Process mapping - Pugh concept selection - FMEA (Failure Mode–Effect Analysis) - Design review - Process management
	Stage 3: Preliminary Design	- High-level design - Flow-down Functional Req. to sub-processes and steps - Perform design, performance, and operating transfer functions	
Optimize Phase	Stage 5: Design Optimization	- Develop detailed design - requirements - Build detailed design - Analyze process capability - Simulate process performance - Prepare control plan - Update scorecard - Define design documentation - Optimize transfer functions	- Transfer function detailing (DOE, hypothesis testing) - Process capability analysis - Design scorecard - Simulation tools - Mistake-proofing plan - Robustness assessment
Validate Phase	Stage 6: Verification	- Pilot plans - Adjust design as required - Full-scale Implementation	- Process control plan - Control plans - Transition planning - Training plan - Statistical process control - Confidence analysis Mistake-proofing - Process capability modeling
	Stage 7: launch Readiness	- Control plans are in place	

*Risk assessment is a required task in all stages

2.8 Voice of Customer (VOC)

Customer satisfaction is a management issue for most companies. Satisfaction assessments are used as performance indicator for services and products. Customer satisfaction is the most important goal of every business: not to supply, not to sell, not to service, but to satisfy the requirements that attract customers to do business (Chaudha, Jain, Singh, & Mishra, 2011).

A fault occurring during many design stages is that design teams expect that what the customer asks for is what they need (Mazur, 2001) (Chaudha, Jain, Singh, & Mishra, 2011) . Many studies recognize that what the customer is looking for is, in fact, only an initial point for designing because design team needs to identify how product/service under development will deliver what customer is looking for. Therefore, systematic approach is essential to help accurately identify customer requirements. One of methods that can do so is the Kano Model (Mazur, 2001) (Chaudha, Jain, Singh, & Mishra, 2011).

2.8.1 Kano Model

Dr. Noriaki Kano delineates two kinds of customer needs: spoken and unspoken (Mazur, 2001). In the model Standard Requirements are those that match what we discover by questioning the customers about what they want. These requirements satisfy (or dissatisfy) in percentage to their existence (or absence) in the product or service. One time delivery would be a good example. The more on time (or late) the delivery, the more they like (or dislike) it (Mazur, 2001).

If the level of customer satisfaction is plotted on a vertical axis, and the performance level for a product characteristic on the horizontal axis, we find that different types of customer requirements lead to different reactions (Mazur, 2001). Figure 2-1 shows how the Kano model differentiates three categories of product requirements that affect customer satisfaction in different ways. Each requirement category is discussed in the following paragraphs (Johansson, Burns, Evans, Barrett, & Karlsson, 2000).

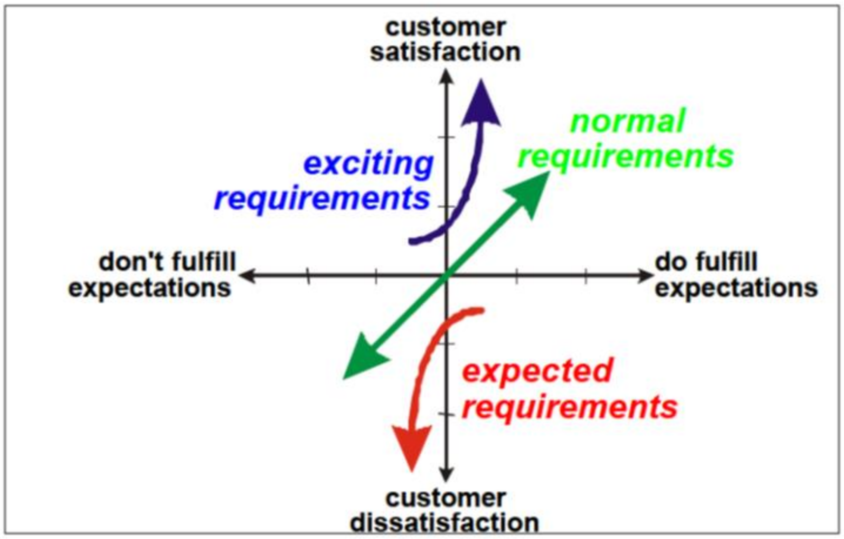

Figure 2-1: Kano model
Source: (Johansson et al. 2000)

The first category is the Expected/Must-Be Requirements or “Basic Qualities”: These are qualities that the customers believe they will be standard features in the product. Because the customer expects them for sure, he may not ask for them - they are unspoken qualities. However, if these features are not there, the customer is very dissatisfied and they become spoken again, through customer complaints (Mazur, 2001) (Johansson, Burns, Evans, Barrett, & Karlsson, 2000) (Sireli, Kauffmann, & Ozan, 2007).

The second category is Exciting/Attractive Requirements or “Delighters”. They are outside the customer's expectations and so are also unspoken. Their nonexistence does not dissatisfy, but at the same time, their existence excites customers. They may attract the customers and bring their business back. This type of feature can distinguish a product from its competitors and is a selling point. However, since customers are incapable of naming these requirements, it is the duty of the organization to discover customer needs and chances to reveal such unspoken items. These requirements can change according to time, location, or other external factors (Mazur, 2001) (Johansson, Burns, Evans, Barrett, & Karlsson, 2000) (Sireli, Kauffmann, & Ozan, 2007).

The third category is One-Dimensional Requirements or “Linear”. They are the spoken needs of the customer. These requirements could be recognized through market research techniques like focus groups and customer interviews. The presence of these requirements generate customer satisfaction, and the absence of these features will dissatisfy the customers. However, the satisfaction of the customer in this case varies linearly with the accomplishment level of these requirement qualities (Mazur, 2001) (Johansson, Burns, Evans, Barrett, & Karlsson, 2000) (Sireli, Kauffmann, & Ozan, 2007).

Sireli, Kauffmann, and Ozan (2007) suggest more three categories of customers' requirements; these are summarized as follows:

Indifferent Requirements: The customer is unconcerned about this type of product characteristic and is not very interested in whether it is present or not. Therefore, its presence or absence will not affect the customer satisfaction level.

Reverse Requirements: Not only do the customers dislike these features, but they are also looking for the reverse of them. Therefore, their presence will affect customer satisfaction level negatively.

Questionable Requirements: These features are either elicited from an incorrectly stated question, or the customer misunderstood the question, or an irrational response was given.

2.8.2 Customer Window Quadrant (CWQ)

The Customer Window Quadrant (CWQ) is an analytical quality tool designed to group and organize customer expectations. This grouping and organizing is built on the level of importance and the level of satisfaction of each expectation from the customer's point of view. As the name suggests, CWQ has four quadrants and each quadrant has own characteristics. The strategies for each quadrant are defined as follows:

Quadrant A: contains the requirements that customer wants but does not get. It is ranked as High Importance/Low Satisfaction. This is the most important quadrant since all customer expectations located in this quadrant need instant action in order to find ways to increase satisfaction level (Gonzalez, Quesada, Gourdin, & Hartley, 2008).

Quadrant B: contains the requirements that the customer wants and gets. It is ranked as High Importance/High Satisfaction. This is the most desired quadrant where all important and critical customer expectations have to be here and remain here. All requirements listed in quadrant

A should receive high attention to move them to this quadrant (Gonzalez, Quesada, Gourdin, & Hartley, 2008).

Quadrant C: contains the requirements that the customer does not want and does not get. It is rated as Low importance/Low satisfaction. Requirements in this quadrant have the lowest importance and should not be the focus. Organizations do not need to make any effort until changes accrue in the market, service strategy, or customer expectations (Gonzalez, Quesada, Gourdin, & Hartley, 2008).

Quadrant D: contains the requirements that the customer does not want but get anyway. It is rated as Low importance/High satisfaction. Requirements found here are not needed and possibly costly. Nevertheless, organizations have to work on removing these items if they are expensive or represent any type of risk to the organization. Excluding this type of quality characteristic from the product will not affect the satisfaction level of the customers (Gonzalez, Quesada, Gourdin, & Hartley, 2008).

The investigators stated that there are a shortage of quantitative tools that could enhance the reliability and efficiency of the collecting process of customer expectations as well as a lack of tools to translate them into the critical requirements of an academic institution, mainly in the higher education field (Gonzalez, Quesada, Gourdin, & Hartley, 2008).

2.8.3 American Customer Satisfaction Index (ACSI)

The American Customer Satisfaction Index (ACSI) started in 1994 as a result of collaboration between a group of scientists at the University of Michigan, the American Society for Quality in Milwaukee, Wisconsin, and the CFI Group in Ann Arbor, Michigan. The aim was to establish an index about satisfaction with the quality of available products and services in the American market (History of the American Customer Satisfaction Index, 2014).

The general form of ACSI is (American Customer Satisfaction Index, Methodology Report, 2005):

$$ASCI = \frac{E[\mathcal{E}] - Min[\mathcal{E}]}{Max[\mathcal{E}] - Min[\mathcal{E}]} \times 100 \quad (1)$$

$$Min[\mathcal{E}] = \sum_{i=1}^{n} I_i \, Min[X_i] \quad (2)$$

$$Max[\mathcal{E}] = \sum_{i=1}^{n} I_i \, Max[X_i] \quad (3)$$

Where:

$\mathcal{E}$: The latent variable for customer satisfaction (ACSI)

$E[\mathcal{E}]$: Expected value of the variable

$Min[\mathcal{E}]$: Minimum value of the variable

$Max[\mathcal{E}]$: Maximum value of the variable

X_i: The manifest variables of the latent customer satisfaction

I_i: The weight of the measurement variables

n: the number of measurement variables

2.9 Quality Function Deployment QFD

Quality function deployment (QFD) is one of the most commonly used tools in TQM, in general, and in DFSS, specifically. QFD was established in Japan during the 1960s. QFD was introduced as a technique for new product development below the umbrella of total quality control. It is a method for defining design qualities that are in keeping with customer expectations and then transforming those customer expectations into design goals and critical quality assurance (QA) points (Chaudha, Jain, Singh, & Mishra, 2011). These points should be used during the production/service development phase because they aid a company to know how to trade-off between what the customer needs and what the company can build. However, it is used in product development and design (Gonzalez, Quesada, Gourdin, & Hartley, 2008) (Chaudha, Jain, Singh, & Mishra, 2011).

Moreover, QFD is a procedure for the development or deployment of features, attributes, or functions that ensure a product or service is of high quality. QFD brings ways of communication throughout a product's life cycle phases. Lower design and service costs, fewer and earlier design changes, decreases in product development time, fewer start-up problems, enhancements in company performance, better service quality and, and increased customer satisfaction are all advantages of QFD applications (Gonzalez, Quesada, Gourdin, & Hartley, 2008) .

QFD can be very useful in responding to the question “How can we deliver quality products and services based on the needs of customers, or the voices of customers?” The two fundamental purposes of QFD are (Gonzalez, 2001):

1- to increase the understanding of customer expectations among the organization; and

2- to enhance the completeness of specifications and to make them related to customer expectations and requirements.

Gonzalez et al. (2004) states that some scientists have implemented QFD in different service areas. This technique was first applied to education at the beginning of the 1990s. One of the earliest uses of QFD in studies in education was presented by Ermer (1995) at the Mechanical Engineering Department of the University of Wisconsin, Madison in 1991. In this study, the requirements of customers, students, academic staff, and industry, were analyzed separately in order to satisfy each of them. Different authors have used QFD for the enhancement of quality in different engineering departments and for college textbook design (Ermer, 1995) (Owlia & Aspinwall, 1998) (Gonzalez, Quesada, Gourdin, & Hartley, 2008). A recent application of QFD in a higher education curriculum redesign was at the Rain Star University, in Scottsdale, Arizona. It was used to design a curriculum for a master’s degree program in acupuncture and oriental medicine. QFD was used to define the requirements and needs of Turkish industry to improve the engineering faculty (Aytac & Deniz, 2005).

Finally, Table 2-3 shows a summary of the contributions of different authors in the literature, pointing out the key related subjects addressed and left out by each author. This table makes the gaps in the literature clear.

Table 2-3 Literature review contributions

Subjects / Authors	Using of Quality Tools in Curriculum Design (QFD, VOC, etc.)	Using Six Sigma in Higher Education	Using DFSS in Higher Education at Course Level	Using DFSS in Higher Education at Program Level	Measuring Customer Satisfaction Level
Jaraiedi, &Ritz (1994)	√				
Lam, & Zhao (1998)	√				
Motwani et al. (1996)	√				
Pitman et al. (1995)	√				
Koksal, & Alpay (1998)	√				
Krishnan, & Houshmand (1993)	√				
Seow, & Moody (1996)	√				
Chang, &Ku (1995)	√				
Ermer (1995)	√				
Rosenkrantz (1996)	√				
Murgatroyd (1993)	√				
Owlia, & Aspinwall (1998)	√				

Subjects / Authors	Using of Quality Tools in Curriculum Design (QFD, VOC, etc.)	Using Six Sigma in Higher Education	Using DFSS in Higher Education at Course Level	Using DFSS in Higher Education at Program Level	Measuring Customer Satisfaction Level
Aytac, & Deniz,(2005)	√				
Akao et al. (1996)	√				
Bier, & Cornesky (2001)	√				
Kukreja, Ricks, & Meyer (2009)	√	√			
Balderrama, Reyes, & Rabelo (2008)	√				
Boonyanuwat et al. (2008)	√				
Gonzalez, Quesada, Gourdin,, & Hartley (2008)	√				
Ziyadeh,& White (2009)	√	√			
Yeung (2010)	√	√			
Kaushik, & Khanduja (2010)	√	√			
Downing (2011)	√		√		
Prasad, Subbaiah, & Padavathi (2012)	√	√			
Halawany (2014)	√ (as a part of DFSS methodology tools)	√ (apply the concept through DFSS methodology)	√	√	√

CHAPTER 3 METHODOLOGY

3.1 Introduction

This research proposes a novel model that introduces the use of DFSS as a methodology to develop a quantitative model for curricula assessment to improve Higher Education institutions. For the purpose of this research, ICOV phases (Identify, Characterize, Optimize, and Validate) will be used because of the availability of a large amount of references on these steps. ICOV phases have seven development stages and seven tollgates. Each development stage has its own tasks; each task is carried out before moving to the next stage. Tollgates, on the other hand, are considered to be milestones in the life of the project (Yang & El-Haik, 2003, p. 93). Each tollgate has its own entrance and exit criteria; the project team checks and evaluates these criteria to assure each stage's requirements have been met before proceeding to next stage. (El-Haik & Roy, 2005, p. 81). Table 3-1 presents a brief description of the DFSS ICOV phases and stages.

Finally, a random department, in this case a Department of Industrial Engineering in an ABET accredited University in the United States of America, was chosen as case study in order to verify the capability of applying the proposed model.

Table 3-1 Brief Description of DFSS ICOV Phases and Stages

Phases	Stages / Work performed
Identify	Stage 1:Idea Creation - Research Problem Statement (Covered in Chapter 1) - Research Objective (Covered in Chapter 1) - Research Scope (Covered in Chapter 1) - Literature Review (Covered in Chapter 2) - Identification of Targeted Customers
	Stage 2: Customer and Business Requirements Study - Determine Customer needs (VOC/VOB) • External Customers Study (Employers & Students) • Internal Customers Study (Academic Dep. & Related units within the institution) - Quantify Customers' Needs
Characterize	Stage 3: Concept Development - Use Kano Model Concept to Translate customer requirements to CTQ - Establish Transfer function
	Stage 4: Preliminary Design - Satisfaction Function development
Optimize	Stage 5: Design Optimization - Satisfaction function detailing - Apply the Quantitative Model as Comparison Tool - Apply the Quantitative Model and QFD as Improvement Tools
Validate	Stage 6: Verification - Use Developed Assessment Tool to compare 2008 and 2013 Curriculum - Conduct Expert Opinion Survey
	Stage 7: Launch Readiness - Final report

In brief, the proposed research methodology contains the following steps:

1- Identify targeted customers.

2- Conduct customer and business requirements study to determine customer needs.

3- Quantify customers' requirements.

4- Use the Kano Model concept to translate customer requirements to CTQ

5- Establish transfer function

6- Detail customer satisfaction level function

7- Apply the Quantitative Model as a comparison tool

8- Apply the Quantitative Model and QFD as improvement tools

9- Verify the capability of applying the proposed model using the case study

Details for each step of the proposed methodology are provided below.

3.2 Identify Targeted Customers

This step aims to define the customers of the higher education institute's curricula, which helps in determining the appropriate methods to gather their requirements. The literature review presented earlier in this research shows that there are three customer groups for education: students, academic staff, and employers (Jiang, Shiu, & Tu, 2007; Nygaard, Hojlt, & Hermansen, 2008; Owlia, & Aspinwall, 1998). Diamond (2008) suggests that the required data for curriculum design projects must be gathered from five areas: students, societies, education institutions, field of knowledge, and results of related research. However, from the curriculum design point of view, this research suggests dividing education customers into two groups: external customers, and internal customers.

External customers include:

- Employers: considered the main customers of curriculum outcome (students). Heavier recruiting at certain universities/ of certain students would indicate higher levels of employer satisfaction. Therefore, capturing their needs is an essential task.
- Students: even though a review of the literature suggests that they do not have enough information about the competencies required in their occupations to make informed decisions, students still compare universities and colleges before applying and have the power to choose from among them.

Internal customers include:

- Academic Departments: These are represented by academic staff. Academic staff shall be considered as the owner of the learning process. They teach, evaluate, and follow up with students. They carry out the responsibilities of delivering the required knowledge, which is purpose of the curriculum, to the students. Therefore, academic staff must have input in the curriculum design process.
- Related units within the institution: these are the units related to the process of curriculum evaluation, assessment, and/or development. Usually these units provide guidelines for the program assessment process and have information about programs' evaluation results. In addition, these units play a role in aligning a program's objectives/mission with the institute's strategic plan. Knowing the requirements of such units will allow us to avoid incompatibility of the new design with institute policies.

The requirements of the external customers will represent the voice of customers (VOC) and the requirements of the internal customers will represent the voice of business (VOB).

As mentioned before, a random department, a Department of Industrial Engineering in an ABET accredited University in the United States of America (IEU), was chosen as a case study. Therefore, in this study,

External customers of IEU include:

- Employers: including all companies that offer an entry-level position for freshly graduated students with a bachelor's degree in Industrial Engineering.
- Students: in general, all high school graduates are potential customers for IEU. However, new college graduates are also considered as part of the student group.

Internal customers of IEU include:

- Academic Department: (academic staff) includes the entire faculty of IEU.
- The related units within the institution: within the selected university, there are several units which could be considered related to curriculum/program and they are:
  - Academic, Faculty, and International Affairs (AFIA): "The unit supports and assures academic development and quality enhancement through: academic program review; facilitation and management of educational programs" (AFIA, 2013).
  - Office of Operational Excellence and Assessment Support (OEAS): The mission of OEAS is "to support efforts to improve the effectiveness and efficiency of University operations and the quality of student learning outcomes through assessment. OEAS will accomplish this by providing support to all administrative

units and academic programs through integrated processes that include continuous quality improvement, survey development, data collection, analysis, and guidance in assessment" (OEAS, 2012).

- Office of Undergraduate Studies: they "establish and administer university-wide academic policies and assist in curriculum development and review and in co-curricular planning and programming" (Undergraduate Studies, 2008). They also "respond to queries and mandates by parties inside and outside the university and represent the university at local, regional, and national forums for undergraduate education" (Undergraduate Studies, 2008).

3.3 Conduct Customer and Business Requirements Study

This step aims to define the proposed methods that will be used to collect the requirements for each customer group derived in the previous step. As mentioned before, the requirements of the external customers will represent the voice of customers (VOC) and the requirements of the internal customers will represent the voice of business (VOB).

3.3.1 External Customers Study

The conducted literature review shows that the majority of authors who worked on gathering VOC (employees and students) in curriculum related research used interviews and/or mail survey tools as primary sources of data. However, among their many advantages, these tools have some disadvantages such as VOC obtained in these ways cannot obtain clarification of ambiguities and also suffers from a lack of depth in data; moreover bias toward the interviewer and bias due to non-response tend to occur (Hart, 1987). These disadvantages are considered a source of noise and should be eliminated or controlled. Thus, the researcher proposes the following methods to collect external customers' needs. For the purpose of this research, job descriptions is used to gather employers' requirements and results of previous surveys/research is used to defined student requirements.

3.3.1.1 External Customers - Employers:

A job description is a document detailing the knowledge, skills, qualifications, and experience required of the employee to accomplish the job objectives and is used to support the selection process (Cushway, 2003, p. 2). In other words, the job description identifies the employer's requirements for the person who is applying to this job. Employers' needs, therefore, can be collected through reviewing jobs descriptions of entry-level positions for industrial engineers (Gonzalez, Quesada, Gourdin, & Hartley, 2008).

Therefore, the researcher suggests that Employers' needs to be collected through reviewing jobs descriptions of entry-level positions for industrial engineers. Thus, the researcher proposes using of Affinity diagram tool, which is a process of grouping observations based on their relationships, to group those requirements into several categories with keeping in mind naming each categories by terms used in universities (Duffy, 2012).

According to the Bureau of Labor Statistics of the U.S. Department of Labor (2012), in 2010 nationwide there was:

- around 228,000 working industrial engineers in 15 different industry categories
    - about 147,000 (64%) in manufacturing
    - around 32,000 (14%) in professional, scientific, and technical services

- 6,570 jobs per year is the projected average number of job openings due to growth and replacement needs (2010-20) for industrial engineers. The average for the State of Florida ranges between 289 and 360 jobs per year (DEO, 2013) (CareerOneStop, 2013).

However, the projected average number of job openings due to growth and replacement needs (2010-20) for industrial engineers would be the population that will be surveyed to define the employers' needs. Equation 4 will be used later in this research to calculate the sample size of job descriptions required to identify employers requirements (Barlett, Kotrlik, & Higgins, 2001):

$$n_o = \frac{t^2 * p(1-p)}{d^2} \qquad (4)$$

Where:

n_o = sample size

t = two-tail t-value for the alpha level (α) selected with infinity degree of freedom

p = maximum possible population proportion

d = acceptable margin of error

For a 95% confidence-level (α = 0.05, t-value = 1.96), p = 0.5, and d = 5%, the sample size (n_o) would be about 384 samples. However, the values of alpha, the maximum possible population proportion, and acceptable margin of error could be set to other values based on the expert team's opinion, which will lead to a different sample size. Appendix A shows samples of jobs descriptions. The Industry-Advisory-Board at the Institute of Industrial Engineers will be the experts who determine the category names of the employers' requirements. The following are examples of desirable qualities from job descriptions.

- Knowledge of inventory control
- Analytical ability and creative problem solving
- Conceptual thinking skills
- Interpersonal skills
- Computer skill including spreadsheets, databases, and graphics software
- Knowledge of project management skills

3.3.1.2 External Customers - Students:

Even though the literature review suggests that students do not have enough information about the competencies required in their occupations to make informed decisions, students still compare universities and colleges before applying and have the power to choose from among them. The researcher believes that students are interested in how the curriculum or the program will help them to achieve their goals after graduation (e.g. employment, graduate studies) more than in what the components of the curriculum are. This belief is supported by the results of the National Survey of Student Engagement (NSSE) (2012, p. 16) conducted by the Indiana University Center for Postsecondary Research, which included more than 21,000 students at 42 U.S. institutions. In this survey, seniors were asked about the factors that influenced their selection of an academic major. Figure 3-1 shows the results of NSSE survey (percentage responding “Quite a bit” or “Very much”).

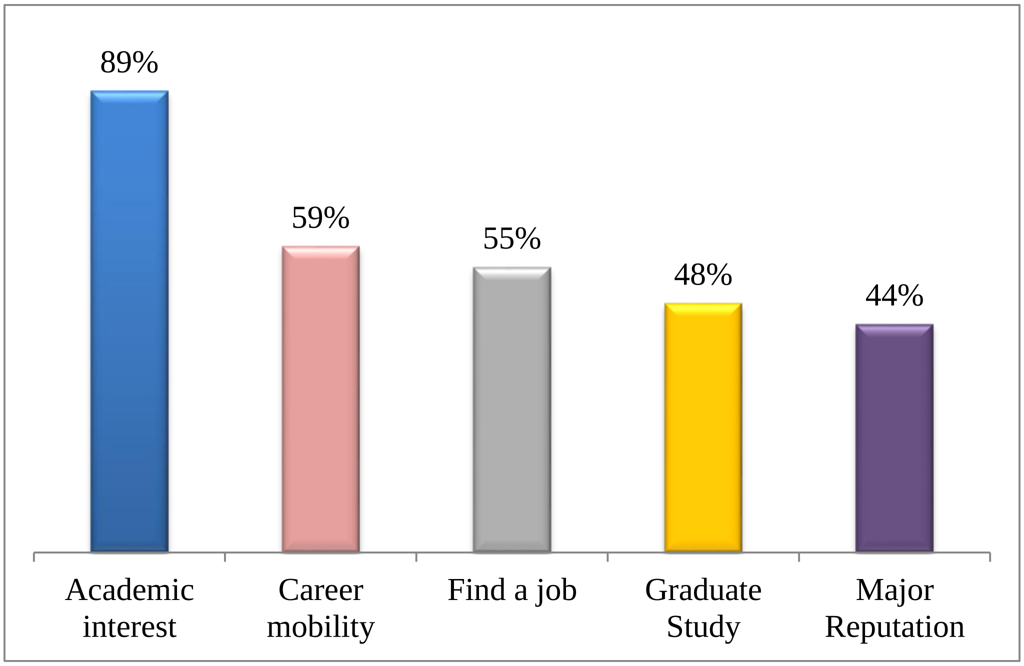

Figure 3-1 VOC -Students Requirements

3.3.2 Internal Customers Study

3.3.2.1 Internal Customers - Academic Department:

Educational objectives, and learning outcomes are the first set of requirements for an academic department. These are sets of statements that describe what a student will know and will be capable of doing after completing certain course/program (Maher, 2004). In other words, educational objectives and learning outcomes are the characteristics that the academic program designer/owner (academic department) wants the student to have after graduating of the program. However, IEU has three educational objectives and eight learning outcomes for a Bachelor's of Science degree student in the Industrial Engineering (BSIE) program. In addition, ABET criteria are part of the academic department requirements.

3.3.2.2 Internal Customers - Related units within the institution:

The review of related units within the selected university (Academic, Faculty, and International Affairs (AFIA), Office of Operational Excellence and Assessment Support (OEAS), Office of Undergraduate Studies) show that they aim to:

1- Assure academic development and quality enhancement
2- Support the academic programs assessment, evaluation, and accreditation process

However, the following is a list of some societies that these units look to for expectations in order to increase the university's reputation and/or program quality.

- Accreditation Societies: being part of an accredited program shows that a university/college/department is devoted to a high level of program quality and that the program serves the requirements of the profession it designed for (ABET Inc., 2013). These characteristics would leverage the competitive advantage of the program. Therefore, meeting the accreditation requirements during the curriculum design would increase the robustness of the program and ease the accreditation processes. In this case, the IEU Accreditation Board of Engineering and Technology (ABET), which has 11 criteria, is the targeted society.
- University Ranking Organizations: many students review the rank of the university/college/department before making a decision to apply (Meredith, 2004) (Amsler & Bolsmann, 2012). This is because of the widespread acceptance of ranking results as indicators of the reputation and quality of the programs offered by these institutions (Meredith, 2004) (Amsler & Bolsmann, 2012). Thus, considering the related ranking indicators during the process of the quantitative assessment model

development would increase the robustness of the design model. The chosen office in this research, Operational Excellence and Assessment Support (OEAS), posts a list of published rankings to assist administrative and academic units in the evaluation of higher education. This list includes:

- Academic Ranking of World Universities (Institute of Higher Education, Shanghai Jiao Tong University)
- Kiplinger's 100 Best Values in Public Schools (Kiplinger's personal finance magazine)
- Top American Research Universities (Arizona State University)
- America's Best Colleges - Top National Universities (US News & World Report magazine)
- US News & World Report Graduate Ranking (US News & World Report magazine)

▪ The Board of Governors (BOG), which requires that the curricula must offer development of:

- Discipline-specific knowledge, skills, attitudes and behaviors
- Communication skills
- Critical thinking skills

The research will review these organizations' and societies' requirements to identify the criteria and indicators which are related to the curriculum and so should be considered during the development process of the quantitative model.

3.4 Quantify Customers' Requirements

The first task in this step is to minimize the number of customers' requirements through studying the requirements of each customer group in ordered to reach manageable number of requirements from design point of view. Initial findings suggest that two groups share some requirements (for example, the academic department and related units within the university both use ABET criteria). In addition, the researcher has observed that there are some requirements directly related to the curriculum and some other requirements indirectly related to the curriculum. The researcher suggests that meeting the directly related requirements will result in meeting the indirectly related requirements. For example, the employers' requirements are directly related to the curriculum. Yet, meeting employers' requirements will result in meeting the students' requirements, which are indirectly related to the curriculum. However, the expert opinions will be used in this research in order to verify these finding.

3.4.1 Quantify Employers' Requirements:

In this research, the use of Affinity Diagrams to group the employers' requirements into major and subgroups will be implemented. The Industry-Advisory-Board at the Institute of Industrial Engineers will be the experts in this research in order to confirm the category names.

The following are examples of the findings from job descriptions.

- Knowledge of inventory control
- Analytical ability and creative problem solving
- Conceptual thinking skills

- Interpersonal skills
- Computer skill including spreadsheets, databases, and graphics software
- Knowledge of project management skills

The researcher paid attention to naming the groups using terminology commonly found in the industrial engineering field. Table 3-2 shows the major group names of the employers' requirements. Quantifying the employers' requirements will be done in the following steps:

1- Identifying the job requirements

2- Grouping the requirements into categories based on expert opinion

3- Calculating the appearing frequency of each requirement for each category

4- Computing the weight of each requirement by dividing its frequency by the total number of the requirements

Table 3-2 Employers' Requirements Major and Subgroups' names

Major Groups
Industrial and Management Engineering Knowledge
Basic Engineering Knowledge
Background/Desirable
Computer Skills
Communication
Critical Thinking/Problem Solving
Team Player/Leadership

3.5 Using the Kano Model Concept on CTQ

One of the objectives of developing the quantitative model is to derive an equation that could estimate the customers' level of satisfaction with the curriculum. For this research, the Kano Model concept will be used in order to group the customers' requirements into Kano categories according to satisfaction level for each category. This will help in estimating the overall satisfaction level of the customers. The Kano Model will group the CTQs into three basic categories:

- "Must be" requirements (M), which category includes the requirements that, if they are not met, the customer will be very dissatisfied and will not consider the product/service as an option.

- One-dimensional requirements (O), which includes the requirements where the customers satisfaction will increase as their fulfillment level increases.

Attractive requirements (A), which includes the requirements that are unexpected yet appreciated by the customers. The absence of attractive requirements will not result in any dissatisfaction but their presence promotes customer satisfaction and increases the competitive advantage. Table 3-3 shows the ranking of CTQ major groups based on the Kano Model.

Table 3-3 CTQ Major Group rankings based on the Kano Model.

Kano Rank	CTQ	CTQ Abbreviation
Must be's (M)	Basic Engineering Knowledge	Eng
	Communication	Com
	Critical Thinking/Problem Solving	Think
	Team player/Leadership	Team
One-dimensional (O)	Industrial and Management Engineering Knowledge	IEK
	Computer Skills	Comp
Attractive (A)	Background/Desirable	Back

The curriculum will be assessed for each CTQ by checking if each is covered in the curriculum by a course(s) and/or as a topic(s) within a course(s). For example, the core courses GEP 8001 "Composition I" and GEP 8002 "Composition II" are designed to develop the communication skills of the students, so we will state that the CTQ "communication" is met by the IEU curriculum. The curriculum will be assigned as 1 if the CTQ is met and 0 otherwise. Each course's control document (syllabus) is the reference to determine if the curriculum is covering the CTQs or not. Appendix B shows the complete list of IEU 2008 and 2013 curricula courses' IDs and titles.

3.5.1 Assessment of "Must be" (M) requirements:

Table 3-4 shows the results of assessing CTQs ranked as "Must be".

Table 3-4 Kano "Must be" CTQ vs. Curricula

Kano Rank	CTQ	Courses met CTQ
Must be (M)	Basic Engineering Knowledge	IECB 8001, IECB 8003 CHEM 8001 PHY 8001, PHY 8002 MATH 8001, MATH 8002, MATH 8003 MATH 8003, GEP 8004 IECB 8005, IECB 8006 IECB 8008, IECB 8009 SAT 8001
	Communication	GEP 8001, GEP 8002 GEP 8003, IECB 8001
	Critical Thinking/Problem Solving	IECM 8004, IECM 8008 IECM 8009, IEEX 8090 IEEX 8099 IECM 8011, IECM 8013 IECM 8014, IECM 8006
	Team Player/Leadership	IECM 8004 IECM 8008 IECM 8009, IEEX 8090 IEEX 8099 IECM 8011, IECM 8013 IECM 8014, IECM 8006

3.5.2 Assessment of One-dimensional (O), and Attractive **(**A**)** requirements:

In same manner, each subgroup under the majors groups will be assessed in order to check if the requirements were met in the curriculum. The curriculum will be assigned as 1 if the CTQ is met and 0 otherwise. Each course's control document (syllabus) is the reference to determine if the curriculum is covering the CTQs or not.

For illustration, the CTQ "knowledge of Six Sigma principles" is covered by the IEU 2008 curriculum within the course IECA 1309 "Quality Engineering". Therefore, the researcher assigned a 1 for this requirement. Yet, the CTQ "Constraint management" is not covered under any course in IEU 2008 curriculum. Therefore, the researcher assigned a 0 for this requirement. Table 3-5 shows the results of assessing CTQ for the subgroup "Quality Measurement and Improvement" under the Kano category One-dimensional".

Table 3-5 CTQ - Subgroup Quality Control and Improvement vs Curriculum

Quality Measurement and Improvement	Curriculum met CTQ "Yes=1" "No=0"
Quality Control management/SPC/Quality Assurance	1
Quality Continuous Improvement Projects/Processes	1
Knowledge of Six Sigma principles	1
Knowledge of Lean Six Sigma principles	0
Structured Problem Solving (DOE)	1
Six Sigma/Lean Sigma/DFSS Certifications: Green Belt	0
Structured Problem Solving (8D)	0
Actively participate in and Support quality internal audit	1
Advanced Product Quality Planning (APQP)	0
Constraint management	0

3.6 Establishing Transfer Function

The researcher suggests the following transfer (Performance) function for each Kano category be calculated as follows:

1- For each sub group:

$$PSG = \sum_{i=1}^{n}(\text{CTQ}w_i * X_i) \quad (5)$$

Where:

PSG: Performance level of sub group (0-1)

n: Number of requirements under the sub group

$CTQw_i$: CTQ weight (0-1) within the sub group

$X_{i:}$ 0 or 1 based on whether the curriculum covered this CTQ or not

2- For each major group:

$$PMG = \sum_{i=1}^{n}(PSG_i * SGw_i) \quad (6)$$

Where:

PMG: Performance level for the major group (0-1)

PSG: Performance level of subgroup (0-1)

n: Number of subgroups within the major group

SGw_i: Subgroup weight (0-1) within the major group

As an illustration, to find the performance level for each subgroup we have to:

1- Calculate the frequency of each CTQ under the sub group
2- Calculate the total number of CTQs under the sub group
3- Divide the frequency of each CTQ by the their total number within the subgroup, which will give us the weight of each CTQ within the sub group (CTQw)
4- Check if the CTQ is covered by the curriculum through checking the course control documents. If it is covered, X =1, or 0 if not
5- Calculate the performance of the subgroup using the PSG equation above (Equation 2)

The performance of the subgroup "Quality Measurement and Improvement" will be calculated as shown in Table 3-6.

Table 3-6 Subgroup "Quality Measurement and Improvement Performance Level"

n	Quality Measurement and Improvement	$CTQw$	X_i	$CTQw_i * X_i$
1	Quality Control Management/SPC/Quality Assurance	0.45	1	0.45
2	Quality Continuous Improvement Projects/Processes	0.18	1	0.18
3	Knowledge of Six Sigma principles	0.13	1	0.13
4	Knowledge of Lean Six Sigma principles	0.08	0	0
5	Structured Problem Solving (DOE)	0.05	1	0.05
6	Six Sigma/Lean Sigma/DFSS Certifications: Green Belt	0.04	0	0
7	Structured Problem Solving (8D)	0.04	0	0
8	Actively participate in and support quality internal audit	0.03	1	0.03
9	APQP	0.01	0	0
10	Constraint management	0.01	0	0
	Total	1	-	PSG = $\sum_{i=1}^{n}(\text{CTQ}w_i * X_i)$ = 0.83

This means that 83% of the requirements under the subgroup "Quality Measurement and Improvement" is covered by the curriculum. In other words, the curriculum satisfies 83% of the VOC under the Quality Measurement and Improvement requirements.

In the same manner, the PSG for each subgroup under the major group Industrial and Management Engineering Knowledge will be calculated. The following Table 3-7 shows the PSG's for the major group "Industrial and Management Engineering Knowledge" (IEK).

Table 3-7 Subgroups under "IEK" Performance Level

Major Group	Sub Group	PSG (0-1)
Industrial and Management Engineering Knowledge	Management	0.66
	Manufacturing, Production, Distribution, and Supply Chain	0.81
	Productivity, Methods and Process Engineering	0.93
	Quality Measurement and Improvement	0.83
	Ergonomics/Human Factors/Safety	0.27
	Financial Engineering	0.83

In order to compute the performance level for the major group "Industrial and Management Engineering Knowledge", we have to multiply the performance level of each subgroup (PSG) by subgroup weight within the major group (SGw_i) and find the total. The process to find the performance level for each major group is as follows:

1- Calculate the performance of the subgroup using the PSG equation above (Equation 2)

2- Calculate the number of CTQs under each subgroup

3- Calculate the sum of numbers of the CTQs under all of the subgroups

4- Divide the number of CTQs under each subgroup from step 2 by the sum of numbers of CTQs under all of the subgroups from step 3. That will give us the weight of each subgroup within the major group (SGw)

5- Calculate the performance of each major group using the PMG equation above (Equation 3)

Table 3-8 show the results of this process.

Table 3-8 Major Group “IEK” Performance Level

Major Group	Sub Group	SGw_i	PSG (0-1)	$PSG_i * SGw_i$
Industrial and Management Engineering Knowledge	Management	0.17	0.68	0.11
	Manufacturing, Production, Distribution, and Supply Chain	0.32	0.81	0.26
	Productivity, Methods and Process Engineering	0.20	0.90	0.18
	Quality Measurement and Improvement	0.13	0.83	0.11
	Ergonomics/Human Factors/Safety	0.09	0.27	0.02
	Financial Engineering	0.09	0.83	0.08
Total		1	-	0.76

This means that 76% of the requirements under the major group “Industrial and Management Engineering Knowledge” are covered by the curriculum. In other words, the curriculum satisfies 76% of the VOC under the Industrial and Management Engineering Knowledge requirements.

Table 3-9 presents a summary for all of the terms used in calculating performance levels.

Table 3-9 Summary of Used Functions to Calculate Performance Level

Industrial and Management Engineering Knowledge	PMG (IEK)	$PMG\ (IEK) = \sum_{i=1}^{n}(PSG_i * SGw_i)$
• Management	PSG (Management)	$PSG = \sum_{i=1}^{n}(\text{CTQ}w_i * X_i)$
• Manufacturing, Production, Distribution, and Supply Chain	PSG (Manufacturing)	
• Productivity, Methods and Process Engineering	PSG (Productivity)	
• Quality Measurement and Improvement	PSG (Quality)	
• Ergonomics/Human Factors/Safety	PSG (Ergonomics)	
• Financial Engineering	PSG (Financial)	
Basic Engineering Knowledge	PMG (Basic)	$PMG\ (Basic) = \sum_{i=1}^{n}(PSG_i * SGw_i)$
Computer Skills	PMG (Comp) $= \sum$ PSG	$PMG\ (Comp) = \sum_{i=1}^{n}(PSG_i * SGw_i)$
• Graphic Design Software	PSG (Graphic)	$PSG = \sum_{i=1}^{n}(\text{CTQ}w_i * X_i)$
• Computer skills/Microsoft	PSG (Microsoft)	
• Database/Programming	PSG (Database)	
• Production Software	PSG (Database)	
• Statistical software	PSG (Statistical)	
Background/Desirable	PMG (Back) $= \sum$ PSG	$PMG\ (Back) = \sum_{i=1}^{n}(PSG_i * SGw_i)$
• Management	PSG (BManagement)	$PSG = \sum_{i=1}^{n}(\text{CTQ}w_i * X_i)$
• Manufacturing, Production, Distribution, and Supply Chain	PSG (BManufacturing)	
• Productivity, Methods and Process Engineering	PSG (BProductivity)	
• Quality Measurement and Improvement	PSG (BQuality)	
• Ergonomics/Human Factors/Safety	PSG (BErgonomics)	
• Financial Engineering	PSG (BFinancial)	
• ISO	PSG (ISO)	
• Certification	PSG (Certification)	
• Others	PSG (Others)	

3.7 Develop Satisfaction Function

In order to develop an equation to measure the overall customer satisfaction level with the curriculum, the researcher suggests using the general formula of the American Customer Satisfaction Index (ACSI). ACSI started in 1994 as a result of collaboration between a group of scientists at the University of Michigan, the American Society for Quality in Milwaukee, Wisconsin, and the CFI Group in Ann Arbor, Michigan. The aim was to establish an index that could provide information about customer satisfaction with the quality of available products and services in the American market (History of the American Customer Satisfaction Index, 2014).

The general form of ACSI is (American Customer Satisfaction Index, Methodology Report, 2005):

$$ASCI = \frac{E[\mathcal{E}] - Min[\mathcal{E}]}{Max[\mathcal{E}] - Min[\mathcal{E}]} \times 100 \quad (7)$$

$$Min[\mathcal{E}] = \sum_{i=1}^{n} I_i \; Min[X_i] \quad (8)$$

$$Max[\mathcal{E}] = \sum_{i=1}^{n} I_i \; Max[X_i] \quad (9)$$

Where:

$\mathcal{E}$: The latent variable for customer satisfaction (ACSI)

$E[\mathcal{E}]$: Expected value of the variable

$Min[\mathcal{E}]$: Minimum value of the variable

$Max[\mathcal{E}]$: Maximum value of the variable

X_i: The manifest variables of latent customer satisfaction

I_i: The weight of the measurement variables

n: The number of measurement variables

To measure the overall customer satisfaction level with a curriculum, those values are represented as follows:

$E[\mathcal{E}]$: Expected value of the variable is the performance level of each major group

$Min[\mathcal{E}]$: Minimum value of the variable is 0

$Max[\mathcal{E}]$: Maximum value of the variable is 1

X_i: The variables of customer satisfaction are the performance level of each major group

I_i: The weight of the measurement variables is set as 1, which implies that all the variables are very, and equally, important

n: The number of measurement variables

We customize the general formula of the ACSI as follows: where Ii is set at 1, $Max[\mathcal{E}] = 1$ and $Min[\mathcal{E}] = 0$, then

$$Min[\mathcal{E}] = \sum_{i=1}^{n} I_i \, Min[X_i] = \sum_{i=1}^{n} 1 * 0 = 0$$

$$Max[\mathcal{E}] = \sum_{i=1}^{n} I_i \, Max[X_i] = \sum_{i=1}^{n} 1 * \ 1 = \sum_{i=1}^{n} 1$$

$$Customer\ Satisfaction\ Level = CSL = \frac{E[\mathcal{E}] - Min[\mathcal{E}]}{Max[\mathcal{E}] - Min[\mathcal{E}]} \times 100 \qquad (10)$$

$$= \frac{\sum_{i=1}^{n} I_i \, [X_i] - 0}{\sum_{i=1}^{n} 1 \ - 0} \times 100$$

$$= \frac{\sum_{i=1}^{n} \, [X_i]}{\sum_{i=1}^{n} 1} \times 100$$

$$= \frac{\sum_{i=1}^{n} \, [X_i]}{n} \times 100$$

Where:

X_i: The performance level of each major group

n: The number of measurement variables

This equation produces a score from 0 to 100 that can be used to compare curricula.

3.8 Detailing the Satisfaction Function

As mentioned before, Kano Model categorizes the customers' requirements as follows:

- "Must be" requirements (M), which include
  - Basic Engineering Knowledge (Eng)
  - Communication (Com)
  - Critical thinking/Problem Solving (Think)
  - Team Player/Leadership (Team)
- One-dimensional requirements (O), which include
  - Industrial and Management Engineering Knowledge (IEK)
  - Computer Skills (Comp)
- Attractive requirements (A), which include Background/Desirable (Back)

Using these categories and the ACSI general formula, we can calculate the satisfaction level for each category under the Kano model as well as overall satisfaction level. Satisfaction levels for each Kano category and the overall satisfaction level for both the IEU 2008 and IEU 2013 curricula are calculated in the implementation and result chapter.

3.9 Proposed Quantitative Assessment Tool as Comparison Tool

In this research, it is suggested that the proposed quantitative assessment tool could be used as tool for comparing two different curricula. The IEU 2008 and IEU 2013 curricula will be compared in the in the implementation and result chapter.

3.10 Proposed Quantitative Assessment Tool and QFD as Improvement Tool

In this research it is suggested that the proposed quantitative assessment tool could be used as an improvement tool through:

1- Working on meeting all the customers' requirements under the "Must be" category since missing any one of them would result in customer dissatisfaction.

2- Working on increasing the satisfaction level for requirements under the one-dimensional category by:

   a. Selecting an elective course out of the offered ones that will increase the satisfaction level.

   b. Introducing currently uncovered CTQs topics into current courses or designing new courses in order to incorporate the missing customers' requirements.

3- Working on increasing the satisfaction level for requirements under the attractive category in same way as Step 2.

The first step in the improvement process is to spot the area where working in meeting the customers' requirements will result in a higher satisfaction level with the curriculum. The first area to work on improving is the "Must be" requirements. This is because any improvement in this area will lead to quick increases in the satisfaction level since missing any will result in customer dissatisfaction. All of the requirements under this group must be met in the curriculum.

The second area in which we should seek improvement is the one-dimensional requirements group. This is because the CTQs under this group are decision points for the customers. Finally, yet importantly, the attractive requirements group is the third area which we should work on improving. These requirements would offer a competitive advantage if met.

Therefore, after meeting the requirements und the "Must be" group, the first step in the improvement process is spotting the area under the one-dimensional requirements group that its improvement will result in the greatest increase in the satisfaction level with the curriculum. However, in order to spot those CTQs, the researcher suggests the following steps:

1- Calculate the gap between the current performance level and the ultimate performance level, which is 1, for each major group under the Kano category one-dimensional requirements.
2- Find the major group with the highest gap as it has the greatest potential to increase the satisfaction level of the curriculum and work on meeting the requirements under it.
3- For each subgroup under the selected major group, calculate the gap between current performance level and the ultimate performance level.
4- Find the subgroup with highest gap as it has the potential to increase the satisfaction level of the curriculum and work on meeting the CTQs requirements under it.

The same steps could be used in order to determine the CTQs under the Attraction requirement group which with improvement will result in increasing the satisfaction level with the curriculum and give it a more competitive advantage.

The second step in the improvement process is to use QFD to determine which elective courses should be introduced to the curriculum in order to meet the uncovered CTQs under the subgroup we selected in step 4 above. However, under the house of quality:

1- Uncovered CTQs will represent the “Customers’ Needs”

2- Weight of the CTQs will reflect the “Customer Importance Ratings”

3- Offered elective courses by IEU Department will represent “Design Parameters”.

4- The relationship between “Customers’ Needs” and the “Design Parameters” will be as 1 if the elective course covers the CTQ and 0 if not.

In addition, the suggested improvement process could be used as a procedure to determine the “restricted elective courses”. That by list the proposed elective courses as “Design Parameters”, and list all of uncovered CTQs as “Customers’ Needs”. The IEU 2013 curriculum will be used to demonstrate the application of the improvement process.

3.11 Implementation and Results

As mentioned earlier, we use a random department, in this case a Department of Industrial Engineering in an ABET accredited University in the United States of America (IEU), to demonstrate the applicability of the proposed quantitative assessment tool. The implementation process uses the 2008 and 2013 curricula of the IEU department. The 2008 and 2013 curricula was used to demonstrate the procedure of using the proposed tool as assessment and compare model. Then the researcher used the IEU 2013 curriculum to implement the proposed improvement tool. Appendix B shows the complete list of IEU 2008 and 2013 curricula courses ID and titles. Chapter 4 details the outcomes of this step.

3.12 Verifications

In order to confirm the reliability of the used methodology and the accuracy of research results, the researcher sought experts' opinions. The selection of the experts was based on their work experience in Industrial Engineering curricula design, development and assessment. A survey was developed aimed at gathering the experts' feedback, including comments on the usefulness and efficacy of a six sigma methodology for curricula assessment and improvement for an ABET accredited Industrial Engineering program. Appendix C is a complete list of the survey questions. The feedback and the results of the survey of experts will be shown in chapter 4 implementation and results.

CHAPTER 4 IMPLEMENTATION AND RESULTS

4.1 Introduction

As mentioned above, a random department, a department of Industrial Engineering in an ABET accredited University in the United States of America (IEU), was chosen to demonstrate the applicability of the proposed quantitative assessment tool. In this research, we specifically use the IEU 2008 and IEU 2013 curricula to show the ability of the proposed quantitative assessment tool to act as an assessment and a comparison tool. We use the IEU 2013 curriculum to show the capability of the suggested improvement tool.

4.2 Customer and Business Requirements Study:

As mentioned earlier, the requirements of the external customers will represent the voice of customers (VOC) and the requirements of the internal customers will represent the voice of business (VOB).

4.2.1 VOC – Employer Requirements Study:

According to the Bureau of Labor Statistics of the U.S. Department of Labor (2012), in 2010 nationwide there was:

- 228,000 working industrial engineers in 15 different industry categories.
    - 147,000 (64%) in manufacturing.
    - 32,000 (14%) in professional, scientific, and technical services.

- 6,570 jobs per year are the projected average number of job openings due to growth and replacement needs (2010-20) for industrial engineers. The average for the State of Florida ranges between 289 and 360 jobs/year (DEO, 2013) (CareerOneStop, 2013).

The projected average number of job openings due to growth and replacement needs (2010-20) for industrial engineers is the population that will be surveyed to define the employers' needs. Equation 11 is used to calculate the sample size of the job descriptions collected to study the employer requirements (Barlett, Kotrlik, & Higgins, 2001):

$$n_o = \frac{t^2 * p(1-p)}{d^2} \qquad (11)$$

Where:

n_o = sample size

t = two-tail t-value for the alpha level (α) selected with infinity degree of freedom

p = maximum possible population proportion

d = acceptable margin of error

For a 95% confidence-level ($\alpha = 0.05$, t-value = 1.96), p = 0.5, and d = 5%, the sample size (n_o) would be about 384 samples. However, the values of alpha, the maximum possible population proportion, and the acceptable margin of error could be set to other values based on the expert team's opinion, which leads to a different sample size. Appendix A shows samples of job descriptions. Affinity Diagrams were used to group the requirements into major and sub groups.

However, special attention was paid to naming the groups using terminology used by the industrial engineering field. Table 4-1 shows the major and sub group names of the employers' requirements.

Table 4-1 Employer Requirements Major and Sub Groups' names

Major Group	Sub Groups
Industrial and Management Engineering Knowledge	Management
	Manufacturing, Production, Distribution, and Supply Chain
	Productivity, Methods and Process Engineering
	Quality Measurement and Improvement
	Ergonomics/Human Factors/Safety
	Financial Engineering
Basic Engineering Knowledge	------
Background/Desirable	Management
	Manufacturing, Production, Distribution, and Supply Chain
	Productivity, Methods and Process Engineering
	Quality Measurement and Improvement
	Ergonomics/Human Factors/Safety
	Financial Engineering
	ISO
	Certification
	Others
Computer Skills	Graphic Design Software
	Computer Skills/Microsoft
	Database/Programming
	Production Software
	Statistical Software
Communication	------
Critical thinking/ Problem Solving	------
Team player/ Leadership	------

4.2.2 VOC – Student Requirements Study:

We observed that students are interested in how the curriculum or the program will help them to achieve their goals after graduation (e.g. employment, graduate studies) more than in what the components of the curriculum actually are. This idea is supported by the results of the National Survey of Student Engagement (NSSE) (2012, p. 16) conducted by the Indiana University Center for Postsecondary Research, which included more than 21,000 students at 42 U.S. institutions. In this survey, seniors were asked about the factors that influenced their selection of an academic major. Figure 4-1 shows the results of the NSSE survey (percentage responding “Quite a bit” or “Very much”).

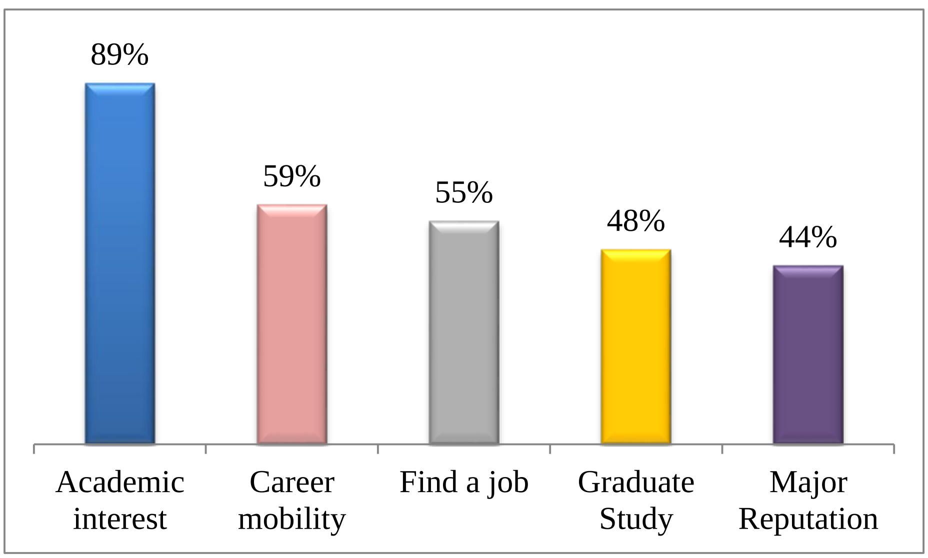

Figure 4-1 VOC -Students Requirements

4.2.3 VOB – Academic Department Requirements Study:

Educational objectives and learning outcomes are the first set of requirements for an academic department. These are sets of statements that describe what a student will know and will be capable of doing after completing a certain course/program (Maher, 2004). In other words, educational objectives and learning outcomes are the characteristics that the academic program designer/owner (academic department) wants the student to have after graduating from the program. IEU has eight learning outcomes for a Bachelor's of Science degree student in the Industrial Engineering (BSIE) program. In addition, ABET criteria are part of the academic department requirements.

4.2.4 VOB – Related units within the institution Requirements Study:

The initial review of the related units within the selected university (Academic, Faculty, and International Affairs (AFIA), Office of Operational Excellence and Assessment Support (OEAS), Office of Undergraduate Studies) shows that they aim to:

1. Assure academic development and quality enhancement
2. Support academic programs assessment, evaluation, and accreditation process

In addition, there are some societies that these units look to define their expectations in order to increase the university reputation and/or programs quality. They are

- Accreditation Societies (ABET in the case of this research case study)
- Universities Ranking Organizations

- The Board of Governors (BOG)
  - Discipline-specific knowledge, skills, attitudes and behaviors
  - Communication
  - Critical thinking

4.3 Summary of Customers and Business Requirements Study

As mentioned before, previous research suggests that students are products of the education system. Yet, a recent survey of universities senior students showed that academic interests, career mobility, and finding a job are the most important factors that influence students' selection of academic major. This research finding suggest the following:

- Due to their lack of knowledge about their major, students have no direct input into the curriculum design, development, and assessment processes. Yet student requirements will be met as a result of meeting employers', academic department, and ABET requirements. In other words, student requirements, such as career mobility and finding a job, are indirectly related to the curriculum.
- Universities Ranking Organizations methodologies do not take the curriculum into consideration in the process of ranking the universities/departments. As a matter of fact, the ranking methodologies focus on evaluating the research, alumni hiring rates, and time to graduate. This also implies those universities' ranking organizations requirements will be met as a result of meeting employers', academic department, and ABET requirements. In other words, their requirements are indirectly related to the curriculum as well.

Table 4-2 shows the summary of VOC and VOB requirements and their relationship to curriculum contents.

Table 4-2 Summary of VOC and VOB requirements

Voice of	Requirements	Relationship to the Curriculum
Employers	Represented by Job Descriptions	Direct
Students	"Career mobility or advancement"	Indirect
	"Ability to find a job"	Indirect
	"Preparation for graduate or professional school"	Indirect
	"Reputation of the major at your institution"	Indirect
Academic Dept.	BSIE Program Learning Outcomes	Direct
	ABET Criteria Outcomes	Direct
Related Units	Accreditation Societies (ABET in the case of IEU Department)	Direct
	Universities Ranking Organizations	Indirect
	The Board of Governors (BOG)	Direct

In addition, by reviewing of all the requirements, one can say that meeting the needs of two groups of customers will lead to meeting the requirements of the rest of the customers. These two groups are the employers and the academic department. That can be said for two reasons:

- Duplicate of requirements (like ABET in the case of Academic Department and Related Units)
- Satisfying the requirements of one customer will result in satisfying the other customer (like ability to find a job in case of Students and Employers)

Therefore, the requirements of the employers will represent the VOC, and the requirements of the academic department will represent the VOB.

4.4 Obtaining VOC:

As mentioned before, the employers' requirements will represent the VOC. VOC was collected through reviewing jobs descriptions of entry-level positions for industrial engineers. Affinity Diagrams were used to group the requirements into major and sub groups. As mentioned above, attention was paid to naming the groups using terminology used by the industrial engineering field. Table 4-3 shows the major and sub groups names.

Table 4-3 VOC major and Sub Groups names

Major Group	Sub Groups
Industrial and Management Engineering Knowledge	Management
	Manufacturing, Production, Distribution, and Supply Chain
	Productivity, Methods and Process Engineering
	Quality Measurement and Improvement
	Ergonomics/Human Factors/Safety
	Financial Engineering
Basic Engineering Knowledge	------
Background/Desirable	Management
	Manufacturing, Production, Distribution, and Supply Chain
	Productivity, Methods and Process Engineering
	Quality Measurement and Improvement
	Ergonomics/Human Factors/Safety
	Financial Engineering
	ISO
	Certification
	Others
Computer Skills	Graphic Design Software
	Computer Skills/Microsoft
	Database/Programming
	Production Software
	Statistical Software
Communication	------
Critical thinking/ Problem Solving	------
Team player/ Leadership	------

4.5 Obtaining VOB:

Program learning outcomes are statements that define knowledge and techniques that the curriculum is preparing students to master by the time of graduation. The IEU undergraduate program has 8 Learning Outcomes (LO):

1. BSIE graduates will demonstrate knowledge of math, science, and engineering fundamentals. (LO1)
2. BSIE graduates will demonstrate competence in the professional practice of industrial engineering, effectively using technical skills. (LO2)
3. BSIE graduates will demonstrate competence in the professional practice of industrial engineering, effectively using communication and life skills. (LO3)
4. BSIE graduates will understand the leadership responsibilities of a practicing engineer. (LO4)
5. BSIE graduates seeking professional employment or admission to graduate education programs will gain employment. (LO5)
6. BSIE graduates will demonstrate academic competence and industrial engineering skills. (LO6)
7. BSIE graduates will demonstrate their ability to communicate through written and oral reports. (LO7)
8. BSIE graduates will demonstrate their ability to apply their industrial engineering skills in an experiential manner. (LO8)

These 8 learning outcomes aim to satisfy ABET Outcomes Criteria, which the IEU engineering programs must demonstrate that their students attain. These criteria are:

a. Ability to apply knowledge of mathematics, science, and engineering

b. Ability to design and conduct experiments, as well as to analyze and interpret data

c. 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. Ability to function on multi-disciplinary teams

e. Ability to identify, formulate, and solve engineering problems

f. Understanding of professional and ethical responsibility

g. Ability to communicate effectively

h. Breadth of education is necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context

i. Recognition of the need for and an ability to engage in life-long learning

j. Knowledge of contemporary issues

k. Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

As mentioned above, for the sake of the current research, employers' requirements represent Voice of customers (VOC), and academic departments Learning Outcomes (LO), and ABET criteria A2K represent Voice of Business (VOB). The VOC is classified into seven major groups, shown in Table 4-4 below along with how well VOC matches VOB.

The Table 4-4 shows a clear relationship between the Employers' requirements (VOC), and the Academic Department's requirements (VOB).

Table 4-4 VOC Relationship to VOB

VOB / VOC	ABET Criteria A2K Does VOC cover the criterion (√):Yes, blank: No											Learning Outcomes (LO) Does VOC cover the criterion (√):Yes, blank: No							
	a	b	c	d	e	f	g	h	i	j	k	1	2	3	4	5	6	7	8
Industrial and Management Engineering Knowledge	√	√	√		√	√		√	√		√		√			√	√		√
Basic Engineering Knowledge	√	√	√		√	√			√		√	√	√			√	√		√
Background/Desirable	√	√	√			√		√	√		√					√	√		
Computer Skills	√	√	√			√			√		√		√			√	√		√
Communication Critical thinking/Problem Solving Team player/Leadership				√			√	√	√	√				√	√	√	√	√	

Based on the findings in above table, we conclude that satisfying of either VOC or VOB will result in satisfying the other. For the sake of research, we choose to examine VOC because:

1- VOB is stated as general guidelines

2- VOB is not articulated from the critical to quality point of view (Not easily quantifiable).

3- VOC is written in almost the same terminology as that used in curriculum

4- VOC is articulated from the critical to quality point of view (More easily quantifiable).

4.6 Quantifying VOC:

After using the Affinity Diagrams process to define the categories of the employers' requirements, the number of requirements under each sub group was divided by the total number of the requirements of its major group to determine the importance in terms of customers' weight of each sub group. For instance, as the total number of requirements under the sub group "Management" is 170, and the total number of requirements under its major group "Industrial and Management Engineering Knowledge" is 1000, the weight of Management Requirements is 170/1000 (0.17).

However, for the groups of "Communication", "Critical Thinking/Problem Solving", "Team player/Leadership", and "Basic Engineering Knowledge" the assigned weight is (1) for each because they are required by both ABET and the Florida Board of Governors (BOG).

Table 4-5 shows the importance in terms of customers' weight for each sub group. Finally, VOC will be used as CTQ in order to avoid:

1- "Lost in Translation" problems.

2- Any source of subjectivity in the process of quantitative assessment tool design.

Table 4-5 VOC Sub group Weight

Major Group	Sub Groups	Weight
Industrial and Management Engineering Knowledge	Management	0.17
	Manufacturing, Production, Distribution, and Supply Chain	0.32
	Productivity, Methods and Process Engineering	0.20
	Quality Measurement and Improvement	0.13
	Ergonomics/Human Factors/Safety	0.09
	Financial Engineering	0.1
Basic Engineering Knowledge	------	1
Background/ Desirable	Management	0.07
	Manufacturing, Production, Distribution, and Supply Chain	0.5
	Productivity, Methods and Process Engineering	0.03
	Quality Measurement and Improvement	0.08
	Ergonomics/Human Factors/Safety	0.03
	Financial Engineering	0.03
	ISO	0.06
	Certification	0.1
	Others	0.07
Computer Skills	Graphic Design Software	0.25
	Computer skills/Microsoft	0.47
	Database/Programming	0.21
	Production Software	0.06
	Statistical software	0.01
Communication	------	1
Critical thinking/ Problem Solving	------	1
Team player/ Leadership	------	1

4.7 IEU 2008 and IEU 2013 curricula

Both IEU 2008 and IEU 2013 curricula required the student to complete 128 credit hours in order to graduate from the program. Those 128 hours were distributed over several groups such as the UCF General Education Program (GEP) and Core Requirements. Table 4-6 shows the degree requirements for each curriculum.

Table 4-6 IEU 2008 and IEU 2013 Curricula Required Hours

Degree Requirements	IEU 2008 Curriculum (hrs)	IEU 2013 Curriculum (hrs)
General Education Program (GEP)	38	38
Common Program Prerequisites (CPP)	19	19
Core Requirements: Engineering Core: Basic	22	2
Core Requirements: Required for the Major	40	59
Restricted Electives	3	7
Departmental Exit Requirements	6	3
Total	128	128

The IEU Department introduced some changes into the new IEU 2013 curriculum, such as combining some courses like IECM 8001 “Engineering Economic Analysis” and IECM 8005 “Principles of Cost Engineering” into one course, IECA 1318 “Engineering Economic Analysis and Cost Engineering”. In addition, there was a replacement for some courses, such as IECM 8003 “Introduction to Industrial Engineering” by the course IECA 1317 “Introduction to IE & MS”. As a result, we are expecting a change in overall Satisfaction Level with the curriculum and the performance level for some major groups.

4.8 Curriculum Assessment

The assessment process for both curricula, IEU 2008 and IEU 2013, will be performed through calculating the performance level of the curriculum's core courses under the:

1- Must-be Requirements, which include:
   a. Communication requirements (0-1)
   b. Critical thinking/Problem solving requirements (0-1)
   c. Team player/Leadership requirements (0-1)
   d. Basic Engineering Knowledge requirements (0-1)
2- One-dimensional requirements, which include:
   a. Industrial and Management Engineering Knowledge requirements (0-1)
   b. Computer Skills requirements (0-1)
3- Attractive requirements, which include Background/Desirable requirements (0-1)

4.8.1 Assessment of Must-be Requirements (M)

Both IEU 2008 and IEU 2013 curricula address all of the requirements under the must-be group through courses rang from General Education Program (GEP), Common Program Prerequisites (CPP), and Core Requirements: Engineering Core: Basic and Major. Table 4-7 shows the courses covering must-be requirements in the IEU 2008 and IEU 2013 curricula.

Table 4-7 Courses Covering Must-be Requirements in IEU 2008 and 2013

Must-be (M) Requirements	Courses meeting Requirements IEU 2008	Courses meeting Requirements IEU 2013
Basic Engineering Knowledge	IECB 8001, IECB 8003 CHEM 8001 PHY 8001, PHY 8002, MATH 8001 MATH 8002, MATH 8003 MATH 8003, GEP 8004 IECB 8005, IECB 8006 IECB 8008, IECB 8009 SAT 8001	IECB 1301, IECB 1302 CHEM 1301 PHY 1301, PHY 1302 MATH 1301, MATH 1302 MATH 1303, MATH 1304 GEP 1304, IECA 1313, IECA 1315 IECA 1316, IECA 1319 SAT 1321
Communication	GEP 8001, GEP 8002 GEP 8003, IECB 8001	GEP 1301, GEP 1302 GEP 1303, IECA 1308
Critical thinking/Problem Solving	IECM 8004, IECM 8008 IECM 8009, IEEX 8090 IEEX 8099 IECM 8011, IECM 8013 IECM 8014, IECM 8006	IECA 1302, IECA 1305 IECA 1306, IECA 1308 IEEX 1399 IECA 1308, IECA 1310 IECA 1312, IECA 1303
Team player/Leadership	IECM 8004 IECM 8008 IECM 8009, IEEX 8090 IEEX 8099 IECM 8011, IECM 8013 IECM 8014, IECM 8006	IECA 1302, IECA 1305 IECA 1306, IECA 1317 IEEX 1399, IECA 1301 IECA 1308, IECA 1310 IECA 1311, IECA 1303

Unfortunately, one of the customers' requirements, "Blueprint/Engineering Drawing skills", is not addressed under either IEU curricula (2008 or 2013). The weight of this requirement is (0.14), which results in a reduction in performance level of both curricula to (0.86). Table 4-8 shows the Performance Level for both IEU 2008 and IEU 2013 curricula core courses under must-be requirements.

Table 4-8 Performance Level of IEU 2008 & 2013 Curricula

Must-be (M) Requirements	Weight	IEU 2008		IEU 2013	
Basic Engineering Knowledge	1	PEng(2008)	0.86	PEng(2013)	0.86
Communication	1	PCom(2008)	1	PCom(2013)	1
Critical thinking/Problem Solving	1	PCom(2008)	1	PCom(2013)	1
Team player/Leadership	1	PTeam(2008)	1	PTeam(2013)	1

Based on the above table, the performance of IEU 2008 and IEU 2013 curricula under the must be requirements is:

$$Must - be\ Customer\ Satisfaction\ Level\ IEU\ 2008 =$$

$$= MCSL\ 2008 = \frac{\sum_{i=1}^{n} [X_i]}{n} \times 100 \qquad (12)$$

$$= \frac{\sum_{i=1}^{4} [X_i]}{4} \times 100$$

$$= \frac{0.86 + 1 + 1 + 1}{4} \times 100$$

$$= \frac{3.86}{4} \times 100 = 96.5$$

$$Must - be\ Customer\ Satisfaction\ Level\ IEU\ 2013 = MCSL\ 2013 = 96.5$$

These indicate that both the IEU 2008 and IEU 2013 curricula satisfy 96.5% of the customer requirements under the must-be category.

4.8.2 Assessment of One-dimensional Requirements (O)

The one-dimensional requirements include two major groups:

- Industrial and Management Engineering Knowledge (IEK)
- Computer Skills (Comp)

In order to validate our results, we have to calculate the performance of both curricula under each of these two major groups in order to determine the final performance level of the one-dimensional requirements.

4.8.2.1 Performance Level of Major Group IEK

The major group of Industrial and Management Engineering Knowledge has six sub groups:

1- Management
2- Manufacturing, Production, Distribution, and Supply Chain
3- Productivity, Methods and Process Engineering
4- Quality Measurement and Improvement
5- Ergonomics/Human Factors/Safety
6- Financial Engineering

The curricula were assessed for each CTQ under each sub group by checking if it is covered in the curriculum by a course(s) or/and by topic(s) within a course(s). If the CTQ is covered, the curriculum is assigned a value of 1, or 0 otherwise. Table 4-9 show this process for the sub group "Productivity, Methods and Process Engineering".

Table 4-9 Sub Group "Productivity, Methods and Process Engineering"

Productivity, Methods and Process Engineering (Customer Weight = 0.20)	CTQ Weight within the Sub Group ($CTQw_i$)	Curriculum met CTQ "Yes=1" "No=0"	
		IEU 2008 Xi	IEU 2013 Xi
Process Engineering/Improvement/Design	0.42	1	1
Productivity planning/improvement	0.18	1	1
Time Studies/Standards	0.12	1	1
Investigate, Evaluate, Analysis new technologies techniques to increase productivity	0.07	0	0
Familiarity with Capability/Capacity/Demand analysis	0.06	1	1
Simulation/Modeling techniques	0.06	1	1
Root cause analysis, and Corrective action	0.05	1	1
Ability to write reports, Business correspondence, and Procedure manuals	0.02	1	1
Information flow	0.01	1	1
Supports VA/VE initiatives	0.01	1	1

By using the equation

$$PSG = \sum_{i=1}^{n}(\mathrm{CTQ}w_i * X_i) \quad (13)$$

Where

PSG: Performance level of sub group (0-1)

n: Number of requirements under the sub group

$CTQw_i$: CTQ weight (0-1) within the sub group

X_i: 0 or 1 based on if the curriculum covered this CTQ or not.

we determine that for the IEU 2008 curriculum, PSG (Productivity) = **0.93**

and for the IEU 2013 curriculum, PSG (Productivity) = **0.93**

These results indicate that both the IEU 2008 and the IEU 2013 curriculum satisfy 93% of the customer requirements under the sub group “Productivity, Methods and Process Engineering”.

In the same fashion, we calculated the performance level for each sup group under the major group “Industrial and Management Engineering Knowledge”. Table 4-10 shows the performance level for each sub group.

Table 4-10 Performance Level of IEU 2008 & 2013 Curricula for Major Group IEK

Industrial and Management Engineering Knowledge	SGw_i	IEU 2008	IEU 2013
		PSG	PSG
Management	0.17	0.66	0.66
Manufacturing, Production, Distribution, and Supply Chain	0.32	0.81	0.93
Productivity, Methods and Process Engineering	0.20	0.93	0.93
Quality Measurement and Improvement	0.13	0.83	0.91
Ergonomics/Human Factors/Safety	0.09	0.27	0.27
Financial Engineering	0.09	0.83	0.83

Based on the results shown in table above and by using the equation

$$PMG = \sum_{i=1}^{n}(PSG_i * SGw_i) \quad (14)$$

Where

PMG: Performance level for the major group (0-1)

PSG: Performance level of sub group (0-1)

n: Number of CTQs within the major group

SGw_i: Sub group weight (0-1) within the major group

we calculated the performance level of the IEU curricula under the major group "Industrial and Management Engineering Knowledge". Table 4-11 shows the performance level of IEU 2008 and IEU 2013 curricula under this major group.

Table 4-11 Performance Level for Major Group IEK

Industrial and Management Engineering Knowledge	SGw_i	IEU 2008		IEU 2013	
		PSG	$PSG_i * SGw_i$	PSG	$PSG_i * SGw_i$
Management	0.17	0.66	0.11	0.66	0.11
Manufacturing, Production, Distribution, and Supply Chain	0.32	0.81	0.26	0.93	0.29
Productivity, Methods and Process Engineering	0.20	0.93	0.19	0.93	0.19
Quality Measurement and Improvement	0.13	0.83	0.11	0.91	0.12
Ergonomics/Human Factors/Safety	0.09	0.27	0.02	0.27	0.02
Financial Engineering	0.09	0.83	0.08	0.83	0.08
$PMG(IE) = \sum_{i=1}^{n}(PSG_i * SGw_i)$	-	-	0.77	-	0.81

We conclude that there is an improvement in the IEU 2013 curriculum performance level in terms of satisfying the Industrial and Management Engineering Knowledge group. This is a result of the improvement in the performance under the sub groups "Manufacturing, Production, Distribution, and Supply Chain" and "Quality Measurement and Improvement" from the IEU 2008 curriculum.

Figure 4-2 provides a comparison of the two curricula under the major group IEK.

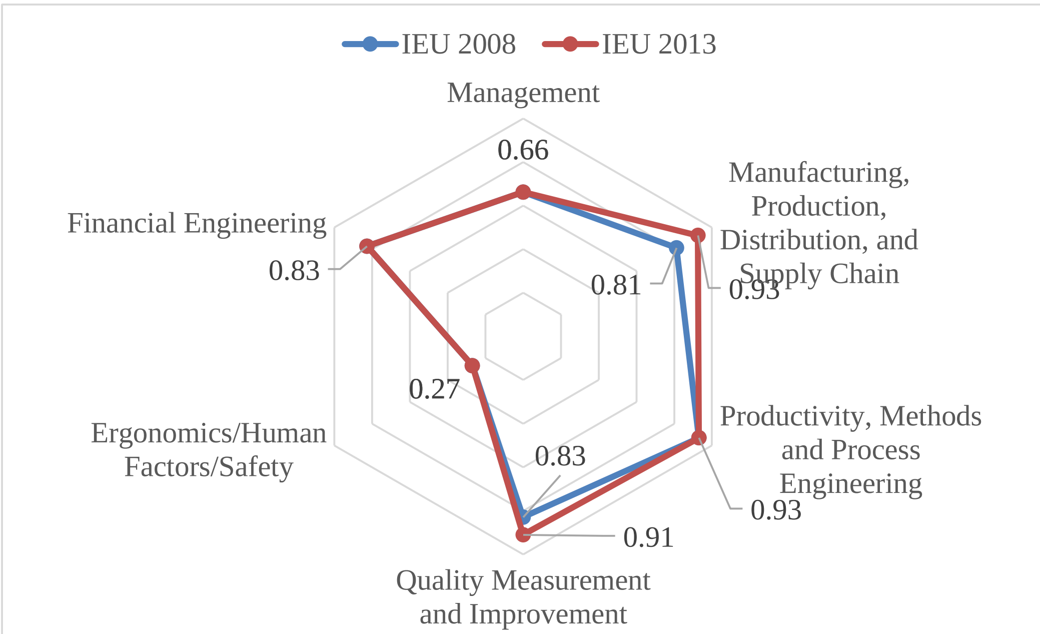

Figure 4-2 IEU 2008 Vs. IEU 2013 Performance under Major Group IEK

4.8.2.2 Performance Level of Major Group Computer Skills (PComp)

Table 4-12 shows the results after evaluating the IEU 2008 and IEU 2013 curricula with respect to the CTQs requirements under the major group "Computer Skills". A 0.15 improvement in the IEU 2013 curriculum resulted from the development of the content under the core course IECA 1303 "Industrial Engineering Applications of Computers". Figure 4-3 provides a comparison of the two curricula under the "Computer Skills" major group.

Table 4-12 Performance Levels Under Major Group Computer Skills

Computer Skills	SGw_i	IEU 2008		IEU 2013	
		PSG	$PSG_i * SGw_i$	PSG	$PSG_i * SGw_i$
Graphic Design Software	0.25	0.69	0.17	0.69	0.17
Computer skills/Microsoft	0.44	0.65	0.29	0.99	0.44
Database/Programming	0.24	0.65	0.15	0.65	0.15
Production Software	0.06	0.73	0.05	0.73	0.05
Statistical software	0.01	1.00	0.01	1.00	0.01
$PMG(Comp) = \sum_{i=1}^{n}(PSG_i * SGw_i)$	-	-	0.67	-	0.82

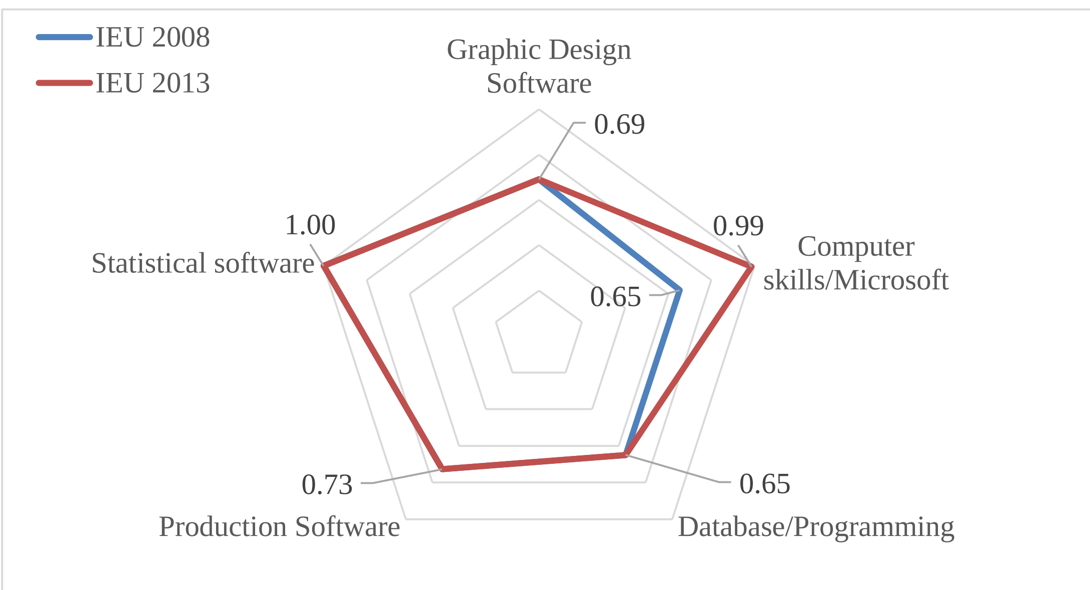

Figure 4-3 IEU 2008 Vs. IEU 2013 Performance under Major Group Computer Skills

Thus, the satisfaction level under the One-dimensional Requirements are:

$$One - dimensional\ Customer\ Satisfaction\ Level\ IEU\ 2008 = OCSL\ 2008 =$$

$$= \frac{\sum_{i=1}^{n} [X_i]}{n} \times 100 \qquad (15)$$

$$= \frac{\sum_{i=1}^{2} [X_i]}{2} \times 100$$

$$= \frac{0.77 + 0.67}{2} \times 100 = 72$$

$$One - dimensional\ Customer\ Satisfaction\ Level\ IEU\ 2013 = OCSL\ 2013$$

$$= \frac{0.81 + 0.82}{2} \times 100 = 81.5$$

These results indicate that the IEU 2008 curriculum satisfied 72% of the customer requirements under one-dimensional category, while IEU 2013 curriculum satisfied 81.5% of the customer requirements under the same category.

4.8.3 Assessment of Attractive Requirements (A)

Under the Attractive Requirements, there is one major group, named "Background/Desirable". The requirements under this group are listed as plusses but not required to be considered as a candidate for the opening position. These requirements could be described as knowledge or experience requirements related specifically to the employer's area of business.

Table 4-13 shows some examples of these requirements. Table 4-14 shows the major group background/desirable and its sub group weights.

Table 4-13 Examples of requirements under the Major Group "Background/Desirable"

Some experience/background in manufacturing or industrial applications
Skilled in the use of metrology equipment (OGP, CMM, etc.)
Thorough experience/knowledge of shipping, inventory, and warehousing standards
Working knowledge of technical plans/work instructions
Design/Lean experience in travel/transportation environments
Experience with Lean principles/Manufacturing methods is desirable
Experience with consulting or Quality improvement teams
(CQE, Black Belt or Green Belt preferred)
DAWAI certification level in acquisition
Experience in DoDI 5000 acquisition
Familiarity with Navy and NAVSEA

Table 4-14 Major Group Background/Desirable and its sub group weights

Background/Desirable	1.00
Management	0.07
Manufacturing, Production, Distribution, and Supply Chain	0.52
Productivity, Methods and Process Engineering	0.03
Quality Measurement and Improvement	0.08
Ergonomics/Human Factors/Safety	0.03
Financial Engineering	0.03
ISO	0.06
Certification	0.10
Others	0.07

Table 4-15 shows the results of the evaluation of the IEU 2008 and IEU 2013 curricula with respect to the CTQs requirements under the major group "Background/Desirable" (Back).

Table 4-15 Performance Levels of Major Group "Background/Desirable" (Back)

Background/Desirable	SGw_i	IEU 2008		IEU 2013	
		PSG	$PSG_i * SGw_i$	PSG	$PSG_i * SGw_i$
Management	0.07	0.83	0.06	0.83	0.06
Manufacturing, Production, Distribution, and Supply Chain	0.52	0.72	0.38	0.83	0.43
Productivity, Methods and Process Engineering	0.03	0.67	0.02	0.67	0.02
Quality Measurement and Improvement	0.08	0.71	0.06	0.71	0.06
Ergonomics/Human Factors/Safety	0.03	0.00	0.00	0.00	0.00
Financial Engineering	0.03	0.00	0.00	0.00	0.00
ISO	0.06	0.40	0.02	0.40	0.02
Certification	0.10	0.00	0.00	0.00	0.00
Others	0.07	0.17	0.01	0.17	0.01
$PMG(Back) = \sum_{i=1}^{n}(PSG_i * SGw_i)$	-	-	0.55	-	0.60

Thus, the performance levels under the Attractive Requirements are:

$Attractive\ \ Customer\ Satisfaction\ Level\ IEU\ 2008 = ACSL\ 2008 =$

$$= \frac{\sum_{i=1}^{n}\ [X_i]}{n} \times 100 \qquad (16)$$

$$= \frac{\sum_{i=1}^{1}\ [X_i]}{1} \times 100$$

$$= \frac{0.55}{1} \times 100 = 55$$

$$Attractive\ \ Customer\ Satisfaction\ Level\ IEU\ 2013 = ACSL\ 2013 = \frac{0.66}{1} \times 100 = 66$$

4.8.4 Summary of the Assessment Process

We can calculate the overall satisfaction level of the IEU 2008 and IEU 2013 curricula using the equation:

$$Overall\ Customer\ Satisfaction\ Level\ IEU\ 2008 = CSL\ 2008 =$$

$$= \frac{\sum_{i=1}^{n} [X_i]}{n} \times 100 \qquad (17)$$

$$= \frac{\sum_{i=1}^{7} [X_i]}{7} \times 100$$

$$= \frac{0.86 + 1 + 1 + 1 + 0.77 + 0.67 + 0.55}{7} \times 100 = 83.57$$

$$Attractive\ \ Customer\ Satisfaction\ LevelIEU\ 2013 = CSL\ 2013$$

$$= \frac{0.86 + 1 + 1 + 1 + 0.81 + 0.82 + 0.60}{7} \times 100 = 87.00$$

In other words, the expected overall satisfaction level of the IEU 2008 curriculum is 83.57%, and the expected overall satisfaction level of the IEU 2013 curriculum is 87% in terms of meeting the VOC through their contents, the higher the score the better the curriculum in meeting the VOC.

The researcher suggests the following to interpret the customer satisfaction level (CSL) score.

1- If the CSL of Must- be requirements is lower than the overall CSL, the CSL of Must-be requirements become the overall score of the customer satisfaction level. This emphasizes the importance of these requirements since missing any requirement under this category results in dissatisfaction of the customer.
2- The overall satisfaction level could be read as follows:
    - $100 \geq$ OCSL ≥ 95: exceeds expectations (Green Zone)
    - $95 >$ OCSL ≥ 90: meets expectations (Orang Zone)
    - $90 >$ OCSL ≥ 85: average (Yellow Zone)
    - $85 >$ OCSL: needs improvement (Red Zone)

Table 4-16 shows the comparison between the satisfaction levels of both IEU 2008 and IEU 2013 curricula.

Table 4-16 Satisfaction Levels of IEU 2008 & 2013 Curricula

Major Groups	Kano Categories		IEU 2008		IEU 2013	
			Xi	CSL	Xi	CSL
Basic Engineering Knowledge	Must be (PM)	PEng	0.86	96.50	0.86	96.50
Communication		PCom	1		1	
Critical thinking/Problem Solving		PThink	1		1	
Team player/Leadership		PTeam	1		1	
Industrial and Management Engineering Knowledge	One-Dimensional (PO)	PIE	0.77	72.00	0.81	81.50
Computer Skills		PComp	0.67		0.82	
Background/Desirable	Attractive (PA)	PBack	0.55	55.00	0.60	60.00
		Overall Satisfaction Level	83.57		87.00	

4.9 Using the Quantitative Assessment Tool and QFD as an Improvement Tool

As mentioned before, the first area to work on improving is meeting the "Must-be" requirements. This is because any improvement in this area will lead to quick increases in the Satisfaction Level since missing any one of them will result in customers' dissatisfaction. All of the requirements under this group must be met in the curriculum. The analysis of the IEU 2013 curriculum shows the applicability of the suggested improvement tool.

4.9.1 Improving the Score for Must-be Requirements

The assessment process shows that the CTQ "Blueprint/Engineering Drawing skills" is not addressed under either IEU curricula. The weight of this requirement is (0.14) so that failing to meet this CTQ resulted in a reduction in performance level of both curricula to (0.86). The introducing of this CTQ into the curriculum contents will result in meeting all of the Basic Engineering Knowledge requirements and improve the performance level under the must-be category, which will lead to improving the overall satisfaction level of the curriculum.

Specifically, adding the "Blueprint/Engineering Drawing skills" to the contents of the IEU 2013 will increase the performance level of "Basic Engineering Knowledge" to 1. That will lead to improving the overall satisfaction level score of the curriculum to 2.23 out of 3. Table 4-17 shows the satisfaction level before and after meeting CTQ ""Blueprint/Engineering Drawing skills".

Table 4-17 Satisfaction Level after meeting CTQ "“Engineering Drawing skills”

Major Groups	Kano Categories		Before		After	
			Xi	CSL	Xi	CSL
Basic Engineering Knowledge	Must be (PM)	PEng	0.86	96.50	1	100
Communication		PCom	1		1	
Critical thinking/Problem Solving		PThink	1		1	
Team player/Leadership		PTeam	1		1	
Industrial and Management Engineering Knowledge	One-Dimensional (PO)	PIE	0.81	81.50	0.81	81.50
Computer Skills		PComp	0.82		0.82	
Background/Desirable	Attractive (PA)	PBack	0.60	60.00	0.60	60.00
		Overall Satisfaction Level	87.00		89.00	

4.9.2 Improving the One-dimensional Requirements

The second area in which we looked for improvement was the one-dimensional requirements group. This is because the CTQs under this group are decision points for the customers. However, the first step in the improvement process is spotting the area under the one-dimensional requirements group in which improvement will result in the greatest increase in the satisfaction level of the curriculum. To do this, we implement the steps detailed in the previous chapter (Research Methodology).

Step 1: Calculating the performance gap for each major group under one-dimensional requirements. “Industrial and Management Engineering Knowledge” and “Computer Skills”. Table 4-18 shows the gap calculations.

Table 4-18 Performance Gap of Major Groups under One-dimensional Requirements

Major Group Under One-dimensional Requirements	Current Performance Level		Performance Gap (1-Current Perf.)
Industrial and Management Engineering Knowledge	PIE	0.81	0.19
Computer Skills	PComp	0.82	0.18

Given these results, the major group "Industrial and Management Engineering Knowledge" has the potential to increase the overall Satisfaction level of the curriculum if we work on meeting the requirements under it.

Step 2: Calculate the performance gap for each sub group under the "Industrial and Management Engineering Knowledge" major group. Table 4-19 shows the gap for each sub group.

Table 4-19 Gap Score for Sub Groups under IEK Requirements

Industrial and Management Engineering Knowledge Sub Groups	IEU 2013 *PSG*	Performance Gap (1 - PSG)
Manufacturing, Production, Distribution, and Supply Chain	0.93	0.07
Productivity, Methods and Process Engineering	0.93	0.07
Quality Measurement and Improvement	0.91	0.09
Financial Engineering	0.83	0.17
Management	0.66	0.34
Ergonomics/Human Factors/Safety	0.27	0.73

Working on meeting the uncovered CTQs under the sub group "Ergonomics/Human Factors/Safety" will result in the greatest improvement in the overall satisfaction level of the curriculum.

The IEU 2013 curricula required the students to register for two courses under the restricted electives. The researcher will consider adding the uncovered CTQs under the "Ergonomics/Human Factors/Safety" and "Management" sub groups into the elective courses for the process of improving the curricula.

4.9.3 Developing the House of Quality

Table 4-20 shows the uncovered CTQs under the selected sub groups and their weights, which will represent the customers' needs.

Table 4-20 Uncovered CTQs and Customers' Weighting

CTQs	Weight
Management	
Coaching and Training (Training)	0.19
Business Plans reviewing/design/development (Business Plans)	0.11
Capital Expenditure Planning (Capex Planning)	0.02
Strategic Planning	0.02
Ergonomics/Human Factors/Safety	
Loss Control Program/Safety engineering Management/Optimization/Improve/Audits (Loss Control)	0.49
Support various Industrial Hygiene activities (IH)	0.06
Provide support to all areas for HSE (HSE)	0.05
Assist in administration of OSHA, ANSI, NFPA, LOTO, other (Safety Standards)	0.05
Participate in accident/injury trends, Investigations, Mitigation, and Corrective action (Accident)	0.05
Participate in Project Hazard Analysis (Hazard Analysis)	0.01
Implementation of lean concepts, Concentration on ergonomic designs, Reduce risk factors (Lean Ergonomic)	0.01

As mentioned before, the elective courses offered by the IEU Department will be considered as the "Design Parameters". Table 4-21 shows the list of the approved technical electives courses in the IEU 2013 curriculum. The relationship between "Customers' Needs" and the "Design Parameters" is 1 if the elective course covers the CTQ and 0 if not.

Table 4-21 IEU Elective Courses

Course Number	Course Name
IEEC 1341	Safety Engineering and Administration
IEEC 1342	Industrial Engineering Applications in The Service Industries
IEEC 1351	Management Information Systems I
IEEC 1352	Project Engineering
IEEC 1353	Usability Engineering
IEEC 1354	Interactive Simulation
IEEC 1355	Manufacturing Systems Engineering
IEEC 1356	Engineering Statistics
IEEC 1357	Total Quality Improvement

Figure 4-4 shows the House of Quality (HoQ) for the uncovered CTQs under the two selected sub groups with the highest performance gap and the approved technical electives by IEU Department. The results from analysis of the HoQ show that the elective course IEEC 1341 "Safety Engineering and Administration" has the potential to improve the performance level of the sub group "Ergonomics/Human Factors/Safety". However, none of the approved electives would improve the performance level of CTQs under the sub group "Management".

Therefore, House of Quality was reconstructed after removing the electives that show no relationship to the uncovered CTQs and the following courses were introduced:

1- IEEC 1359 - Training Systems Engineering
2- IEEC 1360 - Cost Engineering
3- IEEC 1361 - Engineering Management

Figure 4-5 shows the HoQ for the uncovered CTQs under the two selected sub groups with the highest performance gap and the electives suggested by the researcher.

HoQ			Approved Technical Electives "Design Parameters"									
CTQs		Customer Weight	IEEC 1341	IEEC 1342	IEEC 1351	IEEC 1352	IEEC 1353	IEEC 1354	IEEC 1355	IEEC 1356	IEEC 1357	IEEC 1358
Management (0.17)	Training	0.19	0	0	0	0	0	0	0	0	0	0
			0	0	0	0	0	0	0	0	0	0
	Business Plans	0.11	0	0	0	0	0	0	0	0	0	0
			0	0	0	0	0	0	0	0	0	0
	CapExp Planning	0.02	0	0	0	0	0	0	0	0	0	0
			0	0	0	0	0	0	0	0	0	0
	Strategic Planning	0.02	0	0	0	0	0	0	0	0	0	0
			0	0	0	0	0	0	0	0	0	0
Ergonomics/Human Factors/Safety (0.09)	Loss Control	0.49	1	0	0	0	0	0	0	0	0	0
			0.49	0	0	0	0	0	0	0	0	0
	Industrial Hygiene	0.06	1	0	0	0	0	0	0	0	0	0
			0.06	0	0	0	0	0	0	0	0	0
	HSE	0.05	1	0	0	0	0	0	0	0	0	0
			0.05	0	0	0	0	0	0	0	0	0
	Safety Standards	0.05	1	0	0	0	0	0	0	0	0	0
			0.05	0	0	0	0	0	0	0	0	0
	Accident	0.05	1	0	0	0	0	0	0	0	0	0
			0.05	0	0	0	0	0	0	0	0	0
	Hazard Analysis	0.01	1	0	0	0	0	0	0	0	0	0
			0.01	0	0	0	0	0	0	0	0	0
	Lean Ergonomic	0.01	0	0	0	0	0	0	0	0	0	0
			0	0	0	0	0	0	0	0	0	0
Total for Sub Group Management			0	0	0	0	0	0	0	0	0	0
Total for Sub Group Ergonomics/Human Factors/Safety			0.72	0	0	0	0	0	0	0	0	0
Grand Total			0.72	0	0	0	0	0	0	0	0	0
Relative Importance (%)			100									

Figure 4-4 House of Quality of Uncovered CTQs and Approved Technical Electives

HoQ			Approved Technical Electives “Design Parameters”			
CTQs		Customer Weight	IEEC 1341	IEEC 1359	IEEC 1360	IEEC 1361
Management (0.17)	Training	0.19	0	1	0	0
			0	0.19	0	0
	Business Plans	0.11	0	0	1	1
			0	0	0.11	0.11
	CapExp Planning	0.02	0	0	1	1
			0	0	0.02	0.02
	Strategic Planning	0.02	0	0	0	1
			0	0	0	0.02
Ergonomics/Human Factors/Safety (0.09)	Loss Control	0.49	1	0	0	0
			0.49	0	0	0
	Industrial Hygiene	0.06	1	0	0	0
			0.06	0	0	0
	HSE	0.05	1	0	0	0
			0.05	0	0	0
	Safety Standards	0.05	1	0	0	0
			0.05	0	0	0
	Accident	0.05	1	0	0	0
			0.05	0	0	0
	Hazard Analysis	0.01	1	0	0	0
			0.01	0	0	0
	Lean Ergonomic	0.01	0	0	0	0
			0	0	0	0
Total for Sub Group Management			0	0.19	0.13	0.15
Total for Sub Group Ergonomics/Human Factors/Safety			0.72	0	0	0
Grand Total			0.72	0.19	0.13	0.15
Relative Importance (%)			60.5	15.96	10.92	12.61

Figure 4-5 House of Quality of Uncovered CTQs and Suggested Electives

The values in the first row in front of each CTQ have the value of 0 or 1 based on if the elective covers this CTQ or not. The second row is the result of multiplying the value of the first row by the customer weight for the CTQ.

Based on the results of the HoQ shown in Figure 4-5, the elective courses IEEC 1341 “Safety Engineering and Administration”, and IEEC 1359 “Training Systems Engineering” have the greatest potential for improving the two sub groups and the overall Satisfaction Level of the IEU 2013 curriculum.

Table 4-22 shows the performance level of the major group “Industrial and Management Engineering Knowledge” before and after introducing the suggested electives (IEEC 1341 and IEEC 1359). Figure 4-6 shows the comparison between the performance levels under the major group IEK before and after introducing the two courses.

Table 4-22 Group IEK performance Level after Introducing IEEC1341 and IEEC1359

Industrial and Management Engineering Knowledge	SGw_i	PSG Before	PSG After
Management	0.17	0.66	0.85
Ergonomics/Human Factors/Safety	0.09	0.27	0.99

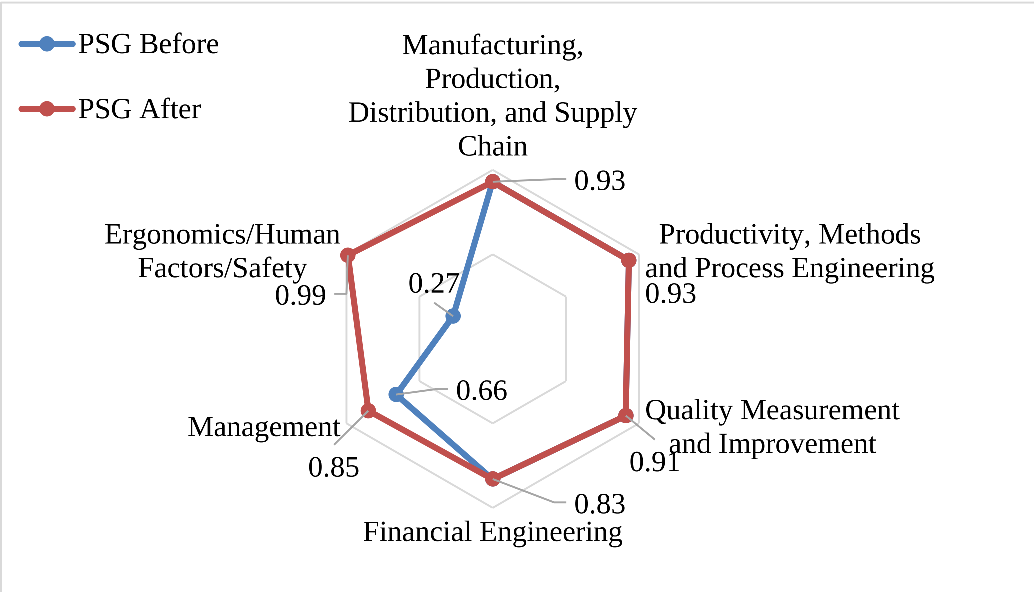

Figure 4-6 Performance Levels under the Major Group IEK

The improvement in the performance of the sup groups will result in improvement of overall satisfaction level of the curriculum. Table 4-23 show the results of the improvement process, which include meeting all of the must-be requirements and introducing the two selected elective courses IEEC 1341 and IEEC 1359.

Table 4-23 IEU 2013 Performance Level Before and After the Improvement Process

Major Groups	Kano Categories		Before		After	
			Xi	CSL	Xi	CSL
Basic Engineering Knowledge	Must be (PM)	PEng	0.86	96.50	1	100
Communication		PCom	1		1	
Critical thinking/Problem Solving		PThink	1		1	
Team player/Leadership		PTeam	1		1	
Industrial and Management Engineering Knowledge	One-Dimensional (PO)	PIEK	0.81	81.50	0.92	87.00
Computer Skills		PComp	0.82		0.82	
Background/Desirable	Attractive (PA)	PBack	0.60	60.00	0.60	60.00
Overall Satisfaction Level			87.00		90.57	

In conclusion, the results from the assessment and improvement process validate the applicability of the proposed quantitative assessment/improvement tool.

4.10 Verifications

In order to confirm the reliability of the used methodology and the accuracy of the research results, the researcher sought experts' opinions on the results and findings of the research on hand. The selection of the experts was based on their work experience in Industrial Engineering curricular design, development and assessments. A developed survey aimed to gather experts' feedback and comments on the usefulness and efficacy of a six sigma methodology for curricula assessment and improvement for an ABET accredited Industrial Engineering program. Appendix C shows the complete list of survey questions.

The survey questions utilized a Likert scale, with Strongly Disagree, Disagree, Neither agree nor disagree, Agree, and Strongly Agree as possible responses. Table 4-24 summarizes the results of the expert opinion survey. The survey was sent to 10 experts and 7 responses were received, equaling a 70% response rate.

In conclusion, the researcher believes that the feedback and comments from the experts' opinions survey support the reliability of used methodology and accuracy of research results and the usefulness and efficacy of a six sigma methodology for curricula assessment and improvement in higher education institutions.

Table 4-24 Summary of Experts Opinions

Survey Question	% of Agree, and Strongly Agree Responses	% of Strongly Disagree, Disagree Responses
Employers are stakeholders (customers) in Higher Education institutions	100%	0%
Students are stakeholders (customers) in Higher Education institutions	40%	30%
Academic Department plays a role in curricula design, development, and assessment.	100%	0%
Other related units within the university could play a role in curricula design, development, and assessment.	85%	15%
Job description is suitable to define employers' requirements.	86%	0%
Major Groups' names (as listed above) are appropriate to categorize main employers' requirements.	86%	0%
Sub Groups' names (as listed above) are appropriate to categorize employers' requirements under each major group.	86%	0%
Industrial Engineering job seekers' **"Must be"** requirements under the Kano Model should have the following skills: - Basic Engineering Knowledge - Communication - Critical Thinking/Problem Solving - Team Player/Leadership	100%	0%
Industrial Engineering job seekers' **"One-dimensional Requirements"** under the Kano Model should have the following skills: - Industrial and Management Engineering Knowledge - Computer Skills	100%	0%
Industrial Engineering job seekers' **"Attractive Requirements"** under the Kano Model can be satisfied with background and other preferred /desirable skills of job seekers.	100%	0%
Student requirements, like career mobility, and a successful job search, are indirectly related to the curriculum	100%	0%

CHAPTER 5 CONCLUSION AND FUTURE RESEARCH RECOMMENDATIONS

5.1 Conclusion

Nowadays, with the rapid changes in the sciences and technologies and the globalization of education, higher education institutions are in need of new techniques and tools that can help in capturing these changes in order to assess student needs and continue to provide quality education?. The objective of this research was to propose a quantitative assessment and improvement tool that would help Higher Education institutions with a tool to do so.

The need for the proposed tool has been suggested due to the lack of quantitative tools that can enhance the reliability and efficiency of the process of collecting higher education customers' expectations in addition to a lack of tools for translating these expectations into critical requirements for higher education curricula.

In response to this need, this research proposed a quantitative model for curriculum assessment and improvement in higher education institutions developed using a design for six sigma methodology. The proposed model includes six main steps: Identify targeted customers, Conduct a customer and business requirements study to determine customer needs, Quantify customers' requirements, Use the Kano Model concept to translate customer requirements to Critical to Quality, Establish transfer function, and Detail customer satisfaction level function. The general formula of the American Customer Satisfaction Index (ACSI) was applied to calculate the overall curriculum customer satisfaction level.

Besides helping to fill the gap in the literature, the proposed quantitative model for curriculum assessment and improvement in higher education offers a way to achieve the ultimate objective of assessment, which is improved student learning. This model can provide curriculum stakeholders with timely feedback about the curriculum and identify areas in need of improvement.

Moreover, the proposed quantitative assessment tool can help the academic departments within higher education institutions to capture and quantify the voice of customers, internally and externally, and translate them into Critical to Quality without any:

1- "Lost in Translation" problems, or
2- Any source of subjectivity

Furthermore, the proposed quantitative assessment tool could be used as a comparison tool between curricula when used to measure and compare the satisfaction level for each one. Therefore, the model may include a seventh step to add to the six above: apply the quantitative model as a comparison tool.

In addition, the suggested improvement process would help the curricula designers in the process of updating the topics covered in courses within the curriculum and in selecting what elective courses to offer to the students in order to increase the Employers' Satisfaction Level of the curriculum.

5.2 Future Research Work Recommendations

The umbrella of the higher education process could be extended. First, cover the high school education process, as their outcomes can be considered as the raw materials for the higher education institutes. Second, cover the employers, which are considered the consumers of higher education process outcomes.

The researcher suggests “supply chain research” that covers high schools and employers that could result in:

1- Moving coverage of some of basic knowledge required by the employers from college curricula to high schools. This will free more time for university academic departments to introduce more advanced knowledge that might be required by the employers and/or reduce the time to market.
2- Determine clear channels between the higher education institutes and the employers to transfer their requirements using more efficient methods.

Furthermore, the researcher suggests a research idea of using the Kano Model to standardize job description design. In addition, a data mining project on collecting employers’ requirements from the job descriptions would be helpful to speed the process of the proposed quantitative model for curriculum assessment and improvement in hand.

APPENDIX A:

JOBS DESCRIPTIONS

Lockheed Martin	
Req ID	258427BR
Industry Job Title	Industrial Engineer Asc
Standard Job Code/Title	E1641:Industrial Engineer Asc
Required skills	Teaming skills
Desired skills	Background in sheet metal/mechanical light assembly manufacturing environment, proficiency with Microsoft Excel, Access, Visual Basic and Database queries. Oracle Database experience, Sql Plus, working knowledge of MTO (Made to Order, formerly WDS) Operating Systems. Demonstrated knowledge of FAR (Federal Acquisition Regulations),and MRP/ERP software. Effective communication skills required for interaction with customers and audit agencies.
Specific Job Description	The position serves as a dual role both as industrial engineer, conducting studies and implementing plans and programs pertaining to cost control, MRP, cost reduction, inventory control and production records review and, Estimating labor and material costs of manufacturing and engineering based on request for proposal (RFP) data submitted by prospective customers. Analyzes specifications, including sketches, blueprints, bills of material, or sample layouts, and calculates production costs using labor and material pricing schedules and historical data. Collects cost data from functional representatives, subcontractors, and vendors. Computes cost estimates of raw materials or subcontracted work and labor. Prepares and maintains historical cost data. Creates cost models for cost estimating elements. Prepares cost reports and presents findings to management, contract personnel, proposal coordinators, customer representatives, price auditors, vendors, and subcontractors.
Standard Job Description	Analyzes and designs sequence of operations and work flow to improve efficiencies in plant and production facilities and equipment layouts; and establishes methods for maximum utilization of production facilities and personnel. May establish or assist in establishing accident prevention measures and may manage training programs for personnel concerning all phases of production operations. Conducts studies pertaining to cost control, cost reduction, inventory control, and production record systems. On the basis of these studies, develops and implements plans and programs for facility modifications and revisions to operating methods. May assist facilities engineers in the planning and design of facilities.
Typical Minimums	Bachelors degree from an accredited college in a related discipline, or equivalent experience/combined education. Entry level.
LMCareers Business Unit	ESS0343 AERONAUTICS COMPANY
Business Area	Aeronautics Company
Department	81S:Finance
Job Class	Manufacturing
URL:	http://www.lockheedmartinjobs.com/jobdesc.aspx?q=&jobDesc=Industrial+Engineer+Asc&jobUrl=https%3A%2F%2Fsjobs.brassring.com%2F1033%2FASP%2FTG%2Fcim_jobdetail.asp%3Fpartnerid%3D25037%26siteid%3D5014%26jobid%3D270001&searchString=&siteChoiceHidden=Campus

? Help

Job details

Job 1 of 1

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Job Posting Title	Associate Industrial Engineer
Job Description	The Walt Disney Company is a world-class entertainment and technological leader. Walt's passion was to continuously envision new ways to move audiences around the world-a passion that remains our touchstone in an enterprise that stretches from theme parks, resorts and a cruise line to sports, news, movies and a variety of other businesses. Uniting each endeavor is a commitment to creating and delivering unforgettable experiences - and we're constantly looking for new ways to enhance these exciting experiences. Bring your individual talents here and discover for yourself why a career with Disney is the opportunity you've been looking for. "It takes people to make the dream a reality." Walt was on to something when he said that, and it continues to ring true today. No matter the stage in your career, being a part of Walt Disney Parks & Resorts means being a part of a team where you help bring innovation to life through unsurpassed products, services and most importantly remarkable experiences. As a Cast Member you are the steward and connection to our legacy and the backbone of our thriving innovations. Join our team and watch your dreams come true.
Responsibilities	This posting is for Industrial Engineering and this role could be located in either Anaheim, California or Lake Buena Vista, Florida. An Industrial Engineer at Walt Disney Parks and Resorts applies a comprehensive set of Industrial Engineering techniques (e.g., statistics, simulation, "Guestology") to conduct highly-complex business analysis, particularly in the areas of operational planning support, capacity/demand analysis, and productivity/process improvement. This role communicates results and recommendations to senior leadership through verbal presentations and written reports.
Basic Qualifications	• Familiarity with capacity/demand analysis and modeling techniques. • Demonstrated analytical ability and creative problem solving. • Demonstrated conceptual thinking skills. • Demonstrated interpersonal skills, including ability to partner with others to handle multiple priorities in a challenging operational environment. • Strong computer skills including spreadsheets, databases, and graphics software. • Ability to work in a fast-paced environment under changing conditions. • Strong project management skills, including the ability to manage multiple tasks simultaneously. • Understanding of Disney heritage and a commitment to change and excellence.
Preferred Qualifications	• Broad understanding of The Walt Disney Company and Walt Disney Parks & Resorts. • Experience with consulting or quality improvement teams.
Preferred Education	Master's degree in Industrial Engineering, Operations Research, Business or equivalent.
Required Education	Bachelor degree in Industrial Engineering.
Job Posting Industries	Leisure and Travel
Additional Information	©Disney is an equal opportunity employer. Drawing Creativity from Diversity.
Primary Location-City	Lake Buena Vista
Primary Location-State	FL
Primary Location-Country	US
Alternate Location-City	Anaheim
Alternate Location-State/Region	CA
Alternate Location-Country	US
Auto req ID	93864BR

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APPENDIX B:

IEU 2008 AND IEU 2013 COURSES LIST

IEU 2008 Curriculum - Core Courses List

Course ID	Course Title	Credit Hours
GEP 8001	Composition I	3
GEP 8002	Composition II	3
GEP 8003	Fundamentals of Technical Presentations	3
GEP 8004	Principles of Macroeconomics	3
GEP 8005	Historical Foundations I	3
GEP 8006	Historical Foundations II	3
GEP 8007	Cultural Foundations	3
GEP 8008	Social Foundations	3
GEP 8009	Science Foundations I	4
GEP 8010	Science Foundations II	3
SAT 8001	Probability and Statistics for Engineers	3
MATH 8001	Calculus with Analytic Geometry I	4
MATH 8002	Calculus with Analytic Geometry II	4
MATH 8003	Calculus with Analytic Geometry III	4
MATH 8004	Differential Equations	3
PHY 8001	Physics for Engineers & Scientists I	3
PHY 8002	Physics for Engineers & Scientists II	4
CHEM 8001	Fundamentals of Chemistry for Engineers	4
IECB 8001	Introduction to the Engineering Profession	1
IECB 8002	Engineering Computer Graphics	2
IECB 8003	Engineering Concepts and Methods	1
IECB 8004	Introduction to C Programming	3
IECB 8005	Engineering Analysis-Statics	3
IECB 8006	Engineering Analysis-Dynamics	3
IECB 8007	Thermodynamics	3
IECB 8008	Structure & Properties of Materials	3
IECB 8009	Principles of Electrical Engineering	3
IECM 8001	Engineering Economic Analysis	2
IECM 8002	Engineering Administration	3
IECM 8003	Introduction to Industrial Engineering	2
IECM 8004	Work Measurement & Design	3
IECM 8005	Principles of Cost Engineering	3
IECM 8006	Industrial Engineering Applications of Computers	3
IECM 8007	Human Engineering	3
IECM 8008	Industrial Control Systems	3
IECM 8009	Industrial Planning & Design	3
IECM 8010	Manufacturing Engineering	3
IECM 8011	Empirical Methods for Industrial Engineering	3
IECM 8012	Quality Engineering	3
IECM 8013	Operations Research	3

Course ID	Course Title	Credit Hours
IECM 8014	Systems Simulation	3
IEEX 8090	Systems Analysis & Design	3
IEEX 8099	Industrial Engineering Senior Design Project	3

IEU 2013 Curriculum - Core Courses List

Course ID	Course Title	Credit Hours
GEP 1301	Composition I	3
GEP 1302	Composition II	3
GEP 1303	Fundamentals of Technical Presentations	3
GEP 1304	Principles of Macroeconomics	3
GEP 1305	Historical Foundations I	3
GEP 1306	Historical Foundations II	3
GEP 1307	Cultural Foundations	3
GEP 1308	Social Foundations	3
GEP 1309	Science Foundations	3
SAT 1321	Probability and Statistics for Engineers	3
MATH 1301	Calculus with Analytic Geometry I	4
MATH 1302	Calculus with Analytic Geometry II	4
MATH 1303	Calculus with Analytic Geometry III	4
MATH 1304	Ordinary Differential Equations I	3
PHY 1301	Physics for Engineers & Scientists I	3
PHY 1302	Physics for Engineers & Scientists II	4
CHEM 1301	Fundamentals of Chemistry for Engineers	4
IECB 1301	Introduction to the Engineering Profession	1
IECB 1302	Engineering Concepts and Methods	1
IECA 1301	Engineering Administration	3
IECA 1302	Work Analysis and Design	3
IECA 1303	Industrial Engineering Applications of Computers	3
IECA 1304	Human Engineering	3
IECA 1305	Production and Distribution Systems	3
IECA 1306	Facilities Planning	3
IECA 1307	Manufacturing Engineering	3
IECA 1308	Empirical Methods for Industrial Engineering	3
IECA 1309	Quality Engineering	3
IECA 1310	Operations Research	3
IECA 1311	Systems Simulation	3
IECA 1312	Systems Engineering	3
IECA 1313	Engineering Analysis-Statics	3
IECA 1314	Introduction to Programming with C	3
IECA 1315	Engineering Analysis-Dynamics	3
IECA 1316	Principles of Electrical Engineering	3
IECA 1317	Introduction to Industrial Engineering	1
MATH 1305	Matrix and Linear Algebra	4
IECA 1318	Engineering Economic Analysis and Cost Engineering	3
IECA 1319	Thermodynamics	3
IEEX 1399	Industrial Engineering Senior Design Project	3

IEU 2013 Curriculum - Restricted Electives Courses List

Course ID	Course Title	Credit Hours
IEEC 1341	Safety Engineering and Administration	3
IEEC 1342	Industrial Engineering Applications in Service Industries	3
IEEC 1351	Management Information Systems I	3
IEEC 1352	Project Engineering	3
IEEC 1353	Usability Engineering	3
IEEC 1354	Interactive Simulation	3
IEEC 1355	Manufacturing Systems Engineering	3
IEEC 1356	Engineering Statistics	3
IEEC 1357	Total Quality Improvement	3
IEEC 1358	Reliability Engineering	3

APPENDIX C:

EXPERT OPINION SURVEY

Using Design For Six Sigma Methodology To Develop Quantitative Model For Curricula Assessment And Improvement In Higher Education Institutions

Expert Opinion Survey: Validation of Research Recommendations

----

Dear Dr.______________:

As an expert in Industrial Engineering curricula design, development and assessments, your input, feedback, and comments will assist in verifying the usefulness and efficacy of a six sigma methodology for curricula assessment and improvement for an ABET accredited Industrial Engineering program.

If you have any query, please contact the researcher at ahalawany@knights.ucf.edu.

Thank you for your participation and your valuable time.

Sincerely yours,

Abdullah Halawany,
Researcher

1. Please check if you agree or disagree with the following statements.

	Yes	No
a) I am/was involved in curricula design, development, and assessment process.		
b) I play/played a part in decision making process regarding curriculum design, development, and assessment.		

2. Research suggests that stakeholders of higher education can be classified into two groups:
   a) External stakeholders or customers (employers and students).
   b) Internal stakeholders or customers (academic department, and other related-units within the educational institution)

Please rate how strongly you agree or disagree with the following statements.

	1: Strongly disagree 5: Strongly agree				
	1	2	3	4	5
a) Employers are stakeholder (customers) in Higher Education institutions					
b) Students are stakeholder (customers) in Higher Education institutions					
c) Academic Department plays a role in curricula design, development, and assessment.					
d) Other related units within the university could play a role in curricula design, development, and assessment.					

Comments:____

____

____

3. Research suggests that employers' detailed job description such as knowledge, skills, qualifications, and experience are essential to selecting the right employees.

Please rate how strongly you agree or disagree with the following statements.

	1: Strongly disagree 5: Strongly agree				
	1	2	3	4	5
a) Job description is suitable to define employers' requirements.					

Comments:____

4. Detailed job descriptions for Industrial Engineering positions can be grouped into major groups with each having its own sub groups (as shown in the table below).

Major Groups	Sub Groups
1.Industrial and Management Engineering Knowledge	1.1. Management
	1.2. Manufacturing, Production, Distribution, and Supply Chain
	1.3. Productivity, Methods and Process Engineering
	1.4. Quality Measurement and Improvement
	1.5. Ergonomics/Human Factors/Safety
	1.6. Financial Engineering
2.Basic Engineering Knowledge	------
3.Background/Desirable	3.1. Management
	3.2. Manufacturing, Production, Distribution, and Supply Chain
	3.3. Productivity, Methods and Process Engineering
	3.4. Quality Measurement and Improvement
	3.5. Ergonomics/Human Factors/Safety
	3.6. Financial Engineering
	3.7. ISO
	3.8. Certification
	3.9. Others
4.Computer Skills	4.1. Graphic Design Software
	4.2. Computer Skills/Microsoft
	4.3. Database/Programming
	4.4. Production Software
	4.5. Statistical Software
5.Communication	------
6.Critical thinking/Problem Solving	------
7.Team player/Leadership	------

Please rate how strongly you agree or disagree with the following statements.

	1: Strongly disagree 5: Strongly agree				
	1	2	3	4	5
b) Major Groups' names (as listed above) are appropriate to categorize main employers' requirements.					
c) Sub Groups' names (as listed above) are appropriate to categorize employers' requirements under each major group.					

Comments:____

____

____

5. According to Kano Model Concept, customer requirements can be classified into three main categories:
    a. The **Must be requirements** which if not met, will cause great dissatisfaction and product/service will not gain traction with users.
    b. **One-dimensional requirements**, which increase customer satisfaction as their fulfillment level increases.
    c. **Attractive requirements**, which if absent will not cause dissatisfaction. Yet, their presence will promote the satisfaction of customers and increase the product/service's competitive advantage.

Please rate how strongly you agree or disagree with the following statements.

	1: Strongly disagree 5: Strongly agree				
	1	2	3	4	5
a) Industrial Engineering job seekers' **"Must be"** requirements under Kano Model should have the following skills: - Basic Engineering Knowledge - Communication - Critical Thinking/Problem Solving - Team Player/Leadership					
b) Industrial Engineering job seekers' **"One-dimensional Requirements"** under Kano Model should have the following skills: - Industrial and Management Engineering Knowledge - Computer Skills					
c) Industrial Engineering job seekers' **"Attractive Requirements"** under Kano Model can be satisfied with background and other preferrd /desirable skills of job seekers.					

Comments:____

____

____

6. A recent survey of senior students showed that academic interest, career mobility, and demand are the most important factors influencing students' selection of academic major. However, my research findings suggest the following statement:

   Although students have no direct input into the curriculum design, development and assessment processes, their needs and requirements will be met as a result of meeting employers, academic department, and ABET requirements. In other words, student requirements, like career mobility, and a successful job search, are indirectly related to the curriculum.

   Please rate how strongly you agree or disagree with the following statement.

	1: Strongly disagree 5: Strongly agree				
	1	2	3	4	5
a) I support the above statement about students and their requirements.					

Comments:____

____

____

End of Survey

Thank you for taking the time to complete the survey!

Abdullah Halawany

REFERENCES

Industry-Advisory-Board. (n.d.). *Industrial Engineering Roles In Industry.* Retrieved 8 12, 2013, from www.iienet2.org/uploadedFiles/IIE/About_IIE/What%20IEs%20Do%20IIE-IAB%20v2.pdf

ABET Inc. (2013). *Why Accreditation Matters to Programs and Institutions*. Retrieved 02 19, 2013, from Abet.org: http://www.abet.org/accreditation-matters-programs-institutions/

AFIA. (2013). *About AFIA*. (UCF) Retrieved 02 20, 2013, from Academic, Faculty, and International Affairs: http://afia.ucf.edu/about-academic-faculty-and-international-affairs/

Alam, I., & Perry, C. (2002). A customer-oriented new service development process. *Journal of Services Marketing, 16*(6), 515-534.

Alkin, M. C. (2011). *Evaluation essentials: From A to Z.* The Guilford Press.

(2005). *American Customer Satisfaction Index, Methodology Report.* University of Michigan, National Quality Research Center.

Amsler, S. S., & Bolsmann, C. (2012, January 1). University Ranking as Social Exclusion. *ournal Of Sociology Of Education, 33*(2), pp. 283-301.

Antony, J. (2002). Design for six sigma: a breakthrough business improvement strategy for achieving. *Work Study, 51*(1), pp. 6 - 8.

Aytac, A., & Deniz, V. (2005). Quality function deployment in education: A curriculum review. *Quality and Quantity, 39*(4), 507–514. doi:10.1007/s11135-004-6814-8

Barlett, J. E., Kotrlik, J. W., & Higgins, C. C. (2001). Organizational research: Determining appropriate sample size in survey research. *Information Technology, Learning, and Performance Journal, 19*(1), 43-50.

Blackmore, P., & Kandiko, C. B. (2012). *Strategic Curriculum Change: global trends in universities / edited by Paul Blackmore and Camille Kandiko.* Milton Park, Abingdon, Oxon; New York: Routledge.

Bligh, J. (1995). Identifying the core curriculum: The Liverpool approach. *Medical Teache, 17*(4), 383.

Bullinger, H., Fahnrich, K., & Meiren, T. (2003). Service engineering--methodical development of new service products. *International Journal of Production Economics, 85*(3), 275-287. doi:10.1016/S0925-5273(03)00116-6

Bureau of Labor Statistics . (2012, February 1). *Industry-occupation matrix data, by occupation*. Retrieved 02 12, 2013, from Bureau of Labor Statistics: http://www.bls.gov/emp/ep_table_108.htm

Campanerut, M., & Nicoletti, B. (2010). *Best Practices for DFSS in the Development of New Services: Evidence from a Multiple Case Study*. The Business Review, Cambridge. doi:2214758731

CareerOneStop. (2013). *Occupation Profile*. Retrieved 02 12, 2013, from CareerOneStop: http://www.careerinfonet.org/occ_rep.asp?optstatus=011000000&soccode=172112&id=1&nodeid=2&stfips=12&search=Go

Chaudha, A., Jain, R., Singh, A. A., & Mishra, P. P. (2011). Integration of Kano's Model into quality function deployment (QFD). *International Journal of Advanced Manufacturing Technology, 53*, 689-698. doi:10.1007/s00170-010-2867-0

Cushway, B. (2003). *Handbook of Model Job Descriptions.* Kogan Page.

D. C. (2013). *Job details*. Retrieved 04 02, 2013, from Disney Careers: https://sjobs.brassring.com/TGWEbHost/jobdetails.aspx?partnerid=25348&siteid=5039&jobid=94223

Davidson, J. E. (2005). *Evaluation methodology basics: The nuts and bolts of sound evaluation.* Sage Publications, Inc.

DEO. (2013). *Employment Projections*. Retrieved 02 12, 2013, from Department of Economic Opportunity: http://www.floridajobs.org/labor-market-information/data-center/statistical-programs/employment-projections

Diamond, R. M. (2008). *Designing and assessing courses and curricula : a practical guide / Robert M. Diamond.* (3rd, Ed.) San Francisco: Jossey-Bass.

Duffy, G. L. (2012). AFFINITY DIAGRAMS. *Quality Progress, 45*(4), 20-21.

El-Haik, B., & Roy, D. M. (2005). *SERVICE DESIGN FOR SIX SIGMA: A Road Map for Excellence.* Hoboken, New Jersey, USA: John Wiley & Sons.

Ermer, D. (1995). Using QFD becomes an educational experience for students and faculty. *Quality Progress, 28*(5), 131-136.

Ferryanto, L. (2007). DESIGN FOR SIX SIGMA. *Jurnal Teknik Industri*(1), 1.

Fitzsimmons, J., & Fitzsimmons, M. (2001). *Service Management: Operations, Strategy, and Information Technology.* Mc Graw-Hill.

Gonzalez, M. (2001). *Quality Function Deployment; A Road for Listening to Customer Expectations.* Mexico City: McGraw Hill.

Gonzalez, M., Quesada, G., Gourdin, K., & Hartley, M. (2008). Designing a supply chain management academic curriculum using QFD and benchmarking. *Quality Assurance in Education, 16*(1), 36-60. doi:10.1108/09684880810848404

Gonzalez, M., Quesada, G., Picado, F., & Eckelman, C. A. (2004). Customer satisfaction using QFD: an e-banking case. *Managing Service Quality, 14*(4), pp. 317-330. doi:687510441

Guijt, I., Kusters, C., Lont, H., & Visser, I. (2012). *Developmental Evaluation: Applying complexity concepts to enhance innovation and use.* Wageningen UR Centre for Development Innovation.

Harden, R. M., & Davis, M. H. (1995). AMEE Medical Education Guide no.5. The core curriculum with options or special study modules. *Medical Teacher, 17*(2).

Hart, S. (1987). The Use of the Survey in Industrial Market Research. *Journal Of Marketing Management , 3*(1), 25-38.

Hasenkamp, T. (2010). Engineering Design for Six Sigma—a systematic approach. *Quality and Reliability Engineering International, 26*(4), 317-324. doi:10.1002/qre.1090

History of the American Customer Satisfaction Index. (2014). Retrieved 2 25, 2014, from American Customer Satisfaction Index: http://www.theacsi.org/about-acsi/history

Huber, C., & Launsby, R. (2002). Straight Talk on DFSS. *SIX SIGMA FORUM MAGAZINE, 1*(4), pp. 25-25.

IEMS. (2013). *Industrial Engineering & Management Systems*. Retrieved 02 12, 2013, from Industrial Engineering & Management Systems: http://iems.ucf.edu/about/ABET.html

Jiang, J., Shiu, M., & Tu, M. (2007). DFX and DFSS: How QFD Integrates Them. *Quality Progress, 40*(10), 45-51.

Johansson, C., Burns, A., Evans, S., Barrett, R., & Karlsson, S. (2000). Delighting the customer across cultural settings. *"Engineering Design Conference 2000", Design for Excellence, Brunel University, June 27th-29th.*

Kukreja, A., Ricks, J., & Meyer, J. (2009). Using Six Sigma for performance improvement in business curriculum: A case study. *Performance Improvement, 48*(2), 9–25. doi:10.1002/pfi.20042

L. M. (2013). *Job Search*. Retrieved 04 02, 2013, from Lockheed Martin Corporation: http://www.lockheedmartinjobs.com/jobdesc.aspx?q=&jobDesc=Industrial+Engineer+Asc&jobUrl=https%3A%2F%2Fsjobs.brassring.com%2F1033%2FASP%2FTG%2Fcim_jobdetail.asp%3Fpartnerid%3D25037%26siteid%3D5014%26jobid%3D270001&searchString=&siteChoiceHidden=Campus

Levander, L. M., & Mikkola, M. (2009). Core Curriculum Analysis: A Tool for Educational Design. *Journal of Agricultural Education and Extension, 15*(3), 275-286.

Long, P., Kovach, J., & Ding, D. (2011). A design for Six Sigma case Study: Creating an IT change management system for a mid-size accounting firm. *International Journal of Engineering, Science and Technology, 3*(7), 56-72. doi:10.4314/ijest.v3i7.5S

Maher, A. (2004). Learning Outcomes in Higher Education: Implications for Curriculum Design and Student Learning. *Journal of Hospitality, Leisure, Sport and Tourism Education, 3*(2), 5-14. doi:10.3794/johlste.32.78

Mast, J. d., Diepstraten, G., & Does, R. J. (2011). Quality Quandaries: Design for Six Sigma: Method and Application. *Quality Engineering, 23*(2), pp. 204-211. doi:10.1080/08982112.2011.560818

Mazur, G. H. (2001). QFD and Design for Six Sigma: A Quality Product Development System.

Menor, L. J., Tatikonda, M. V., & Sampson, S. E. (2002). New service development: areas for exploitation and exploration. *Journal of Operations Management, 20*(2), 135-157. doi:10.1016/S0272-6963(01)00091-2

Meredith, M. (2004). Why Do Universities Compete in the Ratings Game? An Empirical Analysis of the Effects of the U.S. News and World Report College Rankings. *Research In Higher Education, 45*(5), pp. 443-461.

National Survey of Student Engagement. (2012). *Promoting Student Learning and Institutional Improvement: Lessons from NSSE at 13.* Bloomington, IN: Indiana University Center for Postsecondary Research. Retrieved 02 12, 2013, from http://nsse.iub.edu/NSSE_2012_Results/pdf/NSSE_2012_Annual_Results.pdf#page=16

Nygaard, C., Hojlt, T., & Hermansen, M. (2008). Learning-based curriculum development. *Higher Education, 55*(1), 33-50. doi:10.1007/s10734-006-9036-2

OEAS. (2012, 8 10). *About OEAS*. Retrieved 1 10, 2013, from University of Cnetral Folrida Operational Excellence and Assessment Support: http://oeas.ucf.edu/about_oeas.htm

Oplatka, I. (2004). Marketing informal education institutions in Israel: the centrality of customers" active development in service development. *The International Journal of Educational Management, 18*(6), 417-424.

Owlia, M. S., & Aspinwall, E. M. (1998). Application of quality function deployment for the Improvement of Quality in Engineering Department. *European Journal of Engineering Education, 23*(1), 105-115.

Patton, M. Q. (2011). *Developmental evaluation: Applying complexity concepts to enhance innovation and use.* Guilford Press.

Pyzdek, T., & Keller, P. (2010). *The Six Sugma Handbook: A Complete Guide for Green Belts, Black Belts, and Managers at All Levels* (3rd ed.). USA: McGraw-Hill Companies.

Rodgers, M., Grays, M., Fulcher, K., & Jurich, D. (2013). Improving Academic Program Assessment: A Mixed Methods Study. *Innovative Higher Education, 38*(5), 383-395.

Rossi, P. H., Lipsey, M. W., & Freeman, H. E. (2004). *Evaluation: A Systematic Approach* (7th ed.). Sage Publication.

Secolsky, C., & Denison, D. (2011). *Handbook on Measurement, Assessment, and Evaluation in Higher Education.* Routledge, Taylor & Francis Group.

Sireli, Y., Kauffmann, P., & Ozan, E. (2007). Integration of Kano' s Model Into QFD for Multiple Product Design. *IEEE Transactions on Engineering Management, 54*(2), pp. 380-390. doi:10.1109/TEM.2007.893990

Smith, J. A., & & Angeli, I. I. (1995). use of quality function deployment to help adopt a total quality strategy. *Total Quality Management, 6*(1), 35-44. doi:10.1080/09544129550035567

Stevens, E., & Dimitriadis, S. (2004). New service development through the lens of organisational learning: evidence from longitudinal case studies. *Journal of Business Research, 57*(10), 1074-1084. doi:10.1016/S0148-2963(03)00003-1

Suskie, L. (2009). *Assessing student learning: A common sense guide.* San Francisco, CA: Jossey-Bass.

Treichler, D., Carmichael, R., Kusmanoff, A., Lewis, J., & Berthiez, G. (2002). Design for Six Sigma: 15 Lessons Learned. *QUALITY PROGRESS, 35*(1), pp. 33-42.

Undergraduate Studies. (2008). *About US*. Retrieved 1 10, 2013, from Office of Undergraduate Studies: http://www.undergraduatestudies.ucf.edu/about/mission.php

Usman, A., Chakraborty, A., & Chuan, K. C. (2006). Comparative study of DFSS in product and service innovation. *Proceedings Asian Network for Quality Congress 2006 Singapore.* Singapore: ANQ.

Wholey, J. S., Hatry, H. P., & Newcomer, K. E. (2010). *Handbook of practical program evaluation* (3rd ed.). Jossey-Bass.

Yang, C., Chen, S., & Shiau, J. (2006). A DFX and concurrent engineering model for the establishment of a new department in a university. *International Journal Production Economics*, 179-189.

Yang, K., & El-Haik, B. (2003). *Design for Six Sigma A Roadmap for Product Development.* New York: McGraw-Hill. doi:10.1036/0071435999

Yeung, S. M.-c. (2010). Use of QFD - House of Quality in Six Sigma for SCM Curriculum Design. *8th International Conference on "Supply Chain Management and Information Systems (SCMIS)"*, *1*, pp. 4-6.

Ziyadeh, M., & White, B. (2009). In Pursuit of Quality Within The School of Business Curriculum – An Exploratory Study of Continuous Process Improvement Practices In Higher Education. *In The Proceedings of the Information Systems Education Conference, 26*. Retrieved 9 1, 2012, from http://proc.isecon.org/2009/3333/ISECON.2009.Ziyadeh.pdf