Analytical Hierarchy Process To Determine The Weights of Student Outcomes for Engineering Undergraduate Programs for ABET Accreditation

Chukwudi Thomas Nwafor

Submitted to the
Institute of Graduate Studies and Research
in partial fulfillment of the requirements for the degree of

Master of Science
in
Industrial Engineering

Eastern Mediterranean University
June 2016
Gazimağusa, North Cyprus

Approval of the Institute of Graduate Studies and Research

Prof. Dr. Cem Tanova
Acting Director

I certify that this thesis satisfies the requirements as a thesis for the degree of Master of science in Industrial Engineering.

Assoc. Prof. Dr. Gökhan Izbirak
Chair, Department of Industrial Engineering

We certify that we have read this thesis and that in our opinion it is fully adequate in scope and quality as a thesis for the degree of Master of Science in Industrial Engineering.

Asst. Prof. Dr. Hüseyin Güden
Supervisor

Examining Committee

1. Assoc. Prof. Dr. Gökhan Izbirak
2. Asst. Prof. Dr. Sahand Daneshvar
3. Asst. Prof. Dr. Hüseyin Güden

ABSTRACT

Engineering education is becoming more and more versatile and complex due to a number of courses offered by each engineering department.

The criterion 4. a-k of the Accreditation Board for Engineering and Technology (ABET) consists of 2(two) class of interaction based on the program hard skills and soft skills which cover all the sets of programs. Analytical Hierarchy Process (AHP) is utilized for pair-wise comparison of the student's outcomes in Engineering Undergraduate Programs of the whole world wide.

In this study, it is attempted to estimate the realistic weights of the criterion 4 using the classical AHP, the weight of the Nine-Level Fundamental Scale of judgments are expressed via numerical scale order to represent the relative important among the multi-criteria decision making (MCDM) by collecting the responses from the diarchy which comprise of 4 affected parties (students, alumni, employees and academic staffs) at the various department of engineering from all parts of the world based on the outcome of the parties by means of survey questionnaires and internet website has been designed also to implement AHP judgments on the outcomes from the criterion $4_{a\text{-}k}$ of the ABET.

The focus of the data collection is to answer the question, "can the engineering undergraduate program demonstrate the level to which students have attained the anticipated student's outcome?" The evidence of students learning is then used to identify student strengths and weakness related to each of the student outcome for making decision about how to improve the programs teaching and learning process, a defined weight calculated by applying classical AHP method.

The implication of this research is that the faculty members can utilize the weights of the program outcomes generated as a result of this study and implement them for the continuous improvement process.

Keywords: Analytic Hierarchy Process (AHP), student outcomes, multiple-criteria decision making (MCDM), ABET Accreditation.

ÖZ

Mühendislik eğitimi her bir mühendislik bölümünde verilen derslerin sayısına bağlı olarak daha çeşitli ve karmaşık hale gelmektedir.

Mühendislik ve Teknoloji Akreditasyon Kurulu'nun (MTAK) 4. kriteri (a-k) programın bileşenlerine göre (Tasarım, Bilim ve Matematik) tüm kümeleri aşağı yukarı kapsayan 2 (iki) sınıf içerir. Bu çalışmada, mühendislik lisans programlarının öğrenci çıktılarının çiftler halinde karşılaştırılması için Analitik Hiyerarşi Süreci (AHS) kullanılmıştır.

Bu çalışmada, klasik AHP yöntemi kullanılarak 4. kriterin gerçekçi ağırlıklarının belirlenmesi amaçlanmıştır. Dünyadaki çeşitli mühendislik bölümlerinden dört gruba (öğrenci, mezun, iş veren ve akademisyen) öğrenci çıktılarının ağırlıklarını dokuz seviyede karşılaştırmaları için bir anket uygulanmıştır. Toplanan cevaplar çok kriterli karar verme çalışmalarının bir parşaçı olarak AHP yöntemiyle 4. kriterdeki öğrenci çıktılarının (a-k) göreli ağırlıklarının belirlenmesinde kullanılmıştır.

Veri toplamanın odağı "mühendislik lisans programı öğrencilerinin öğrenci çıktılarına beklenen ulaşım seviyesini sağladığını gösterebilir mi?" sorusunun cevabını bulmaktır. Daha sonra, öğrencilerin her bir öğrenci çıktısıyla ilgili olarak güçlü ve zayıf yönleri ve klasik AHP ile bulunan ağırlıklar kullanılarak mühendislik bölümlerinin öğretme ve öğrenme süreçlerinin geliştirilmesiyle ilgili karar verilebilir.

Fakülte üyeleri bu çalışmayla bulunan ağırlıkları sürekli gelişim süreçlerinde kullanabilirler.

Anahtar Kelimeler: Analitik Hiyerarşi Süreci (AHS), öğrenci çıktıları, çok kriterli karar verme (ÇKKV), MTAK Akreditasyonu.

ACKNOWLEDGEMENT

I would love to direct my sincere gratitude to my supervisor Prof. Huseyin Guden for his inspiration, endless guidance and priceless advice in all segments of this study. I feel very fortunate to work with him. I am also indebted to the examining committee for accepting to recite and review this thesis. I would like to express my warm thanks to my beloved family (Nwafor Emmanuel, Nwafor Paul, Nwafor Obuneme, Nwafor Ernest) and my beloved Mum and sister for supporting me at every stage of my education and providing the best of everything through-out my stay in this great institute of learning.

I be obliged a lot to my mentor Prof. Paul Ozor who provided me with help and reinforcement during this study and research, and I am sincerely grateful to all my friends, Engr. Ibrahim.

I also want to thank the Chair Assoc. Prof. Dr. Gökhan Izbirak, Asst. Prof. Dr. Sahand Daneshvar, Assoc. Prof. Dr. Adham Mackieh, Prof. Dr. Bela Vizvari and others, for their unending support, advice and contribution to teach, guide and nurture me all through these years. I really appreciate.

Finally, I want to thank the Almighty God for life, and everything He has done for me “Baba I am grateful indeed”.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Chapter 1

INTRODUCTION

1.1 Overview of History of Engineering Education (OHEE)

Engineering skills all covers human intelligent and initiative which all started from the early stage of creation, man discover that for him to survive and live comfortable, he must use local implement as tools for cultivate a small space where him and is family can stay but as time goes on things started getting better and there were need to explore his giving environment positively which lead to industrialization. The word Engineering means branch of organized cognizance which involve practical tenet and talent , designing, foregathering, creating, edifice, manufacturing large structures such as engines, bridge, boats through the converting of raw material to finished product

But based on the ABET defined Engineering as mathematics, experimental evidence and scientific approach towards economics, social, research component, material and processing

In present decade we are concern to some societal and global challenges such as increase in population, increase in competitiveness, higher number of college, universities, number of the engineering faculties and increase in engineering program can affect engineering decisions, application and professionalism, quality basically on the standard of students graduating every year is nothing to talk of in respect to the institute that issue such engineering diploma to their graduates but their facilities, staffs, laboratories etc. are poor and insufficient to produce an excellent graduate since some faculty committee and department advisory have expressed less concern in developing the professional skills specified by institution of assessment of engineering known as ABET, and most college, universities and polytechnic has recently devoting less attention in impacting the mathematical skills which are main course of engineering education and this has affected the economy of many countries negatively since it is cumbersome to sustain the level of initiating result which we help to promote satisfaction of ends of the people but the number of unqualified graduating engineers producing every year by different schools has cause much tension, due to graduates lacking the basic mathematical measurement and knowledge of general sciences which promote design of materials, many construction firms close down because of poor services and this has decrease the level supply and thereby much waste are incur during processing goods and which can improved through proper education system. Engineering types are;

- Chemical engineering – cover principles of physics, basic chemistry, molecular and algebraic math.
- Civil engineering – application of design, mathematics, physical physics and general science
- Mechanical engineering – application of design, mathematics, physical physics and general science
- Electrical engineering – application of design, mathematics, physical physics and general science
- We have others field which are recognized as mining, manufacturing engineering, acoustical, bioprocessing engineering, aerospace, biomedical

engineering, computer, petroleum, system, Agricultural engineering and environment engineering ,metallurgical engineering agricultural, industrial management engineering, material engineering, nuclear engineering and for each of this has a unique standard of courses which are aligned with basic physics, chemistry and mathematics.

1.2 Synopsis of Professional Assessment Councils (SPAC)

To succeed with this ideal of constant improvement, they institutions evaluating the engineering programs of universities, school of technology in the entire countries by proposing an affecting knowledge performance measures, approaches and method assessment has adopted to resolve this issues for the proper maintenance and advancement toward the improving of engineering education, thereby producing engineers who are entrepreneurs. The little number of this professional board of assessment is:

- Eastern European Foundation for Quality Management (EEFQM) Council of UK.
- Malcolm Aldridge National Board Quality Award (MANBQA) Council of US.
- National Accreditation system for Engineering Education Russian (NAEER) Council of Russian.
- Canada Engineering System Accreditation Board (CESAB) of Canada.
- Korea Accreditation Board Engineering Education (KABEE) Council of Korea.
- Japan Accreditation Board for Engineering System Education (JABESE) Council of Japan.

Accreditation of engineering education has become of mandatory exercise to improve the standard teaching of basic curriculum of program outcome in entire world.

The professional board granting approval to programs in US and beyond is ABET which has gained local and foreign recognition since 1932 been the year it was founded. ABET Inc. is been the recognized US accrediting universities granting program in engineering which recently over 2000 engineering programs at more than 350 institutions in US receive accreditation.

1.3 Definitions of Selected ABET Terminologies Vision

- Education Objective level – this defined the goal that must be achieved through a well-defined curriculum.
- Student outcome – this values the ability, knowledge and acts that students require in their matriculation through the program and specified instruction that describe what graduate must know by time of his graduation. Describe the ability, capacity and knowledge in which graduate must acquire during his program. This is what the academic education department or institute is fully expected from the graduating engineering student to possess at completion of program in their various institute of learning and faculty of each engineering should access the student in each semester so as to know whether achieve the program objectives and to use it for fostering future improvement of the goal objective of the programs.
- Assessment– these are steps or processes carry out and prepare data or judgments to evaluate the level of student outcomes and program education objectives i.e. a system of gathering, analyzing and interpreting judgments on

how to suite a given standard. Assessment is a continuous process and should occur periodically. From view of ABET, it means the evaluation of knowledge that the individual graduate possesses and can be able to show upon the completion of each semester. Assessment is achieved by straight measures and in which straight measures covers the weight of teaching by the lecturers and the indirect point out on the survey at completion semester. The graduate of engineering should attain ABET focus which are given fig1.3.1

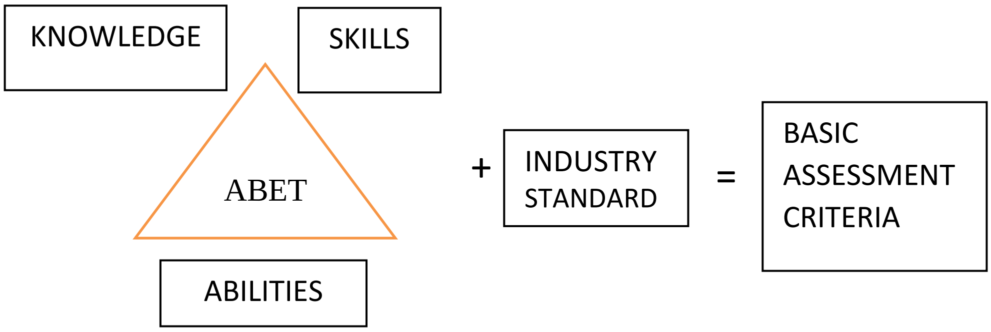

Figure 1.3.1. Cycle of performance index

- Evaluate - this is a system of analyzing and interpreting the evidence accumulated through assessment practices i.e. it predict the extent degree to which a student outcome are being achieved for continuous improvement.
- Learning outcome - This covers all the cycle related to student outcome in skills, abilities and knowledge that are acquired as the program proceed all through the semesters observed by the engineering student.
- Program objective - Program objective explains what engineering graduates are expected to attain during and after graduation. Program objective are evaluated and measured by the assessment of learning outcomes through outcome and the result gotten are used to analyze the program education objectives.

- Criterion - this is a standard or test by which individual outcomes may be compared and judged.

1.4 General idea of Criteria

The various levels of criterion are :

- Focus Criterion 1: Students

It define that student outcome must review student curricular and career matters which will greatly improve policies on acceptance of transfer students on validation of courses taken for credit.

- Focus Criterion 2: Program Education System Objective (PESO)

The objective of any system should be accordant with the mission of the institution and the appraisal process should periodically review document and demonstrate the limit to which these objectives are achieve.

- Focus Criterion 3: Student outcome level

This cover the a-k outcome of ABET [1].

- Focus Criterion 4: constant improvement level

Each program must show product of actions to improve the system and action must base on result from level criterion 2 and criterion 3

- Focus Criterion 5 : Curricular Outcome

These cover subject areas appropriately toward engineering courses and must devote time bearing to each program component (math and general sciences).

- Focus Criterion 6: Faculty level

The faculty level must be sufficient and demonstrate competence to cover all the curricular courses of the program in relation to factors as education level, diversity of backgrounds, level engineering expectance, teaching effectiveness level of ability to communicate, level of scholarship etc.

- Focus Criterion 7: Facilities level

Facilities simply mean the number of classrooms, laboratories and associated equipment must be adequate and also guarantee the safety of program objectives and provide conducive learning environment.

- Focus Criterion 8: Support level

There should be adequate institutional support level, financial support level, resources and constructive leadership to ensure the quality and continuity of the program.

- Focus Criterion 9: Program Criteria level

The program must be applicable to a given discipline level.

1.5 History of Multiple-Criteria Decision Making (MCDM) and AHP

According to (Saaty T.1988) decision situations involve a hantle of decision criteria which may be out of similar measurable standard with one another. Decision analysis cover some uncertain issues, so it important to think about issue in a concentrate manner before drawing into conclusion of what to consider as a possibility among series of pre-specified result in any possibilities. The assertion within excellence of messages in any decision situation can vary from the scientifically-derived opinions basically upon personal feelings not upon observation. Reality concerning making decision can be differs in aspect of one choice to which were interpreted as data about a decision of a problem is known as Multiple- Criteria Decision Makıng (MCDM). MCDM is an analysis of data by which a message process within an order of techniques to guide deciders who are faced with such decision situations of making numerous evaluations. MCDM aid in solving this conflicts which occurred in comparing and evaluating these choice accord to the diverse criteria, deriving a format which we bring the best judgment Since Multi-Criteria Decision Making include a certain element of objective toward morals and ethics of the persons implementing AHP. The Analytic Hierarchy Process (AHP) is a general theory of measurement used to derive ratio scales from both discrete and continuous pair comparison.

According to (Saaty T.1977), AHP is a Multi-Criteria Decision Making approach that uses some mathematical attributes and the input details are easily attained. AHP is an approach for decision making under complex criteria at different levels. It gives the ranking of multiple criteria by multiple decision makers based on pairwise comparison of these criteria. Thus, it is a robust way to mathematically transform decision makers' judgments and references into numerical results. Unfortunately, some of the decision data cannot be assessed exactly in reality, or different decision makers may express their opinions differently of the student outcomes for the undergraduate programs are obtained by comparison of the numbers of criteria and alternatives (Wayne L. Winston 1994), thus to arrive at better decision making ones uses a pair-wise comparison method by combining both qualitative and quantitative factors in the evaluation of all alternatives and qualitative factors a-k of ABET are of prime importance.

1.6 Synopsis of Questionnaire Approach and Outcomes

This paper focuses specifically on how to determine the weights of students outcome which are basically center or often colloquially referred to as the hard and soft skills they, are all in the ABET designated criterion outcomes as[1]:

- Outcome a (knowledge of mathematics and engineering science)
- Outcome b (analyze and interpret data)
- Outcome c (design a system component)
- Outcome d (function on multi-disciplinary team)
- Outcome e (solve engineering problems)
- Outcome f (professional and ethical responsibility)
- Outcome g (communicate effectively)
- Outcome h (global and societal context)
- Outcome i (lifelong learning)
- Outcome j (contemporary issues)
- Outcome k (tools necessary for engineering practices)

From the above student outcome use wants to evaluate which groups of outcome we generate as vision perspective on the role in accomplishing our program educational objectives and significance that the ABET designated outcome had for engineering student using the brainstorming approach, we can sought answer to the basic questions, “What does this outcome mean to engineers?, What behavior or traits will be observed in student who achieve these outcomes?, How can these outcomes be developed?” Answers to these questions definitely lie on the effective determine the actual weight of the outcome using Classical AHP approach. Engineering Faculty and department advisory board (alumni and employer constituencies) which are the gatekeepers has prioritized the entire set of eleven (11) outcomes and felt that not all the eleven outcomes contribute equally to the achievement of ABET program objectives in engineering education, consequently not all eleven student outcomes would be weighted in our assessment process, which each outcome was assessed and the weight of the assessment result is determined for program continuous improvement at the end of the study.

In order to make the task easier in this paper, the above stated 11 student outcomes was classified into two classes: class 1 (Qualitative to program) and class 2 (Quantitative to program) using the above classes as a measurement theories of AHP based on pair-wise comparison of engineering matrix which focus on the judgment on how much more a contain element dominates another considering inconsistency and improvement of judgment prior to a final decision.AHP takes into consideration the inconsistency and improvement of judgment prior to a final decision has stated the objective by building a decision criteria in which any group of the students outcomes is analysis according to the classes by disintegration of the general problem into individual criteria i.e. given the hierarchy of the problem in term of overall the goal, criteria and alternative through a well proper definition of the criteria base on qualitative and quantitative in the respect of gathering rational data for the multi-decision criteria and alternative which was designed to solve complex problems which involves multiple criteria. The advantage of AHP (According to T.

L. Saaty 1980) is to take subjective judgments of individuals in decision process and the decision-maker has to provide the judgment about the decision criteria and the alternative which are specified on each criterion through the provision of ranks of alternatives indicating the overall priorities (i.e. given the prioritized matrix by pair-wise comparison value using Fundamental scale number (1/9,9) to reduce differences associated with exact ratio and the exact alternative is chosen by estimating the relative priorities (weights) of decision criteria through consistency among the pair-wise comparison given by decision maker, which can continue the decision process if the consistency ratio is acceptable, otherwise we have to revise the pair-wise judgment before proceeding for the calculation.

AHP is an approach for decision making under complex criteria and different levels, it gives the ranking of multiple criteria by multiple decision makers based on pairwise comparison of the criteria. Thus, it is a robust way to mathematically transform decision-makers judgments and references into numerical results. Sadly, some of the decision data cannot be determined exactly in the reality or various decision-makers may give their view differently by means of preference relations but to avoid these uncertainties, AHP is developed and applied under these Numerical circumstances, with respect to possible pairwise comparison values among various decision-makers.

This paper contains sections literature review, methodology of research issues using AHP, problems definition, numerical results of the research and conclusions.

Chapter 2

LITERATURE REVIEW

Engineering Education should be accorded special privilege in any growing sector, since it integrates and optimize other areas of economics sector thereby given the graduate a better chance to be useful in industry government, academia and to demonstrate a wide professional growth, leadership, ethical, social responsibility within any organization. Hence the institutes must be empowered with all standard of knowledge which can be impacted in "explicit and tacit" ideas (Nonaka and Talkeuchi 1995) to the future engineers.

2.1 Education &Engineering Quality Accreditation

ABET was launch in 1932 and today it is the global accreditation leader in engineering. Technology institute quality Accreditation has become a mandatory exercise to improve the learning and teaching of basic curriculum of program outcome in all over the world particularly in United States the Accreditation Board for Engineering and Technology (ABET) is in charge of the accrediting of university education programs in Technology within other related sphere. From the clear view, seeking school that need their courses to be granted accredited must meets the required eleven 11 criteria (ABET 2011) and eight 8 criteria (ABET 1995).

The following criteria which are termed as EC2000, which covered student program outcome and assessment professional component, Faculty, Facilities, Instructional support and funding thus has some relation as the Accreditation System for

Engineering Education Russian Council having the same 8 criteria (AEER2002) likewise the Canada Accreditation System Council (CEAB2002) having three(3) criteria for their engineering institutions. While basically Korea Accreditation Engineering Education Council (KAEE2003) and Japan Accreditation Board for Engineering Education Council (JABEE2003) which declare the standards of Engineering Education in terms of 6 criteria (ISO90000 (BSI)) is another framework.

Since 1932, ABET Inc., has been the recognized U.S accreditation of post-secondary degree granting program in engineering (EC2000). ABET currently accredits nearly 2000 engineering programs at more than 350 institutions. ABET seek that schools meet to all level excellent, that engineering course get to a level of heıght of accepted range called accreditation criteria for most of 2^{rd} halve the 20^{th} century (ABET1996). ABET's accreditation criteria dictated all major elements of a lıcensed program including program curriculum, Faculty and Facilities.

In the mid-1990's, (According to ASEE1997). But based on the ABET defined Engineering as mathematics, experimental evidence and scientific approach towards economics, social, research component, material and processing. These criteria became known as engineering criteria (EC2000).

2.2 Analytic Hierarchy Process

MCDM and how to make wise decision (Saaty T. L 1990), mathematical psychology (Saaty T. 1977) precisely described its use in respect of mass (Thurstoni 1927; Yokoyama 1921). [1/9] science which deals with way in which the human body work (Fachnerd 1861; Stone 1957). AHP is a power tool for this purpose (Blius S Xu 1987) in real application conventional (Saaty 1980).

Presently a lot etymologies covers AHP as insight (RV Ray and Sengh D, 2001; KB et.al 2004) are in concept toward performance evaluation of technical education institutions. Since Pani Mukherjee 2011). AHPs can be used to evaluate actıvıtıes of faculty (Digendra Nath Ghosh 2012) and university planning (Dr.Willian Paughton, & Halvard Nystvom 2014).

2.3 Wide Application of AHP

departmental advisory and committee are the asset of institution, Selection Faculty members for great position toward learning involves consideration of more qualitative criteria and achieve better with AHP (John R. Eirandzol 2005). AHP was developed to tolerate careless assumptions values with similarity (Dehamed Chutterjee & Dr.The reviewed of literatures covered various facts of the application of AHP. Back from the initial section of AHP it was clearly used for example in bank (Haghighi, Divandari & Keimasi 2010; Kahraman 2009), Manufacturing system (IC & Yurdakul 2009), Operators evaluation (Sen & Cinar 2010), Drug selection (Berhoune & Bonan 2010), Site selection (Efendigil & Sonar Kara 2009), Software evaluation (Cebeci 2009), Evaluation of website performance (Liu & Chen 2009), Strategy selection (Lin & Lin 2009), Suppliers selection (Batis & Martakos 2010; Wang & Yang 2009), Selection of Recycling technology(Lee & Kreng 2010), Firms competence evaluation (Soltani & Vahdani 2009), Weapon selection (Yavaz & Killnc 2009), Underground mining method selection (Mikaeli & Ataei 2009) and its sustainability (Yu &Zhang 2010) Software design (Kao &Wu;2009) Organizational performance evaluation (Kao 2009), Staff recruitment (Exonesekera &Chu 2009), Construction method selection (Pan2009), Project selection (Amiri 2010), Customer requirement rating (Li, Tang & Lou 2010), Energy selection (Kahraman &Kaya 2010) and many others and several papers has compiled the AHP success stories

(Wasil &Harker 1989; Ho 2008; Kumar & Vaidya 2006, Vargas 1990; Zahedi 1986; Sipahi & Timor 2010), continuous improvement of graduating student based on the skills, ability and knowledge achieved during completion of their program (Murray, Perez et.al 2008).

Chapter 3

THE PROBLEM DEFINITION

In the present research the focus is to determine the weight of students outcomes on the Engineering Education System in relation to ABET, as far as engineering training scheme stands involved in U.S and other countries like Turkey, ABET is the certified routine valuation machinery in lieu of constant progress for student outcomes for decision making on by what method to headway the programs teaching/learning processes as a product of evidence of Facility appraising of observing students effort linked toward the platform desires opinions to cogitate the following:

The vision of norm 4 (Constant Progress) is continuously valuation of the programs not continuously valuation of single students. Assessment of the attainment of learner results by the platform should be equal efforts on the routines of a sum of student and ex-student friends. Program Facility improvement perception into how well it is developing its outcomes though the evaluation of pupil result assessment results for the selected student cohort. In general results are reported in terms of proportion of pupils in the undergraduate group who meet the curriculum's targets. The program's interpretation of the results informs decision making for continuous improvement purposes.

Application of Criterion 4 (Continuous improvement of related to student's outcomes) is on the learning of students and not the assessment or evaluation of individual courses). At the platform equal valuation and appraisal should be dedicated on the learning of new things which stemmed from the experiences in the program by the time of graduation. The purpose is toward making available information on the program's efficacy (its capability toward realize what was designed to achieve).

Pupil's outcomes should be presents clearly in direction for facility mutual accepting of the prospects for learner's book learning and to attain constancy through the syllabus. Right from the beginning of the semester ıt is advisable for the lecturers to defıne the goals and objectıve of the course so that the mindset of the pupils should be channel toward that angle of achieving the target objectıve of the syllabus and thereby makıng the work easy for the lecturer and student.

A platform should be draw whıch ensures that data bring together from all pupils are channel towards achieving undergraduate outcome, A platform should be created where all information about learner are analysis and this mandatory exercise are carried out which we help to improve the teaching calendar and will also attract other student from the different country. Platform must include the same percentage of learner characteristics (Score mean, sex, variety etc.)

The greatest approach toward identify the result of achievement of pupils is through the keeping of dated record of each Learning outcome of syllabus. It is true that the level of achievement in any learning ground depend strongly on the altitude of pupil and the environment where they came from. Learning ought not to be measure by the platform of courses or even grade of the pupil in the department but through constant assessment of each pupil in their daily exercise toward the course on the view of discovering the strength and confidence of pupil. The above concept of definition is summaries using the conceptual frame structure given in figure 3.5.1. to guide how engineering system should be implement so as to achieve the definition and of ABET toward the outcome.

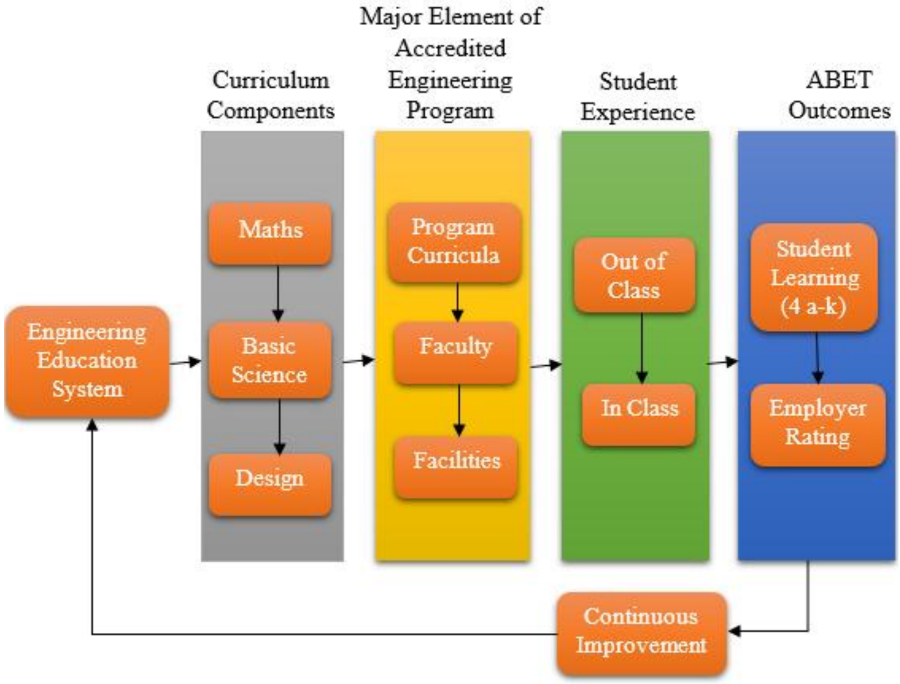

Figure 3.5.1. Conceptual Framework for Engineering Education System

Chapter 4

METHODOLOGY

4.1 Analytical Hierarchy Process (AHP) Procedure

Research methodology has four approaches adopted to investigate the problem with AHP method. AHP methods are:

1. State the objective by building a decision criterion in which any group of the student outcome is analyzed giving toward the classes by disintegrating the general problem into individual criteria. That is, giving the hierarchy of the problematic fashionable relations of the overall goal, criteria, and alternatives.
2. Define the criteria centered arranged the qualitative and measureable in the respect of gathering rational data for the multi-decision criteria and alternative which was designed to complex problems which involve multiple criteria, the advantage of AHP is to take general results of individuals in decision process and the judgment fabricator devises toward run the results approximately the decision criteria and the alternative which are specified arranged each criterion. AHP provides ranks of alternatives indicating the overall priorities; that is, giving the prioritized matrix by pair-wise comparison value.
3. Pick the alternatives by estimating the relatives priorities (weights) of decision criteria through consistency checking, AHP provides the consistency testing to test the amount of consistency among the brace-

wise comparisons given by decision maker, which we can continue the decision process if only the consistency ratio [16] is acceptable (CI/RI < 0.10), otherwise we have to raise the pair-wise judgment before proceeding for the calculations.

4. Calculating final weight of options and ranking them giving to the random index of the mass of the conclusion of the analysis.

The AHP steps described above can be best implicit over and done with a lasting argument of an example application on the survey map out for the responses in this paper.

4.2 System Classification of Outcomes

Step 1: In this example, assuming you are made a chair of a new engineering department and you need to design a course program which will help the student of the department to attain the following skills, knowledge and behaviors at their time of graduating in their chosen program using criteria $4_{a\text{-}k}$ student outcome of ABET given below to deliberate on which class of the outcome will lead to continuous improvement. Below is the student outcome [1]:

- Outcome. a (knowledge of math and engineering science)
- Outcome. b (analyze and interpret data)
- Outcomes .c (design a system component)
- Outcomes. d (function on multi-disciplinary team)
- Outcomes .e (solve engineering problems)
- Outcomes. f (professional and ethical responsibility)
- Outcome .g (communicate effectively)
- Outcomes. h (global and societal context)

- Outcomes. i (lifelong learning)
- Outcomes. j (contemporary issues)
- Outcomes .k (tools necessary for engineering practices)

By a well-designed program, curriculum, contents of courses throughout the study time till the time for graduation, students of the program [16] should attain the above student outcomes. From the point of engineering the weights (w) of the above student outcome can be different, so the new elected chair need be to design the curriculum in such a way to align with the weight of pupil outcome, determining the weights of the pupil results will help in designing the curriculum of the engineering programs and subjects of the courses.

Step 2: In this paper, we wanted to determine the weights of above student outcomes in engineering fields and in order to make the task easier we classified 11 outcomes in two(2) and it is clearly shown in figure 4.2.1

- Class 1 (hard skills) → outcome a , b, c, e, h and k
- Class 2 (soft skills) → outcome d, f, g, i and

4.2.1 Class 1 (Qualitative to program)

a) [Ability to apply knowledge of making Math's, science & engineering] 1

b) [Ability to design & conduct experiment as well as analyze & interpret data]2

c) [Ability to design a system component & process to meet desired needs within realistic constraints such as populatıon factors, ethical, health & safety, manufacturing & sustainability]3

e) [Ability to identify, formulate & solve engineering problems] 4

h) [The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental & societal context] 5

k) [Ability to use the techniques, skills, & modern engineering tools necessary for engineering practices] 6

where n = 6

4.2.2 Class 2 (Quantitative to program)

d) [An ability to function on multi-disciplinary teams] 1

f) [An understanding of professional and ethical responsibility] 2

g) [An ability to communicate effectively]3

i) [A recognition of the need for and ability to engage in life-long learning] 4

j) [A knowledge of contemporary issues]5 where n = 5

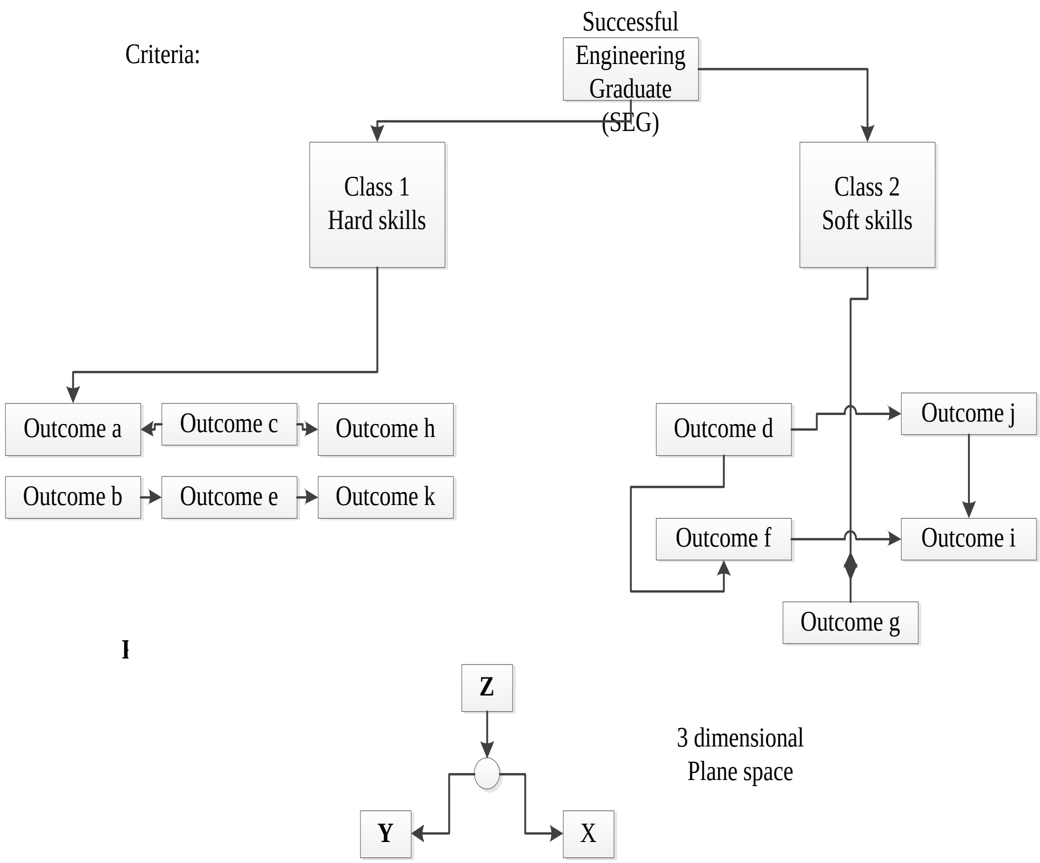

Figure 4.2.1. Hierarchy Classification of Outcomes.

In the pairwise comparison matrices, the ratio between the weighted of compared pairs of factors (student outcome) are shown in cell (*ij*) and the ratio *wi/wj* where *wi* is the weighted of factor *i* and *wj* is the weighted of factor *j* and due to human judgments are not too certain and difficult to determine certain ratios, we are able to introduce some number and linguistic variables. Intensities of 2, 4, 6, and 8 can be used to express intermediate values while the reciprocals such as 1/3, 1/5, 1/7, 1/9 indicate the opposite respectively of the values 3, 5, 7, and 9 as shown in the table 4.2.1.

Table 4.2.1. Fundamental Scale Table

Fundamental scale	Linguistic variables		Numerical No
1	Absolute Unimportant	AU	(1/9)
2	Strongly Unimportant	SU	(1/7)
3	Fairly Unimportant	FU	(1/5)
4	Weakley Unimportant	WU	(1/3)
5	Equally Important	EI	(1)
6	Weakly Important	WI	(3)
7	Fairly Important	FI	(5)
8	Strongly Important	SI	(7)
9	Absolutely Important	AI	(9)

In summary generating a rational data for comparing the alternatives, this requires the analyst (decision-maker) to make pairwise comparison of elements at each level relative to each activity at the next higher level in the hierarchy. In the system explain the importance of each criteria relative to the system acceptance need to established by the help of bottom AHP relational scale of the real numbers from 1 to 9 is used to systematically assign preferences, when comparing two attributes (or alternatives) **X** and **Y** with respect to an attribute **Z** (Successful Engineering Graduate) in a higher level as illustrated below using class 1 comparison ranking is:

$^1/_9$ = **Y** has absolute Unimportant over **X** with respect to **Z**

$^1/_7$ = **Y** has strongly Unimportant over **X** with respect to **Z**

$^1/_5$ = **Y** has fairly Unimportant over **X** with respect to **Z**

$^1/_3$ = **Y** has weakly Unimportant over **X** with respect to **Z**

1= **Y** has equally important over **X** with respect to **Z**

3= **X** has weakly important over **Y** with respect to **Z**

5**=** **X** has fairly important over **Y** with respect to **Z**

7= **X** has strongly important over **Y** with respect to **Z**

9= **X** has Absolute important over **Y** with respect to **Z**

e.g. gauges comparison matrix Table 4.2.2

Table 4.2.2. Gauges Comparison Matrix Table

X

Y

FOCUS	a	b	c	e	h	k
a	1					
b		1				
c			1			
e				1		
h					1	
k						1

In the matrices, the first nontetravial comparison is (**a, b**). the question is: compare "**a**" by other student outcome "**b**" and from the view of the Linguistic variable the judgment assuming "**a**" is strongly important (means that the ratio *Wa/Wb* is 7), i.e. "**a**" is 7 times strongly important over "**b**", so the reciprocal value $^1/_7$ is entered in the (**b, a**) position. The value 7 is automatically entered in the transpose position (**a, b**). As another illustration "**b**" is judged to be between fairly important than "**c**" and hence the value 5 times is entered in the (**b, c**) position with the reciprocal($^1/_5$) automatically entered in the (**c**, **b**) position and so on.

4.3 Summary of AHP Approach

$$C = \begin{bmatrix} a_{11}\, a_{12} & \dots & a_{1n} \\ a_{21}\, a_{22} & \dots & a_{2n} \\ \dots & \dots & \dots \\ a_{n1}\, a_{n2} & \dots & a_{nn} \end{bmatrix} \qquad (4.3.1)$$

Step 1: Let n be the number of criterion and $w_{1,}$ $w_{2,}$… w_n be the corresponding relative priority given by the numerous decision makers (DM) and in which the judgement matrix C which contains pairwise comparison values a_{ij} for all i,j E (1,2,...n).

Step 2: For multiple decision makers let n be the number of decision makers and a_{ijk} be the pairwise comparison values of the criteria i and j given by the decision maker k, where k = 1,2,…n. Then by using Arithmetical average of the whole judgement resulting. $a_{ij} = (a_{ij}{}^{1*}.a_{ij}{}^{2*}....a_{ij}{}^{*n})^{1/n} = (\pi^n.a_{ij}{}^k)^{1/n}$ (4.3.2)

Decısıon weıght = Summatıon of the weıght of decısıon crıterıon weıght

Step 3: Utilizing the pair-wise comparison of step2 an Eigen value (λmax) and Eigen vector (W_i) is used to determine the relative priority of each attribute to each attribute one level up in the hierarchy by Normalizing the matrix [C] . Normalizing each column to get a new judgment matrix C_{norn}. Thus this can be noting that for each of C's column follow by dividing each entry I column I of C by the sum of the entries in column I, yielding ;

$$C=\begin{bmatrix} \frac{W_1}{W_1} & \frac{W_1}{W_2} & \cdots & \frac{W_1}{W_n} \\ \frac{W_2}{W_1} & \frac{W_2}{W_2} & \cdots & \frac{W_2}{W_n} \\ \vdots & \vdots & & \vdots \\ \frac{W_n}{W_1} & \frac{W_n}{W_2} & \cdots & \frac{W_n}{W_n} \end{bmatrix} \qquad (4.3.3)$$

Thus normalizing the matrix means to divide each element in every column by the sum of that column which will now help us to determine the average of the criteria weight (w).After normalizing (C_{norm}), then estimate w_i as the average of the entries in row I of C_{norm}. This yield:

$$\begin{aligned} W_1 &= \left(\frac{W_1}{W_1}+\frac{W_1}{W_2}+\ldots+\frac{W_1}{W_n}\right)\Big/n \\ W_2 &= \left(\frac{W_2}{W_1}+\frac{W_2}{W_2}+\ldots+\frac{W_2}{W_n}\right)\Big/n \\ W_n &= \left(\frac{W_n}{W_1}+\frac{W_n}{W_2}+\ldots+\frac{W_n}{W_n}\right)\Big/n \end{aligned} \qquad (4.3.4)$$

Step4; Defined the actual normalized weight of each student outcome by multiply each estimate weight w_i with the individual weight of the specified class weight w_{cl} i.e

$$W_a = w_i . w_{cl} \tag{4.3.5}$$

Where W_a= actual weight of the student outcome, w_i = estimate weight

4.4 Procedure to Check for Consistency

The procedure in checking for consistencies [8]:

I. Determine the weight of the sums vector W_S

$$W_S = C . W_i \tag{4.4.6}$$

II. Find the consistency vector (λ)

$$\lambda = \frac{1}{n}\sum_{i=1}^{i=n}\frac{Ws}{Wi} \tag{4.4.7}$$

Where: n = numbers of criteria

W_S = the sum weight, W_i = estimate weight

III. Consistency index, CI

$$CI = \frac{(\lambda - n)}{(n-1)} \tag{4.4.8}$$

IV. Consistency ratio, CR

$$CR = \frac{CI}{RI} \tag{4.4.9}$$

Random index is a constant ranking of consistency values as shown in the table below for comparing the consistency index depending on the number of criterion.

Table 4.4.1. The value of the random index

Serial number	n (number of criteria)	RI (Random index)
1	2	0.000
2	3	0.580
3	4	0.900
4	5	1.120
5	6	1.240
6	7	1.320
7	8	1.410
8	9	1.450
9	10	1.510

Table 4.4.1. gives the average value of CI if the entries in C where chosen at random, subject to the constraint that all the diagonal entries must be equal to one (1). When comparing CL to random index (RI) for the appropriate value of n for a perfect consistent decision maker the i^{th} entry in (C).{W_i} = n. If $\frac{CL}{RI} < 0.10$, the degree of consistency is satisfactory. But if $\frac{CL}{RI} \geq 0.10$, a serious inconsistency exists and the AHP research may not yield any meaningful result in such case.

Chapter 5

NUMERICAL RESULT

5.1 Data Collection Section

Data gathered through questionnaire survey contain there pair-wise comparing matrix **(PCM)** with clear details of the criteria's were defined. The questionnaires were distributed among sample e-learners and ask them for comparing the importance of each **PCM** indicator to another one and compare the importance of each criterion under each indicator. The scale used in this questionnaire is presented in table 4.21. and the survey were sent to 300 e-learners in Turkey and all around the world universities of knowledgeable authority in engineering fields courses via email which 206 responses were obtained or received as feedback, and the respond rate approximately 68%. To calculate the final score of each indicator and criterion:

Table 5.1.1. Response Rate of Respondent

Response rates from population		
Data Source	Number of Responses	Response Rate (%)
Overall	206	68
Academia	52	17
Industrial Engineering	22	7

5.2 Performance Evaluation Analysis Values

Table 5.2.1. Weight of Comparison Matrix Table between Class 1 and Class 2

	C_1	C_2
C_1	1	5.245492
C_2	0.19064	1
	1.19064	6.245492

Class 1

Table 5.2.2. Weight of Comparison Matrix in Class

	a	b	c	e	h	k
a	1	3.151919	1.320789	1.067098	4.08375	3.371675
b	0.317267	1	1.4929	1.273221	0.98523	1.761874
c	0.757123	0.669837	1	1.038619	2.5861	1.450762
e	0.937121	0.77546	0.962817	1	4.107906	5.94405
h	0.244873	1.014984	0.386673	0.243433	1	0.975682
k	0.296588	0.567577	0.689293	0.168235	1.024924	1
Sum	3.552972	7.179777	5.852472	4.790606	13.78791	14.50404

Step 1: For each of C Matrix divide each entry of column i of C by the sum of the entries in column i and this yields a new matrix Cnorm. Note that the sum of the entries in each column must be equal to one.

Step 2: To find the estimate weight (w_i) is the average of the entries in row i of Cnorm.

$$W_{CL1} = \frac{0.8398+0.8398}{2} = 0.8398$$

$$W_{CL2} = \frac{0.1601+0.1601}{2} = 0.1601$$

5.2.1 Total Overall Respondents

Steps: Overall response from 206 respondents Normalized table. T = 206

0.8398	0.8398	WC_1	0.8398	$\lambda = 2$
0.1601	0.1601	WC_2	0.1601	CR=0

Normalized Format

Table 5.2.3 Overall Arithmetic Mean Weights of Class1

						w_i		W^T
0.2814	0.439	0.2256	0.2961	0.2324	w_a	0.2829	W^T_a	0.2376
0.0892	0.1392	0.2550	0.0714	0.1214	w_b	0.1570	W^T_b	0.1319
0.2130	0.0932	0.1708	0.1875	0.1000	w_c	0.1636	W^T_c	0.1374
0.2637	0.1080	0.1645	0.2979	0.4098	w_e	0.2421	W^T_e	0.2033
0.0689	0.1413	0.0660	0.0725	0.0672	w_h	0.0778	W^T_h	0.0653
0.0834	0.0790	0.1177	0.0743	0.0689	w_k	0.0764	W^T_k	0.0642

Class 2

Table 5.2.4. Overall Arithmetic Mean Weights of Class 2

	d	f	g	i	j	w_i	W^T
d	1	1.4646	1.0010	1.0820	0.3419	0.1540	0.0246
f	0.6827	1	0.8492	0.7582	4.1228	0.15544	0.0248
g	0.9989	1.1775	1	3.3503	4.7240	0.250854	0.0401
i	0.9241	1.3187	0.2984	1	5.4137	0.164601	0.0263
j	2.9245	0.2425	0.2116	0.1847	1	0.1084	0.0173
	6.5304	5.2033	3.3604	6.3754	15.602		

$\lambda = 5.69$ **CI= 0.09 CR= 0.08s**

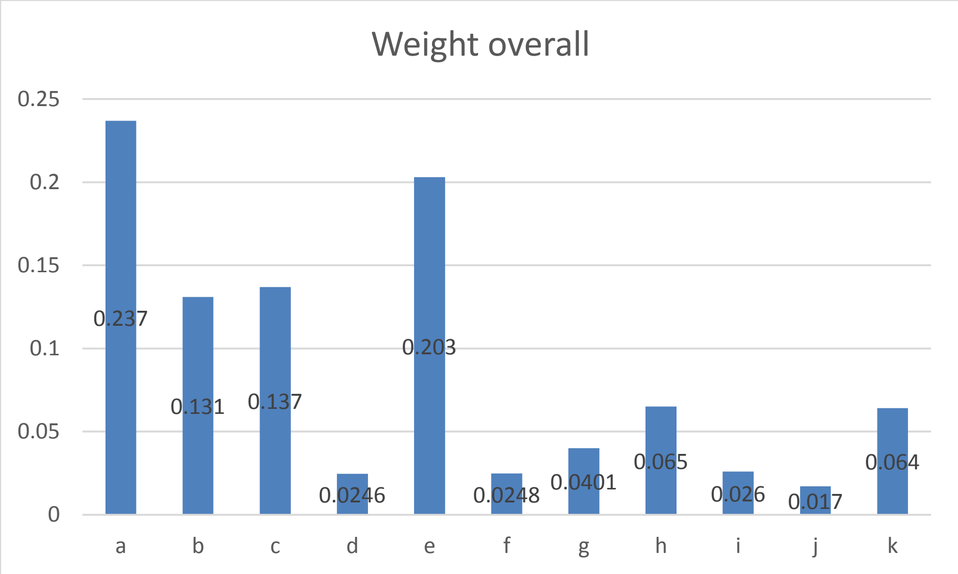

Figure 5.2.1. Overall Weight Bar Chart

5.2.2 Academia Respondents Outcome

Academia Respondents T = 52

Table 5.2.5. Academic Response Comparing Matrix between Class 1 and class 2

	C_1	C_2	w_i
C_1	1	4.757631	0.826317
C_2	0.210189	1	0.173683
	1.210189	5.757631	

$\lambda = 2$ **CI= 0 CR= 0**

Class 1

Table 5.2.6. Academia Arithmetic Mean Weight for Class 1

	a	b	c	e	h	k	w_i	W^T
a	1	2.4894	1.0332	0.9732	4.0169	0.4955	0.2103	0.1738
b	0.4017	1	1.0015	3.0256	2.0234	1.0142	0.1938	0.1601
c	0.9678	0.9984	1	1.0399	2.0153	1.0493	0.1657	0.1369
e	1.0274	0.3305	0.9615	1	4.0997	1.0476	0.1710	0.1413
h	0.2489	0.4946	0.4961	0.2439	1	0.5978	0.0715	0.0591
k	2.0179	0.9859	0.9529	0.9545	1.6727	1	0.1874	0.1548
	5.6640	6.2989	5.4454	7.2373	14.82835	5.204588		

$\lambda = 6.5605$ **CI=0.1121 CR=0.09**

Class 2

Table 5.2.7. Academic Arithmetic Mean Weight for Class 2

	d	f	g	i	J	w_i	W^T
d	1	1.541026	0.79243	0.75641	4.769231	0.21972	0.038162
f	0.648918	1	0.759951	0.501465	4.846154	0.175305	0.030447
g	1.261941	1.315874	1	3.004884	3.897436	0.311997	0.054188
i	1.322034	1.994156	0.332792	1	6.474115	0.24516	0.04258
j	0.209677	0.206349	0.256579	0.154461	1	0.047818	0.008305
	4.442571	6.057405	3.141751	5.417221	20.98694		

$\lambda = 5.299$ **CI=0.0747 CR=0.0667**

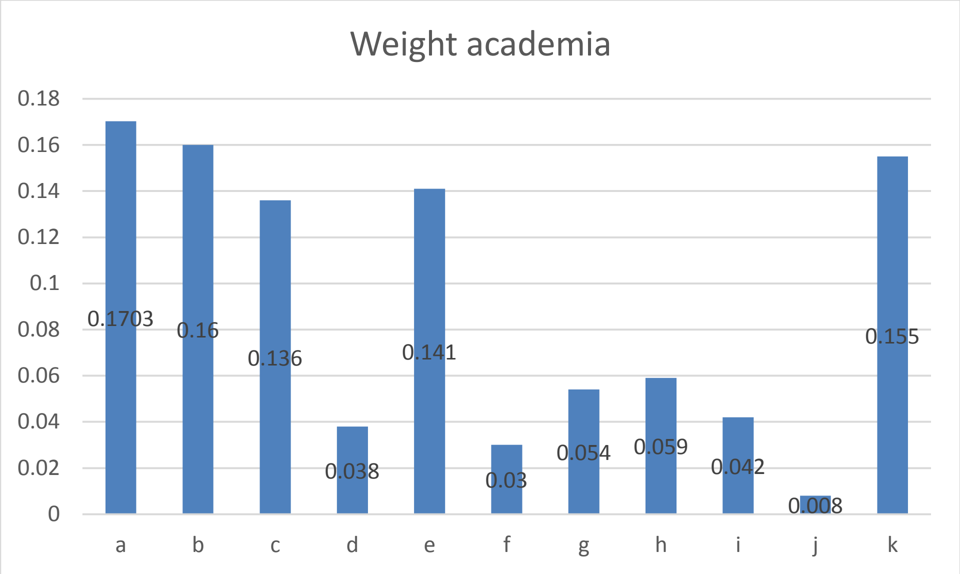

Figure 5.2.2. Academia Weight Bar Chart

5.2.3 Industrial Engineering Respondents Outcome

Total number of respondents from industrial engineering T = 22

Table 5.2.8 Arithmetic Mean weight comparing matrix of Class 1 and Class 2

	C1	C2	w_i
C_1	1	5.909	0.8553
C_2	0.16923	1	0.1447
	1.16923	6.909	

$\lambda = 2$ **CI=0 CR=0**

Class 1

Table 5.2.9. IENG Arithmetic Mean weight of Class 1

	a	b	c	e	h	k	w_i	W^T
a	1	3.4182	1.3085	2.2424	3.7091	3.5671	0.3072	0.2628
b	0.2925	1	1.4929	4.0333	2.0848	2.7994	0.2118	0.1812
c	0.7642	0.6698	1	2.6303	3.0606	3.1111	0.2039	0.1744
e	0.4459	0.2803	0.3802	1	3.606	4.5272	0.1493	0.1277
h	0.2696	0.4797	0.3267	0.2773	1	1.4545	0.0698	0.0597
k	0.280	0.3572	0.3214	0.2208	0.6875	1	0.0577	0.0493
	3.0526	**6.2052**	**4.8297**	**10.4041**	**14.148**	**16.4593**		

$\lambda = 6.614$ **CI=0.1229 CR=0.094**

Class 2

Table 5.2.10. IENG Arithmetic Mean Weight for Class 2

	d	f	g	I	j	w_i	W^T
d	1	2.6667	1.0095	1.254	4.0909	0.290748	0.042071
f	0.375	1	1.4124	1.2667	2.6606	0.196993	0.028505
g	0.9906	0.708	1	3.4661	3.7818	0.276704	0.040039
i	0.7975	0.7895	0.2885	1	4.7859	0.176274	0.025507
j	0.2444	0.3759	0.2644	0.2089	1	0.059281	0.008578
	3.4075	**5.5401**	**3.9748**	**7.1957**	**16.3192**		

$\lambda = 5.391$ **CI=0.097 CR=0.087**

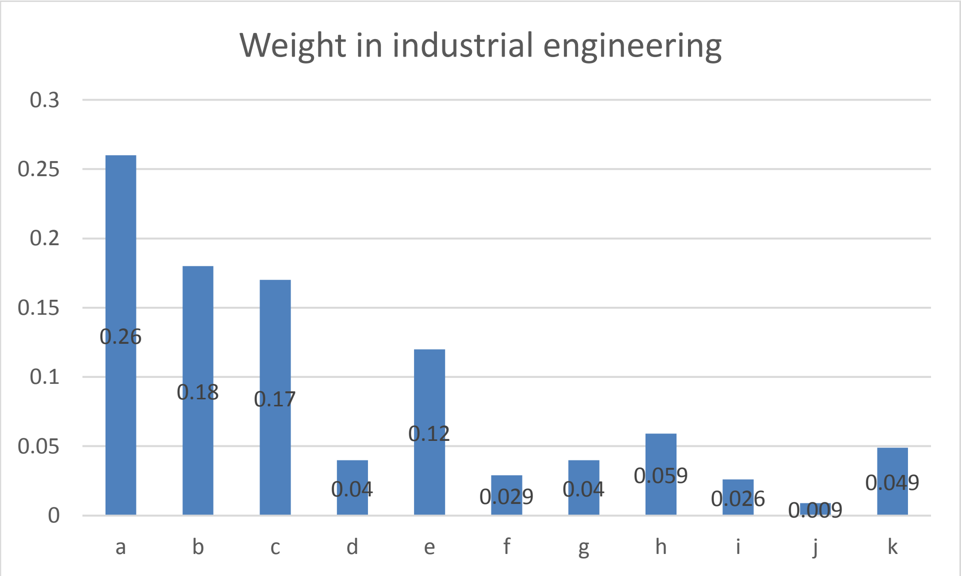

Figure 5.2.3. Industrial Weight Bar Chart

5.3 Self-Study of Curriculum Design Evaluation of ABET

Table 5.3.1. Relationship of courses to student outcome

	Courses	a	b	c	d	e	f	g	h	i	j	k
1ST Semester	PHYS101	5	5	4		4						4
	MATH151	5		3		3						3
	CMPE110			4	3	4				4		3
	CHEM101	3	4									
	ENGL191							3				
2nd Semester	PHYS102	5	5	4		4						4
	MATH152	5				3						3
	MENG182	4	3	3		3			3			3
	ENGL192							3				
	MENG102	4										4
	IENG102				3		3	3	3	3	3	
3rd Semester	MENG231	4	3	3	3	4						3
	MATH322	4	5	4		3						3
	IENG212	5	3	5		4						4
	MATH241	5				3						3
	ECON231				3				3		5	
	MENG244	5	3	5	4	4		3				4
4th Semester	EENG225	5										3
	IENG374	5	3		3	5		3		3	4	3
	MGMT201								3	3	4	
	MENG363	5	4	4	3					3		4
	ENGL201				3			5				
	ACCT203	4		3	4	4		3	4		3	5
5th Semester	IENG385	5	5	3		3						4
	IENG313	5	5	5		5			3			5
	IENG323	3	3	3	5	5	5	5	3			5
	IENG301	4	5	5		5	5		3	3	3	5
	SOCI100			4	5	3	4	5	4		4	3
	IENG300				5		5	4		3	3	
6th Semester	IENG332	5	5	5	3	5	3					
	IENG314	5	4	3		4						
	IENG372		5	5	5	5	5	5	5	4	4	4
	IENG355				3		5		4	4	4	
	IENG458						5	3		3	4	
7th Semester	IENG362	5	5	5	3	4	4	4	3		3	5
	IENG431	5	5	5		5						5
	UE-S&B				5		5	3		3		
	TUSL181							3		3		
	IENG441	3	4	5	5	5	5	5	3	3	3	4
	IENG440		3		3	3		4	3	4	3	3
	IENG400	5	4	5	5	5	5	5	3	4	5	5
8th Semester	IENG482	5	5	4		3						4
	IENG417	5	4	4		4						4
	IENG447	5	5	5	5	3	5	3	3	5	4	5
	UE-AH				3			3		5		
	IENG442	5	5	5	5	5	5	5	5	5	3	5
	IENG444	3	3	3	4	3	3	5	3	3	4	3
	IENG419		3	5	5	5	5	5	4	4	4	5

Table 5.3.1. working analysis

Sum	141	116	121	97	128	77	90	65	72	70	139
Average	2.93	2.41	2.52	2.02	2.666	1.60	1.87	1.354	1.5	1.458	2.895
Sum of average	23.2	23.2	23.2	23.2	23.2	23.2	23.2	23.2	23.2	23.2	23.2
G_i	0.12	0.10	0.10	0.08	0.114	0.06	0.08	0.058	0.064	0.062	0.124

Format of evaluation of self-study Report Analysis

$$AR_i = \frac{\sum ni}{n} \qquad (5.3.10)$$

$$\sum ARi = \sum ARa + ARb + ARc + \cdots ARn \qquad (5.3.11)$$

$$G_i = \frac{eq1}{eq2} \qquad \text{for all } i = a \ldots .k \qquad (5.3.12)$$

Where AR is the average of the outcome based on the courses

$\sum ARi$ is the sum total of all the average of the courses

G_i is the grade weight of the outcomes in curriculum

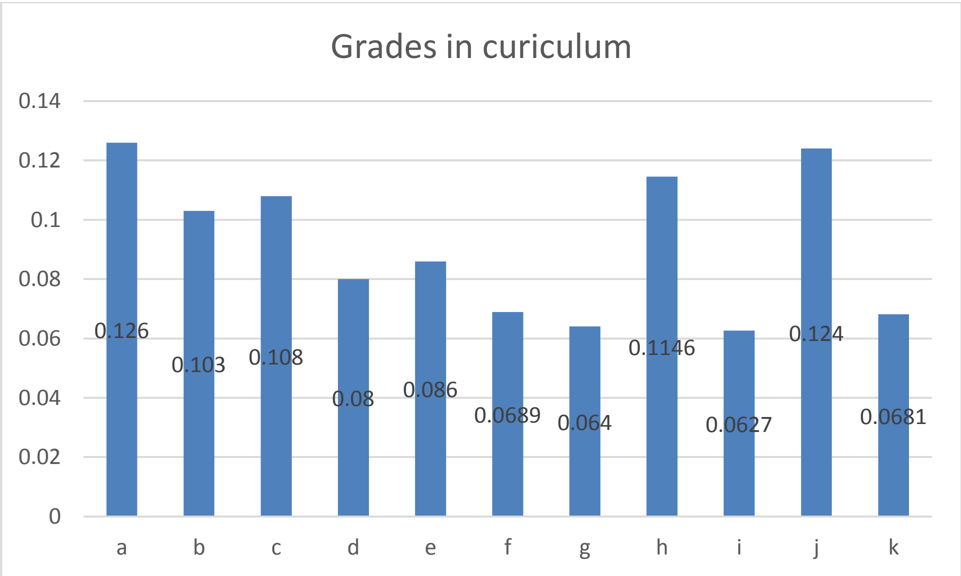

Figure 5.3.1. Curriculum Grades Bar Chart

Table 5.3.2 Summary of Weights Categories

SO	Grades Curriculum	Overall Weight	Academic Weight	Industrial Eng. Weight
a	0.126	0.237	0.173	0.26
b	0.103	0.131	0.160	0.18
c	0.108	0.137	0.136	0.17
d	0.086	0.0248	0.038	0.04
e	0.114	0.203	0.141	0.12
f	0.068	0.024	0.030	0.029
g	0.030	0.04	0.054	0.04
h	0.058	0.065	0.059	0.059
i	0.065	0.026	0.042	0.026
j	0.062	0.017	0.008	0.008
k	0.124	0.064	0.155	0.049

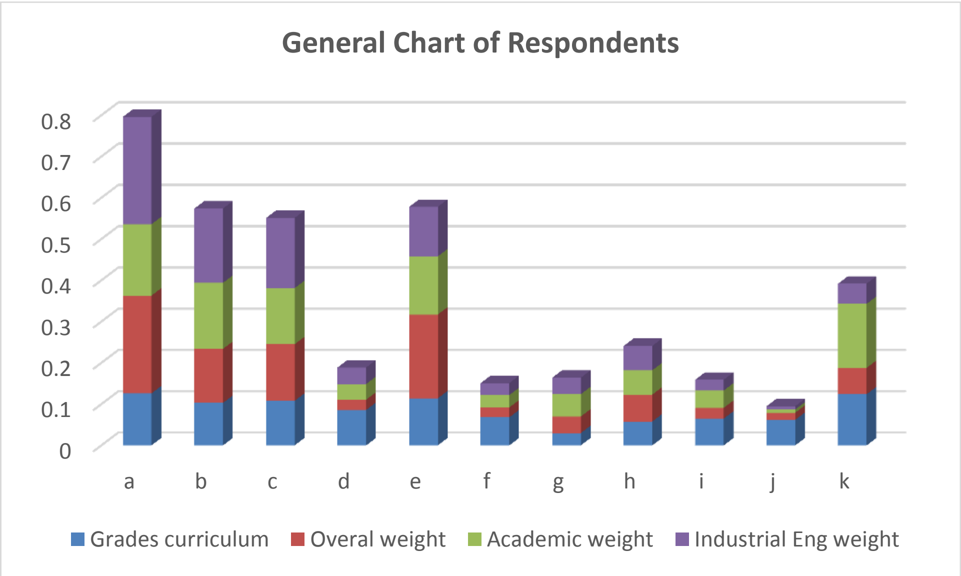

Figure 5.3.2.General bar chart of respondents

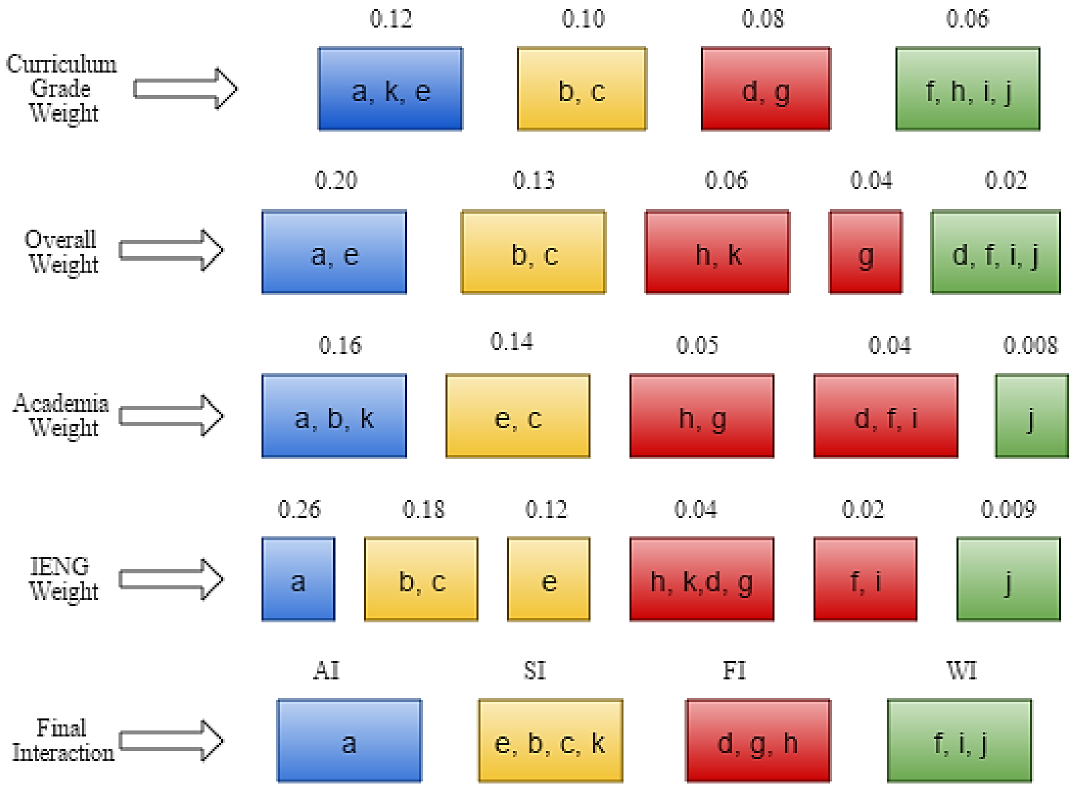

Figure 5.4.1. General Structural Group Ranking of Student Outcomes

Working analysis resulting to the structural approximation ranking estimate weights of the grouping of the above final interaction is the average column classification of each levels according to assign weight on the box.

$$W_a = \frac{0.12+0.20+0.16+0.26}{4} = 0.19$$

$$W_b = \frac{0.10+0.13+0.16+0.18}{4} = 0.14$$

$$W_c = \frac{0.10+0.13+0.14+0.18}{4} = 0.14$$

$$W_d = \frac{0.08+0.02+0.04+0.04}{4} = 0.05$$

$$W_e = \frac{0.12+0.20+0.14+0.12}{4} = 0.14$$

$$W_f = \frac{0.06+0.02+0.04+0.02}{4} = 0.04$$

$$W_g = \frac{0.08+0.04+0.05+0.04}{4} = 0.05$$

$$W_a = \frac{0.06+0.06+0.05+0.04}{4} = 0.05$$

$$W_i = \frac{0.06+0.02+0.04+0.02}{4} = 0.04$$

$$W_j = \frac{0.06+0.02+0.04+0.02}{4} = 0.02$$

$$W_k = \frac{0.12+0.06+0.16+0.04}{4} = 0.10$$

By conclusion, from the final interaction level above in Figure 5.2.5. we synthesis that the curriculum satisfies the general classification of the rankings since outcome "a" is the absolute most important, outcome "e", "b", "c" and "k" are strongly important, uotcome "d", "g" and "h" are faily important and finaly outcome "f", "i" and "j" are weakly important. And there is a unique feature about outcome "k" which the department's advisory should look into for continuous improvement of engineering education.

5.4 Consistency Checking

To check for consistency in pairwise comparison matrices, we use the following four (4) steps process.

Step1: Compute $W_S = C.W_i$

1.828034

1.010734

1.046684

1.56072

0.50332

0.482783

Step2: Compute λ

The consistency vector (λ)

$$\lambda = \frac{1}{n}\sum_{i=1}^{i=n}\frac{Ws}{Wi}$$

Where: n = numbers of criteria

W_S = the sum weight

W_i = estimate weight

λ = 6.420311

Step 3: To compute the consistency index

$$CI = \frac{(\lambda - n)}{(n-1)}$$

CI = 0.084062

Step 4: Compare CI to the random index = Consistency ratio (CR)

Since we have 6 criteria, n = 6

$$CR = \frac{CI}{RI}$$ where RI = 1.24 from ranking

CR = 0.067792 (Consistency is satisfied since $\frac{CI}{RI}$ is less than 0.10).

5.5 AHP Hierarchy For Curriculum Design Evaluation

As described earlier, we can now "synthesize" the objective of the class weights with the actual weights of each of the pupil outcome on each objective to obtain an overall weight for each alternative [7]. From the analysis on class 1 we find that the outcome "a" has the most preferable weight ($W_a = 0.263$) followed by the weight outcome "b" is ($W_b = 0.211$) and while outcome "j" has the least preferred weight and this may be the assumption that most graduate are not grounded well on model engineering skills while still at school but achieve that when they go to the labor market or firm where they gain employment usually send them for further courses training on modern engineering skills. But on that angle I will appeal to the department chair to look on this area of outcome "k" and more motivation should be created for student to achieve these skills now while they are at school than when out of school because the later costs a lot.

Furthermore this research is a pilot study center to provide a comprehensive perspective of the analysis AHP method in determining the actual weight of the student outcome and relate it to the present curriculum to compare with the level of expectation or benchmarks of the actual weight achieved on the academic sector is more alike of that of the present objective grade weight of the curriculum but of a slight difference of ± 0.05 on the student outcome j, d and f but based on the overall weight data analysis, it shows that there are large significant difference which run across the student outcome but much light should be thrown on that of outcome "a" and this will give more insight to improve student skills in solving mathematical issues. So this is the duty of the departmental advisory board and the program review committee to allocate more time or weight to outcome "a". The outcome "k" received significantly less weight compared to the weight of curriculum. This is apparently because the respond think that outcome “k” is not important in long learning process except after graduation. However, unlike the outcome “a” and “e” which has 2 times more weight than the curriculum weight because the respondent strongly believe that more load should be given on that aspect to exposed the weakness in calculus which affect other areas of basic engineering science, but similarly, the objective student outcome curriculum weight (d and i) is two times more compared to the weight of the respondent mainly because the respondent think minimized weight should be given to such areas of soft skills which depends mainly on the diverse backgrounds, knowledge, skills, creativity and motivation by department and staff members to engage the student on various activities such as seminars, making varieties of presentations, writing report on other areas of literatures, work-shops, could activate the organization performance, thereby creating extra time for other pressing outcomes such as outcomes “a, b, c”. Also, outcome “b, c and h” of the overall respond and objective outcome of the curriculum have the same allocation of weight assigned to it both in the vision of academic outcomes correspondent and industrial engineering outcome respondent. Meaning that most majority of the respondent has the same judgment towards that sector because they are thought regularly.

5.6 Personal Recommendations and Contributions

1. There should be more active engagement by students in their own learning which can easily be achieve when lecturers engage students with more assignment, presentations, team works and practice.
2. There should be more involvement in engineering mathematics, design and they should return more feedback on their work with students for more

understanding because with such approach there will be less withdraw students from their dream course in engineering since this has caused many students to drop from engineering to business department simply because they lack the basic elementary foundation in mathematics due to a poor background from their elementary high school.

3. On the part of outcome “k” which most respondent from student gave less weight can be improved and employed on industrial training (internship) which lasts for 2 or 3 months should be increased to 6 month training cycle on industrial company and it is the duty of the departmental chair and supervisor to make sure that student are fully engage on that training because it will bring more significant increase in their emphasis on the use of modern engineering tools, learn work and engineering design.
4. There is also need for advisory department and committee member to focus on professional skills might also be expected to lead to change in teaching methods as faculty members seek to provide students with opportunities to learn and practice their teamwork, design and communication skills since most of the student find it difficult to understand their class lecture due to their poor orientation in English language which also result to poor performance in their report writing and verbal expression during their studies.
5. In contrast, roughly one quarter of the overall respondents believe that the outcome “j” which is the knowledge of contemporary issues should be given less weight due to awareness of diversity issues or their unwillingness to discuss and challenge prejudice or discrimination among student and the only way to correct this is through communal and mutual interactions during group or team work.

6. Finally, the main view of this student analysis outcome was important approach that will help to provide the departmental advisory board and program review committee with a right critical review of our curriculum, teaching, time allocation and these will lead to the implementation of continuous improvement in programs giving more rooms to the benefactors being students to attain their chosen dreams. Although the source, directions and the strength of the program curriculum analysis of this research will reshape the students in and out of their class room experience

Chapter 6

CONCLUSION

This paper presents an evaluation of weights of student outcome, and develop a curriculum evaluation framework based on the AHP result and also compare the given load of the curriculum with the present weight incurred from this study by conducting a performance evaluation which can reflect the overall individual weight of each criterion based on objective of ABET. The analysis significance will help in decision making techniques for determining the weights of student outcome using AHP approach which is for effective innovate to resolve these issues of student outcome based on ABET which will help to stimulate the maintenance and improvement of quality standards of engineering education system.

This paper presents the best allocation of weight to the a-k outcome assessment method of engineering program. The criteria assessment and evaluation are intended to assure quality and foster the systematic pursuit of improvement in quality of engineering education that satisfies the needs of constituencies in dynamic and competitive environment, while ABET should absorb and recognize the fact in connection to this analysis and compare capabilities of a-k criterion in promoting quality in engineering education which is the paramount significant in generating the technical man power required for building a strong nation since engineering has direct bearing on the economy of the country and to achieve this, the system should continuously revisit to identify the strong and weak component (mathematics, engineering design, and basic sciences) of programs in engineering, thereby promoting engineers who are employable in the market or to be successful entrepreneurs in their chosen field of study.

But the significance of this approach in the introduction of Classical AHP to determine the weight of student outcome since it involves consistency checking as a capability to capture the vagueness and reliability of human judgment which are irrationally done consciously or subconsciously relying on the improvement of judgment prior to the final decision to be considered. The professional accreditation of engineering and technology (ABET) programs is an important tool of quality assurance of engineering education used world-wide. The accreditation criteria and procedure should be revised regularly in accordance with the current international standard and regulations. However, to be competitive and to allow a world-wide recognition of accredited educational programs, the national accreditation system should take into account international framework and standard concerning graduate attribute in skills, knowledge and abilities.

The future researcher should direct their bearing toward limiting the zero errors that occurs when dealing with fuzzy AHP but provide special software's that can handle such task. And however there is also need to reduce the rate of inconsistency that occurs when dealing with several Multi-Criteria Decision making,

REFERENCES

[1] Nichols, J. O. (1995). Student outcome assessment and institution effectiveness, Press NY: Agathon.

[2] Zionts, S. & Wallenius, J. (1976). An interactive programming method for solving *MCDM problem*. 22(6), 652-663.doi:10:1016/j.ijhm.1976.04.005

[3] Golden, B., Wasil, E., & Harkey, P. (1989). *The Analytic pr*ocess. Germany, Heidelberg: Springer-Werla.

[4] Saaty, T. (1988). The Analytic Hierarchy Process. Pittburgh. In P.F. Zahedi, *The Analytic Hierarchy Process-a survey of the method and its applications,* (pp. 96-108) Interfaces 16.

[6] Knney, R. & Raiffa, H. (1976). Decision Making with Multiple Objectives, New York: Wiley.

[6] Wayne Winston L. (1994). Operation Research (pp. 798-800).

[7] Saaty, T. L. (1980). *The analytic hierarchy process*. New York, MC: Graw-Hill.

[8] Taha, H. A. (2003). *Operation research person education* Inc., FayeHevilla.

[9] Gezxu, V. Q., & Lin, H. (2008). The design and application in a generic AHP evaluation system (pp. 789-799).

[10] Luo, Z. & Yang, S. (2000). Comparative study on several scales in AHP systems engineering-theory. (pp. 51-60).

[11] Forman, P. H., & Gass, S. I. (2001). The analytical hierarchy process: an exposition. *operation research*, 49(4),467-487.doi:10.1016/jijhm.2001.04.005

[12] Bouyssou, D., Penny, P., & Pirlet, M. (2000). Non transitive decomposition measurement of general plane work for MCDM and decision uncertainty, Budapest: Hugany.

[13] Briedis, D. J., & Miller, D.. (1999). The curriculum aftermaths, production of the conference exposition ASEE conf. *an exposition Charlotte*, NC.

[14] Abet criteria for accrediting engineering programs. (2001,July 04). Retrieved from http://www.abet.org

[15] Gourty, J. M. (1997). Assessment workshop institutionalizing assessment and continuous improvement gate way coalition.

[16] ABET accreditation policy and procedure manual accreditation board of engineering. (2016,Mark 10). Retrieved from http://www.abet.org.

[17] Accreditation board of Engineering and Technology ABET (1997). Engineering criteria 2000: criteria for accreditation programs in Engineering in the United States ASEE prism, 5(6),41-42.doi:/ji.jhm.1997.03.009

[18] Saaty, T. L., & Forma, I. H. (2000). *Expert Choice-Advanced Decision support systems software.* Expert choice inc., Pittsburgh.

[19] Saaty T. L. (1990). How to make a decision using AHP, *European journal of operation research* 48(8),9-26.doi:10.1016/ji.jhm.1990.04.09

[20] Hwang, C. L., & Masud, A. (1979). Multiple objective Decision making methods and Application. *A state of the Art Survey*.