Curtin
University of Technology

Title

STAKEHOLDERS' SATISFACTION WITH CIVIL ENGINEERING GRADUATES

Thesis

By:
Albani Musyafa
Student No. 13058568

Supervisor:
Professor David Scott

Co-Supervisor:
Dr. Susan Joan Gribble

Chairperson:
Dr. Hamid Nikraz

This thesis is presented as a part of the requirements for the award of degree of Doctor of Philosophy of the Curtin University of Technology

DEPARTMENT OF CIVIL ENGINEERING
FACULTY OF ENGINEERING SCIENCE AND COMPUTING
CURTIN UNIVERSITY OF TECHNOLOGY

December 2009

Declaration

This thesis contains no material which has been accepted for the award of any other degree in any institution.

This thesis contains no material previously published by any other person except where due acknowledgement has been made.

All of data are original from the participants.

Signature :…….

Date :…….

Abstract

Engineering education is being viewed as a fundamental matter in modern industry because engineering education produces graduates that are very important to the continued development of industry. Because of its importance, the quality of the engineering education should be improved continuously. Basically, the quality of education can be divided into the quality of the process and the quality of the outcome. The process includes the quality of the teaching, learning and curriculum, and the quality of the outcome is the quality of the competencies possessed by graduates. While the quality of curriculum and learning have been discussed in many scientific reports, the quality of competence is rarely discussed. Therefore, a study on the quality of graduates' competence will be useful to augment recent studies on the quality of engineering education.

The objective of this study is to analyse data of graduate quality so that useful information is obtained to help engineering education providers put strategies in place to improve its quality. The information includes the models linking quality and satisfaction.

Data for this study including competence of graduates, performance of graduates, satisfaction of stakeholders, and expectations of stakeholders were obtained by survey with the questionnaire sets developed based on established variables and indicators. The targeted respondents are industry personnel monitoring graduates in workplaces. For comparison, data from academicians and professionals also were collected. Because of the diverse nature of engineering disciplines, the survey is limited to Civil Engineering graduates completing their studies from universities in Australia in recent years.

The collected data were analysed using statistical methods in levels of samples and population. The variables related to competencies have been ranked so that the weaknesses and strengths of the competencies can be understood. The variables related to the expectations of stakeholders are also ranked so that the competencies that should be prioritized in education are identified. The characteristics of stakeholders' satisfaction is defined based on the performance of graduates. Reliable models linking graduates' competence and the stakeholders' satisfaction have been developed. These findings will be useful to improve the quality of engineering education especially in the division of Civil Engineering.

Acknowledgments

The author is grateful to Professor David Scott for supervising and his continuing encouragement of the study especially during the data collection.
The author would like to express his gratitude to Dr. Susan Joan Gribble for valuable discussions and inputs for the study especially during the instrument development.
The author also thanks Professor. Dr. Widodo for his continuing interest and encouragement in both the preparation and realisation.
The author also wishes to thank:
Ms. Sucy Leong for administration and documentation especially during the data collection;
Mr. Ken Whitbread for academic English improvement and proofreading;
Respondents and their organizations for participating in supplying valuable data;
Our families, friends and communities for supporting this study.
The Government of the Republic of Indonesia and the Islamic University of Indonesia in Yogyakarta for funding support.

Contents

Figures

Equations

Tables

1. INTRODUCTION

The purpose of the thesis is to study the quality of graduate attributes of Civil Engineering in higher education. The attributes would include competence and performance of graduates. To analyse the quality, other factors such as the satisfaction and expectations of stakeholders with the graduate also would be studied to obtain useful information for providers of Civil Engineering education to improve its outcome quality.

The study has been conducted by reviewing literature, collecting data and analysing data. The data were collected using questionnaire sets developed based on factors, variables and indicators. The respondents were industry personnel who have closely monitored graduates working in workplaces. For comparison, data from academicians and professionals were also collected. All the data were analysed using statistical techniques.

The results of analyses will reveal useful information. The variables of competencies are ranked so that the weaknesses and strengths of the competence of graduates can be defined. The variables of expectations are ranked so that the competencies that should be prioritized by in education can be known. The characteristics of stakeholders' satisfaction will be defined based on the performance of graduates and reliable models linking the graduates' competence and the stakeholders' satisfaction can be developed. These findings will be useful to improve quality of engineering education especially in the division of Civil Engineering. Section 1.1 presents the background to the study exploring the importance of higher education in general and more especially in the Civil Engineering field.

1.1. Background of the study

Higher education or post-secondary education is non-compulsory education provided by tertiary institutions such as universities and other higher education institutions that award academic degrees. Studies in higher education are undertaken at undergraduate and postgraduate levels. The undergraduate level emphasizes the realm of teaching whereas the postgraduate level emphasizes research. Students at undergraduate level are awarded Bachelor degrees after completing a designated period of study while those who undertake postgraduate receive Masters or a Doctoral degree.

The main activities of higher education can be categorised into: teaching; research and social service. Teaching is the activity that directly delivers knowledge, skills and attitude to students and communities; Research is an activity to develop science and technology useful for communities; and Social service is an activity to improve quality of communities. These activities indicate that higher education is very important in modern society. UNESCO, the international organization specializing in educational affairs, states that higher education now acts as an essential component of development for individuals, communities and nations (*Reforming Higher Education* 2005). Because of the importance of higher education, the percentage of the population undertaking it can be an indicator of the development of a country. In developed countries, a high proportion of the population, up to 50 %, enters higher education at some time in their lives to develop knowledge and skills (*Higher education: Overview* 2007).

The importance of higher education can also affect the socio-economic sector because it significantly generates economic activities. One report has stated that higher education is very important as a significant industry in its own right (*Higher education: Overview* 2007). Hundreds or thousands of people can be employed in higher education institutions so that they can generate a multiple economic effect. In a developed country, higher education has been acknowledged as a contributor to the country's intellectual, economic, cultural and social development (*Higher education summary* 2007). Higher education is very important to economies, industries, individuals and communities (Spinks, Silburn & Birchall 2007; Tryggvason & Apelian 2006).

One of the prominent products of higher education is trained and skilled personnel namely graduates. Graduates of higher education in various workplaces can contribute valuable knowledge and skills to industry as they are trained and educated personnel (*Higher education: Overview* 2007). Through technical entrepreneurship, they can bring about technical revolutions that can meet the challenges in modern society (Wani, Garg & Sharma 2003). Graduates are also the future professional workforces, future leaders that may provide jobs, drive the economy, facilitate cultural and trade activities, and improve international relationships (*Higher education summary* 2007).

In an education-industry relationship, higher education institutions are viewed as suppliers of trained and skilled personnel to industry as the majority of graduates begin their

careers in industry (Richter & Loendorf 2007). Many strategic positions in industries are held by graduates. For example, the management of construction has traditionally been the function of the civil engineer i.e. Civil Engineering graduates (Haltenhoff 1986).

Finally, because of the importance higher education, especially its graduates, its quality is an interesting topic of study. The study in this area needs to be focused on a certain faculty or division because each division relates to a certain industry. There are faculties and divisions representing different fields of study or academic disciplines. The number and type of faculty can vary depending on the development of industries, careers, professions and market needs. One such academic discipline is the engineering field.

1.1.1. Engineering in higher education

Engineering has a number of definitions based on contexts, but according to the Accreditation Board for Engineering and Technology (ABET), it is defined as:

> The creative application of scientific principles to design or develop structures, machines, apparatus, or manufacturing processes, or works utilizing them singly or in combination; or to construct or operate the same with full cognizance of their design; or to forecast their behaviour under specific operating conditions; all as respects an intended function, economics of operation and safety to life and property (Crnjac Milic, Martinovic & Fercec 2007).

Based on this definition, engineering discipline can be defined as a division or discipline in higher education studying the applied sciences to design, analyse, and construct works for practical purposes.

The field of engineering, like many other academic disciplines, encompasses several specialised sub-disciplines which are concern with different areas of engineering work and to some extent can be outlined as follows:

1. Aerospace Engineering - The design of aircraft, spacecraft and related topics;
2. Chemical Engineering - The conversion of raw materials into usable commodities;
3. Civil Engineering - The design and construction of public and private works, such as bridges and buildings;
4. Electrical Engineering - The design of electrical systems, such as transformers, as well as electronic goods;

5. Mechanical Engineering - The design of physical or mechanical systems, such as engines, kinematical chains and vibration isolation equipment;
6. Mining Engineering - The extraction of raw materials from the earth, including ores, natural gases and crude oils; and
7. Software Engineering - The design and development of software for use in digital systems (Pavlov et al. 2007).

The sub disciplines focus on specific issues. In each of these fields, there exists considerable overlap, especially in the areas of the application of sciences to their disciplines such as physics, chemistry and mathematics (Pavlov et al. 2007). Although initially an student engineer is trained in a specific discipline, throughout continued engineering education, the engineers may become multi-disciplined, having worked in several of the outlined areas (Pavlov et al. 2007). People who practice engineering are called engineers and one of the requirements as licensed engineers is the completion of education in the engineering field.

1.1.2. Civil engineering in higher education

According to the Institution of Civil Engineers (ICE), Civil Engineering is defined as:

> A great art, on which the wealth and well-being of the whole of society depends. Its essential feature, as distinct from science and the arts, is the exercise of imagination to fashion the products, processes and people needed to create a sustainable physical and natural built environment. It requires a broad understanding of scientific principles, knowledge of materials and the art of analysis and synthesis. It also requires research, team-working, leadership and business skills." (*What is Civil Engineering?* 2007).

Based on this definition, Civil Engineering can be defined as a sub-discipline of engineering that entails applied sciences to design, analyse, or construct public and private works, such as bridges, roads, railways, dams, water supply and wastewater treatment, harbours, tunnels and mining construction, power projects, offshore structures, and domestic, commercial, and industrial buildings. Civil Engineering is the oldest engineering discipline after military engineering (*Civil engineering* 2007) and it was defined to distinguish it from military engineering (Allendoerfer et al. 2007). Civil engineering is traditionally broken into several sub-disciplines including:

1. Construction engineering;

2. Environmental engineering;
3. Geotechnical engineering;
4. Structural engineering;
5. Transportation engineering
6. Water resources engineering;
7. Materials engineering; and
8. Coastal engineering (*Civil engineering* 2007).

Civil Engineering graduates generally work in the industry as civil and construction engineers, consulting engineers, general contractors or specialist subcontractors (*Civil Engineering* 2005).

1.1.3. Issues in engineering education

Although issues in engineering education are a multifaceted problem (Upadhyay et al. 2007), the issues can be examined under several categories. Firstly, one issue is enrolment in engineering education. Secondly, there is the issue of the education process of students.

1.1.3.1 Enrolment in engineering education

Enrolment is an important issue in engineering education because it can affect its quality. In order to boost the development of engineering education, the enrolment should be improved (Luo, Qi & Mao 2005). This basically, may be solved by encouraging students in Kindergarten to Year 12 (K-12) programs to enrol in engineering education. However, this approach could produce a distorted perception that many students enrolled in engineering programs drop out or complete with a low competency level (Mountain & Riddick 2005). Therefore, this impact can affect the quality and nature of engineering education resulting in graduates not meeting industry and professional standards and expectations.

1.1.3.2 Process in engineering education

The education process is an important issue in engineering education because graduates are developed through the process. The process can be examined in three main areas: teaching; learning and the curriculum,, all of which can affect the quality of engineering education.

Teaching is a process of providing students with knowledge, skills and professional attitudes by teachers or lecturers which is usually conducted in classrooms but can include

activities such as fieldwork. Teaching in tertiary education is vital to producing qualified graduates who are employable. In order to meet the expectations of the engineering profession, engineering education needs to continuously learn new approaches of effective teaching (L Dee Fink, Ambrose & Wheeler 2005).

Learning is the conscious manner of students' acquisition of different types of knowledge, skills or attitudes, both in and out of classroom supported activities (*Learning* 2008). Recent studies on student learning in higher education indicated that there are relationships between the characteristics of the learning methods and the quality of graduates (Christiansson 2005; F. K. Fink & Kjaersdam 2004; Tynjala et al. 2005; Zualkernan & Sakka 2005).

The curriculum in education can be viewed as a guide or the goal of education. It is the set of courses, course work, and content offered at a school or university through which students should be graduates who would be a success in professional society (*Curriculum* 2008). The role of the curriculum is very important and many reports have discussed it high-lighting efforts that need to be made to develop curriculum so that it meets with the expectations of practices in professions and industries (Earnest 2005; Heitmann 2005; Luo, Qi & Mao 2005; Powell 2005). Fulfilment leads to the improvement of the quality of graduates. In practical terms, quality can be defined as employability of the graduate. Effective curricula in design and delivery are, therefore, important for graduates' quality.

1.1.4. Education outcome

All the issues indicate that the matter of education outcomes is important that is graduates must obtain certain competencies developed through the process of education. Therefore, a qualified graduate is the goal of the education.

However, some reports indicate that the quality of graduate competence seriously needs to be improved to meet the requirements of industry (Earnest 2005; Heitmann 2005; Luo, Qi & Mao 2005; Powell 2005). The quality can be examined based on assessment and expectations of the industry and profession.

1.2. Formulation of the problem

As mentioned in section 1.1, the role of engineering education is very important for industry. One of main contributions of engineering education is to provide qualified graduates and because of the importance, the quality of graduates is an aspect that should be measured continuously (*Higher Education and Education for All* 2005).

Recently, some reports as presented in section 1.1.4 have indicated that the quality of engineering graduates needs to be improved to meet industry needs. The improvement of graduates quality can be achieved by improving enrolments and the education process including teaching methods, learning methods, and the curriculum. Any improvements should be followed up by investigating the outcome of education.

Many studies as presented in section 1.1.3 have been conducted to improve the quality of engineering education graduates, however, no extensive investigation has not been reported in scientific journals on how well engineering graduates fit stakeholders' expectations in an industry that is undergoing rapid change.

This investigation should be conducted within a framework of education and industry relationship (Gregory 2006; Stansfield 2005). The industry can be assumed as stakeholders of engineering education. The investigation in this framework needs to focus on a certain faculty or division because each division has own specific needs and Civil Engineering would be the focus of an investigation as explained in sections 2.4.

1.3. Objectives of the study

As stated in section 1.2, this study will focus on the quality of graduates of Civil Engineering. In order to make this study specific, the objectives are formulated as follow.

The **first objective** of this study was to measure the quality of Civil Engineering graduates. The quality is defined as competencies mastered by graduates, so the measurement was focused on the graduates' competence. The measured competence can be viewed as actual or existing competence mastered by the graduates. The actual competence could also be ranked that show the seeds of graduates' actual competence. This is the main objective of this study.

Once this objective is understood, several related factors are very valuable to be examined and analysed. The factors include: stakeholders' expectations and satisfaction with their competence; and graduates' performance in workplace.

The **second objective** of this study was to measure the stakeholders' expectations with graduates' competence. The expectation was measured to know the importance levels or rankings of the competence that should be mastered by graduates. With certain methods, the importance levels were compared with rankings of actual competence. Comparison between the actual and expectation would produce lists of priority of competence.

The **third objective** of this study was to compare between stakeholders' expectations. This objective needs to be achieved because the stakeholders consist of various groups. The comparison revealed differences among groups of stakeholders (King & Fries 2003).

The **fourth objective** of this study was to select competencies that should be prioritised to be mastered by graduates. The prioritised competencies was achieved based on comparison between rankings of expected competence and rankings of actual competence.

The **fifth objective** of this study was to investigate the relationship between graduates' performance and stakeholders' satisfaction. The investigation revealed the characteristics of stakeholders' satisfaction based on graduates' performance. In order to investigate the relationship, these factors that conceptually have relationships with graduates' competence were measured.

The **sixth objective** of this study was to develop models linking graduates' actual competence and stakeholders' satisfaction with graduates. The models formulate the relationship between the two concepts. The formulation can be used to understand the relationship between them.

The **seventh objective** of this study was to feedback to civil education providers because this study should benefit large communities especially in engineering education. The rankings of competence, the rankings of expectations, the differences among stakeholder groups, the prioritised competencies, the characteristic of stakeholders' satisfaction and the models could provide valuable information to improve the quality of Civil Engineering education. For instant, the seven objectives in this study were:

1. to investigate actual graduates' competence and its rankings;
2. to investigate rankings of expected graduates' competence;
3. to compare expectations on the graduates' competence;
4. to select competencies that should be prioritised to be mastered by graduates;
5. to investigate relationship between graduates' performance and stakeholders' satisfaction with graduates' competence;
6. to develop models linking graduates' competence and stakeholders' satisfaction; and
7. to provide feedback to education providers.

To achieve the objectives, the theoretical framework, the definitions, the relationships and the variables are needed. Justification and development of these objectives will be presented in section 2.4.

1.4. Outline of the study

An outline of the study is proposed to briefly explain its stages, limitations and benefits of this study. The stages are a breakdowns of this study that each part has specific aim. The limitations are definitions of objects of this study so that this study could be conducted within certain constrains. The benefits are positive effects of this study for communities..

1.4.1. Stages of the study

To conduct a scientific study, the topic must have a systematic method that includes stages with certain targets or aims. Table 1- 1 shows the seven stages or seven chapters contained in this thesis. Each stage will be a chapter.

Table 1- 1 Tasks of study completion

Task	Chapter
1. Introducing the background, objectives and outline of the study	1
2. Presenting the literature review related to the theory, concepts, variables and their relationship	2
3. Developing a methodology to collect primary data	3
4. Investigating the quantity and quality of collected data	4
5. Analysing collected data	5
6. Discussion of the findings	6
7. Drawing conclusions and making recommendations	7

Source: Resume of section 1.4.1

The first task was to introduce the background, the problems, and the objectives. This task has been explained in the introduction chapter. The second task was to develop a theory including concepts, variables and the relationship between them. The concepts consist of competence, performance, satisfaction and expectation. Examination of the relationship between them should deliver new information as to the objectives and this dealt with in the literature review. The third task i.e. the chapter on methodology developed and established methods to obtain the data needed. The fourth task was to present and describe the collected data so that its quantity and quality can be understood. This task will be contained in chapter of data collected. The fifth task, data analysis, will analyse the data so that new information as stated in the objectives can be obtained. The sixth task is to discusses the findings so that the advantages and disadvantages of this study can be understood. This task will be contained in chapter of finding and discussion. The seventh task is to draw conclusions the study and make recommendations.

1.4.2. Limitations of the study

There are many graduates, branches and levels of engineering education with variety in learning methods and varying curricula. There are too many different stakeholders of

engineering education. It is impossible to cover every aspect of the problems so limitations must be made to enable the study to be conducted within the planned timeframe.

The limitations include: kinds of engineering institutions; graduates; stakeholders; and the locations of samples. Institutions will be limited to civil engineering and construction education. Kinds of graduates would be limited to 4-year program graduates who have completed the education less than three years i.e. 2004, 2005 or 2006. Stakeholders would be limited to industry personnel, academicians and professionals. Data collection would be limited to Australia. For instance, this study is limited to:

1. Civil engineering and construction education;
2. 4-year education or undergraduate program;
3. Graduates that completed the education in 2004, 2005 or 2006;
4. Stakeholders that are industry personnel, academicians and professionals; and
5. Data that would be collected in Australia.

The limitation in data sources would be explained in section 3.6.

1.4.3. Benefits of the study

Improvement of the quality in education is very difficult task (Bilsel & Erdil 2004), hence studies in the quality of education are very useful. The findings of this study will benefit to society in the following ways:

6. Actual graduates' competence could be used to evaluate the effectiveness of the education processes.
7. Expectations could be used to improve the quality of the education.
8. Comparisons could be made to understand differences between or among stakeholders in the expectations of graduates.
9. Prioritised competencies could be used to gradually improve the quality of education.
10. The models could be used to predict the satisfaction level based on graduates' competence.
11. The models could be used by human resource departments as a job application support system to select required personnel in the construction industry.
12. The model also could be used to evaluate and improve the curriculum and learning methods.

The study would be useful for communities to improve the quality of education, especially in the civil engineering and construction fields. Improvement of the quality should increase the employability of their graduates (Middleton 2005).

1.5. Summary of the introduction

A study on the competence of engineering graduates is very important in evaluating and improving current engineering education. Others factors related to graduates' competency such as graduates' performance, stakeholders' satisfaction and stakeholders' expectations also need to be investigated in order to make the study more valuable. Many benefits will be achieved if this study is properly undertaken.

The aim of this chapter is to introduce the problem, to design the objectives and to present an outline of the study. The problem is formulated based on the gap between the actual quality and expected quality of engineering education. The objectives assume factors that have relations with the quality and have been arranged so that new information can be obtained. The outline described the stages, limitations and benefits of the study. The introduction has given general information of the study so the next i.e. chapter 2 contains the literature review to develop and justify the objectives of the study.

8. CONCLUSIONS AND RECOMMENDATIONS

This chapter draws together conclusions of this study and makes recommendations about further studies. The conclusions are based on the results of study discussed in the previous chapters and recommendations are made to improve and continue further studies in this field. The conclusions and recommendations are presented in the same sequence as the objectives of this study.

8.1. Ranking of graduates' competence

8.1.1. Conclusion on Objective 1

The study revealed rankings of actual competence mastered by civil engineering graduates as presented in Table 6-2 to Table 6-4. The competence was divided into three factors i.e. knowledge, skills and attitude that each factor has nine variables. Each variable sits at a certain level in the rankings. Table 6-2 shows the rankings of knowledge, Table 6-3 the rankings of skills, and Table 6-4 the rankings of attitude.

These rankings have been validated so that they could represent ranking of competence of civil engineering graduates. The calculation of the rankings assumed that the weight of each stakeholder is the same. These rankings should be a concern in civil engineering education because these rankings do not fully meet with stakeholders' expectation and satisfaction with graduates (sections 6.1 and 6.4). The graduates' competence that should be concern to be improved are:

4. understanding the principles of management and business (K8);
5. ability to communicate effectively with the community at large (S4); ability to function effectively in teams with the capacity to be a manager (S8); ability to function effectively in teams with the capacity to be a leader (S9); and
6. ability to undertake lifelong learning (A2).

8.1.2. Recommendation to improve Objective 1

In order to improve the reliability of the rankings, the number of samples needs to be increased so that the normal distribution for each variable can be reached. Calculation of the

rankings assumed that the weight of each stakeholder is the same (section 8.1.1). Further analyses that use variations of weigh also need to be conducted. Further studies with different methods should be conducted to confirm the rankings. The different methods include: research variables, measurements, data collection methods and data resources. The research variables should be improved by including suitable attributes for certain countries or regions because each country should have specific curriculum in civil engineering education. The measurement should use the Semantic Differential Scale or the Rating Scale in order to confirm this finding. The data collection methods should include the use of interviews, and data source should include more stakeholders, including government in order to get more complicated data and wider stakeholders.

8.2. Rankings of expected competence

8.2.1. Conclusion on Objective 2

This study also revealed rankings of expected competence that should be mastered by civil engineering graduates as presented in Table 6- 5 to Table 6- 7. The expected competencies were divided into three factors i.e. knowledge, skills and attitude that each factor has nine variables. Each variable sits at a certain level in the rankings. Table 6- 5 shows the rankings of expected knowledge, Table 6- 6 the rankings of expected skills, and Table 6- 7 the rankings of expected attitude.

These rankings have been validated so that they can represent of stakeholders' expectations of civil engineering education. In the calculation, each group of stakeholders had the same weight. These rankings should be a concern in civil engineering education because these rankings will affect stakeholders' satisfaction with graduates (section 6.2). The stakeholders' expectation that should be concern are:

1. expectation with graduates' ability to understand the problem identification, formulation and solution (K4);

2. expectation with graduates' ability to use technologies appropriately (S2); to access, evaluate and synthesise information (S3); and to communicate effectively with the community at large (S4); and
3. expectation with graduates' ability to develop effective interpersonal skills in their workplace (A9).

8.2.2. Recommendation to improve Objective 2

In order to get more reliable ranking of expected competence, sample numbers needs to be improved so that the normal distribution for each variable can be reached. This study assumed that the weight of each stakeholder is the same (section 8.2.1). However, further analyses using variations of the weight need to be conducted. Further studies with different methods should be conducted to confirm the ranking. The different methods include: research variables, measurements, data collection methods, data sources and data analyses. The research variables should be improved by including suitable attributes for certain countries or regions because each country should have specific expectation with graduates' attributes. As regards measurement, the Semantic Differential Scale and the Rating Scale. The data collection methods should include the use of interviews to avoid incorrect responses. The data source ought to include a wider selection of stakeholders including government. The data analyses should use the Analytical Hierarchy Process (AHP) in order to know more detail about the importance of graduates' attributes.

8.3. Differences between stakeholders' expectations

8.3.1. Conclusions on Objective 3

The study disclosed the differences among stakeholders' expectations with civil engineering graduates as presented in Table 6-11 to Table 6-13. The differences were measured in three factors of graduates' competence i.e. knowledge, skills and attitude, each with nine variables. Table 6-11 shows the knowledge that were expected differently by stakeholders, Table 6-12 the skills, and Table 6-13 the attitude. The differences have been

validated so that they can represent differences of stakeholders' expectation with civil engineering graduates. The differences were calculated with criteria established by researcher.

These differences should be a concern in civil engineering education especially academicians or educators that their perception are different with other stakeholders. The differences are as the following.

1. In the knowledge factor, employers consider graduates' competence in understanding "principles and concepts" as the most important knowledge that should be mastered by graduates, while the others (graduates, academicians, professionals) do not so.

2. In the skills factor, employers, graduates and professionals considered graduates' ability in the communication with the community at large as the most important skills that should be mastered by graduates, while academicians did not so.
3. In the other skills factor, graduates, academicians and professional considered graduates' competence to function effectively in teams with the capacity as a leader the least important skills that should be mastered by graduates, but employers did not so.

8.3.2. Recommendation to improve Objective 3

Data in this analysis is the same as the data used to achieve ranking of expected competence (section 8.2.1), therefore, the recommendations how to improve data has been mentioned in section 8.2.2. This differences were investigated using criteria established by the researcher (section 8.3.1). Further analyses should be conducted using different criteria to confirm the results in this analysis.

8.4. Prioritised competence

8.4.1. Conclusions on Objective 4

The study revealed the graduates' competencies that should be prioritised in civil engineering education based on stakeholders' perceptions as presented in Table 6- 14 to Table 6- 16. The competencies were divided into three factors i.e. knowledge, skills and attitude, each with nine variables. Table 6- 14 shows the knowledge that should be prioritised by education, Table 6- 15 the skills, and Table 6- 16 the attitude.

The competencies that should be prioritised in civil engineering education are as the following. In the knowledge field, there were two competencies that should be prioritised i.e. graduates' abilities:

1. to understand problem identification, formulation and solution (K4); and
2. to understand laws, regulations and standards associated with civil engineering (K7).

In the skills field, there were three competencies that should be prioritised i.e. graduates' abilities:

1. to use technologies appropriately (S2);
2. to access, evaluate and synthesise information (S3); and
3. to communicate effectively not only with engineers but also with the community at large (S4).

In the attitude field, there were three competencies that should be prioritised i.e. graduates' abilities:

1. to undertake lifelong learning (A2);
2. to use effective group skills in his or her workplace (A8); and
3. to develop effective interpersonal skills in his or her workplace (A9).

8.4.2. Recommendation to improve Objective 4

The prioritised attributes or competencies are valid to represent competencies that should be prioritised based on stakeholders' perceptions. However, the data in this analysis is the same as the data of graduates' competence (section 8.1.1) and expected competence (section 8.2.1). The recommendations how to improve the data has been mentioned in sections 8.1.2 and 8.2.2. This study uses the criteria that were established by the researcher. Further analyses should be conducted employing different criteria to confirm the results in this analysis.

8.5. Relationships between performance of graduates' job and stakeholders' satisfaction

8.5.1. Conclusions on Objective 5

The study revealed the relationships between graduates' performance and stakeholders' satisfaction. The performance was divided into three factors i.e. time, cost and quality as

presented in Table 6- 17 The relationships were measured using the statistical technique of Spearman Rho test. This measurement has shown that:

1. Time performance of graduates' job has significant and positive relationship with stakeholders' satisfaction in about 80 % of cases;

2. Cost performance of graduates' job has significant and positive relationship with stakeholders' satisfaction in about 40 % of cases;
3. Quality performance of graduates' job has no significant relationship with stakeholders' satisfaction (section 6.5).

The stakeholders' satisfaction relates to the graduates' performance especially in time and cost performance. However, graduates' time performance is more important because it often exists. In order to clarify the relationships, they are drawn as shown in Figure 6- 15.

8.5.2. Recommendation to improve Objective 5

In order to more get reliable relationship between performance of graduates' job and stakeholders' satisfaction, the sample number needs to be improved so that the normal distribution for each variable can be reached. This study used methods of sample selection that were established by the researcher (section 5.5). Further analyses should be conducted using different criteria to confirm the results in this analysis.

Further studies with different methods should be conducted to confirm the relationship. The different methods include: research variables, measurements, data collection methods and data resources. The variable of performance should be improved according to actual jobs in the workplaces. Regarding measurement, the Ratio Scale or Interval Scale should be used. The data collection methods should include the use of interviews to do complex measurement about the performance. The data source should include a wider selection stakeholder, including government.

8.6. Models linking graduates' competence and stakeholders' satisfaction

8.6.1. Conclusion on Objective 6

The study has revealed models linking graduates' competence and stakeholders' satisfaction. The models were in linear equations as presented in section 7. Based on a sample, 12 models were developed. The models consist of:

1. 2 models linking graduates' knowledge and stakeholders' satisfaction;
2. 7 models linking graduates' skills and stakeholders' satisfaction; and
3. 3 models linking graduates' attitude and stakeholders' satisfaction.

Based on the number of models it is concluded that graduates' skills has more relationship with stakeholders' satisfaction.

The models can used to predict stakeholders' satisfaction based on graduates' competence. The most reliable models of each category were plotted in Figure 7- 2.

8.6.2. Recommendation to improve Objective 6

Data in model development is the same as the data of graduates' competence and stakeholders' satisfaction. Recommendations how to improve the data has been stated in sections 8.1.2 and 8.5.2. With different data type, other models such as the Non Linear Regression model or the Discriminant model could be developed in order to achieve more reliable models. The model development used criteria of model development and selection (correlations and significance) that were established by the researcher. In future, further analyses should be conducted using different criteria to confirm the results in this analysis.

8.7. Summary of the conclusions and recommendations

All objectives of this study presented in section 1.3 have been realised. The major outcome of this study is a contribution toward the improvement in the quality of civil engineering education. The ranking of graduates' competence could be used to evaluate the strength and weakness of graduates. The ranking of expectations can be used to improve the quality of the education. The differences between stakeholders in their expectations can be used to better understand the characteristics and expectations of the various stakeholders. The prioritised competencies could be used to gradually improve the quality of education. The

models can be used to estimate the stakeholders' satisfaction level or the quality of graduates based on graduates' competence. The models also could be used to evaluate and hence to improve the curriculum and learning methods especially in the civil engineering and construction fields.

Finally, the quality of civil engineering graduates could be improved by improvement in graduates' competence in skills, knowledge and then attitude. The most important competencies, as assessed by all stakeholders are:

1. ability to use technologies appropriately (S2);
2. ability to access, evaluate and synthesise information (S3);
3. ability to communicate effectively with the community at large (S4);
4. ability to function effectively as an individual (S5)
5. ability to function effectively in teams with the capacity to be a manager (S8);
6. ability to understand the problem identification, formulation and solution (K4);
7. ability to understand laws, regulations and standards (K7);
8. ability to understanding the principles of management and business (K8);
9. ability to undertake lifelong learning (A2); and
10. ability to develop effective interpersonal skills (A9).

However, the various stakeholders have a difference in perception of importance of graduates' ability in communication with the community at large (S4). Employers, graduates and professionals considered the ability as the most important skills that should be mastered by graduates, while academicians differed.

Regardless of these differences the results from the project can be the basis for designing and improving civil engineering courses.

Reference

Abdul-Shukor, A 2003, 'Learning assessment on the effectiveness of teaching delivery in manufacturing engineering education', *Global Journal of Engineering Education,* vol. 7, no. 2, pp. 227-36.

Abu-Eisheh, SA 2004, 'Assessment of the output of local engineering education programs in meeting the needs of the private sector for economies in transition: the Palestinian territories case', *International Journal of Engineering Education,* vol. 20, no. 6, pp. 1042-1054. Retrieved: Dec 2004, from Compendex.

Aldridge, S & Rowley, J 1998, 'Measuring customer satisfaction in higher education', *Quality Assurance in Education,* vol. 6, no. 4, pp. 197-204. Retrieved: Apr 2005, from Compendex.

Allendoerfer, C, Bates, R, High, KA, Meadows, L, Masters, K, Stwalley, C & Adams, RS 2007, 'Communities of practice in engineering education: How do we investigate diversity and global engineering?' in *Annual Frontiers in Education Conference*, IEEE, Milwaukee, WI, USA, p. 1.

Anwar, S & Rasolomampionona, DD 2005, 'Electrical engineering education in Poland: A case study', in *Annual Conference and Exposition*, American Society for Engineering Education, Portland, OR, USA, pp. 5071-5076.

Arikunto, S 1998, *Prosedur Penelitian: Suatu Pendekatan Praktek* Rineka Cipta, Jakarta.

Attitude in psychology 2008, Wikipedia. Retrieved: 8 Sept 2008, from http://en.wikipedia.org/wiki/Attitude_(psychology).

Azapagic, A, Perdan, S & Shallcross, D 2005, 'How much do engineering students know about sustainable development? The findings of an international survey and possible implications for the engineering curriculum', *European Journal of Engineering Education,* vol. 30, no. 1, pp. 1-19. Retrieved: August 2005, from Compendex.

Bary, R & Rees, M 2006, 'Is (self-directed) learning the key skill for tomorrow's engineers?' *European Journal of Engineering Education,* vol. 31, no. 1, pp. 73-81. Retrieved: Mar 2007, from Compendex.

Bilsel, A & Erdil, E 2004, 'Experience gained in applying abet criteria to an Electronic Engineering Program in a Turkish University', *International Journal of Engineering Education,* vol. 20, no. 1, pp. 77-82. Retrieved: Jun 2004, from Compendex.

Bradley, A 2005, 'Accreditation Criteria Guideline', in *Accreditation Management System: Education at the Level of Professional Engineer*, Engineers Australia Accreditation Board, Canberra.

Brandon, D 2006, 'Educating materials engineers', *International Journal of Engineering Education,* vol. 22, no. 5, pp. 910-916. Retrieved: Dec 2006, from Compendex.

Brito, C, Ciampi, MM & Budny, D 2007, 'New trends in engineering education worldwide', in *Annual Conference and Exposition*, American Society for Engineering Education, Chantilly, VA 20153, United States, Honolulu, HI, USA, p. 9.

Brodie, P & Irving, K 2007, 'Assessment in work-based learning: investigating a pedagogical approach to enhance student learning', *Assessment and Evaluation in Higher Education,* vol. 32, no. 1, pp. 11-19. Compendex.

Burgess, S, Booker, J, Barr, G & Alemzadeh, K 2005, 'An investigation into engineering graduates' understanding of probability theory', *International Journal of Engineering Education,* vol. 21, no. 3, pp. 512-524. Retrieved: 2005, from Compendex.

Burgstahler, S, Corrigan, B & McCarter, J 2004, 'Making distance learning courses accessible to students and instructors with disabilities: a case study', *Internet and Higher Education,* vol. 7, no. 3, pp. 233-246. Retrieved: Jun 2005, from Compendex.

Burns, GR & Chisholm, CU 2003, 'The role of Work-Based Learning methodologies in the development of life-long engineering education in the 21st Century', *Global Journal of Engineering Education,* vol. 7, no. 2, pp. 179-187. Retrieved: Feb 2005, from Compendex.

Caspersen, R 2002, 'Encouraging engineers to learn cross-cultural skills', *Global Journal of Engineering Education,* vol. 6, no. 2, pp. 135-137. Retrieved: Feb 2005, from Compendex.

Chalidabhongse, J, Jirapokakul, N & Chutivisarn, R 2006, 'Facilitating job recruitment process through job application support system', in *International Conference on Management of Innovation and Technology*, Institute of Electrical and Electronics Engineers Computer Society, Singapore, pp. 111-115.

Chen, KS & Huang, ML 2006, 'Performance measurement for a manufacturing system based on quality, cost and time', *International Journal of Production Research,* vol. 44, no. 11, pp. 101-123. Retrieved: Dec 2006, from Compendex.

Chenail, RJ 2004, 'When Disney meets the research park: metaphors and models for engineering an online learning community of tomorrow', *Internet and Higher Education,* vol. 7, no. 2, pp. 107-121. Retrieved: Aug 2005, from Compendex.

Chiang, AC-C & Fung, IP-W 2004, 'Redesigning chat forum for critical thinking in a problem-based learning environment', *Internet and Higher Education,* vol. 7, no. 4, pp. 311-328. Retrieved: Oct 2005, from Compendex.

Chisholm, CU 2003, 'Critical factors relating to the future sustainability of engineering education', *Global Journal of Engineering Education,* vol. 7, no. 1, pp. 29-38. Retrieved: Feb 2005, from Compendex.

Chong, BK & Crowther, F 2005, 'A new framework for measuring the quality of outcomes-based engineering education', in *Annual Frontiers in Education*, 35 edn, IEEE, Indianopolis, IN, USA, pp. 1-22.

Christiansson, P 2005, 'Building management and ICT learning in civil engineering education', in *International Conference on Computing in Civil Engineering*, American Society of Civil Engineers, Cancun, Mexico, pp. 93-104.

Civil Engineering 2005, Curtin University of Technology, Perth. Retrieved: 20 Sept 2007, from http://www.civil.eng.curtin.edu.au/description.cfm.

Civil engineering 2007, Wikipedia. Retrieved: 21 Sep 2007, from http://en.wikipedia.org/wiki/Civil_engineering.

Competence: human resources 2007, Wikipedia. Retrieved: 21 Sept 2007, from http://en.wikipedia.org/wiki/Competence_%28human_resources%29.

Costley, C & Armsby, P 2007, 'Work-based learning assessed as a field or a mode of study', *Assessment and Evaluation in Higher Education,* vol. 32, no. 1, pp. 21 - 33. Compendex.

Crnjac Milic, D, Martinovic, G & Fercec, I 2007, 'Analysis of desirable changes in engineering education in the context of university education reform', *Tehnicki Vjesnik,* vol. 14, no. 3-4, pp. 31-36. Retrieved: Nov 2007, from Compendex.

Curriculum 2008, Wikipedia. Retrieved: 4 Sept 2008, from http://en.wikipedia.org/wiki/Curriculum.

Curtin, UoT 2005, *Civil Engineering*, Perth. Retrieved: 20 Sept 2007, from http://www.civil.eng.curtin.edu.au/description.cfm.

De Camargo Ribeiro, LR & Mizukami, MDGN 2005, 'Student assessment of a problem-based learning experiment in civil engineering education', *Journal of Professional Issues in Engineering Education and Practice,* vol. 131, no. 1, pp. 13-18. Retrieved: Jul 2005, from Compendex.

Devon, R, Bilen, S, Mckay, A, De Pennington, A, Serrafero, P & Sierra, JS 2004, 'Integrated design: what knowledge is of most worth in engineering design education?' *International Journal of Engineering Education,* vol. 20, no. 3, pp. 424-432. Retrieved: 2004, from Compendex.

Dym, CL, Rossmann, JS & Sheppard, SD 2004, 'On designing engineering education: lessons learned at Mudd design workshop IV', *International Journal of Engineering Education,* vol. 20, no. 3, pp. 470-474. Retrieved: 2004, from Compendex.

Earnest, J 2005, 'ABET engineering technology criteria and competency based engineering education', in *Annual Frontiers in Education*, 35 edn, IEEE, Indianopolis, IN, USA, pp. 2-7.

Eunok, K & Janghyun, P 2005, 'A study on renovative plan for engineering educational curricula and courses for SoC (system on chip) design architects in Korea's IT industry', in *International Conference on Microelectronic Systems Education*, IEEE Computer Society, Anaheim, CA, USA, pp. 13-14.

Expectation 2008, Wiktionary, The free dictionary. Retrieved: 3 April, from http://en.wiktionary.org/wiki/expectation#English.

Fink, FK & Kjaersdam, F 2004, 'UICEE Centre for Problem-Based Learning (UCPBL)', *Global Journal of Engineering Education,* vol. 8, no. 1, pp. 65-70. Retrieved: Feb 2005, from Compendex.

Fink, LD, Ambrose, S & Wheeler, D 2005, 'Becoming a professional engineering educator: A new role for a new era', *Journal of Engineering Education,* vol. 94, no. 1, pp. 185-194. Retrieved: Jun 2006, from Compendex.

Forsythe, PJ 2007, 'A conceptual framework for studying customer satisfaction in residential construction', *Construction Management and Economics,* vol. 25, no. 2, pp. 171-182. Retrieved: July 2008, from Compendex.

Froyd, J, Layne, J & Watson, K 2006, 'Issues regarding change in engineering education', in *Annual Conference on Frontiers in Education*, 36 edn, IEEE, San Diego, CA, USA, p. 6.

Gao, X-F, Hu, C-S & Zhong, D-H 2007, 'Study synthesis optimization of time-cost-quality in project management', *System Engineering Theory and Practice,* vol. 27, no. 10, pp. 112-117. Retrieved: Dec 2007, from Compendex.

Gijbels, D, van de Watering, G & Dochy, F 2005, 'Integrating assessment tasks in a problem-based learning environment', *Assessment and Evaluation in Higher Education,* vol. 30, no. 1, pp. 73 - 86. Compendex.

Gol, O, Nafalski, A, Nedic, Z & McDermott, KJ 2004, 'Engineering awareness raising through high school mentoring', *Global Journal of Engineering Education,* vol. 8, no. 2, pp. 139-146. Retrieved: Mar 2005, from Compendex.

Grasso, D, Callahan, KM & Doucett, S 2004, 'Defining engineering thought', *International Journal of Engineering Education,* vol. 20, no. 3, pp. 412-415. Retrieved: 2004, from Compendex.

Green, LN & Bonollo, E 2004, 'The importance of design methods to student industrial designers', *Global Journal of Engineering Education,* vol. 8, no. 2, pp. 175-182. Retrieved: Apr 2005, from Compendex.

Gregory, A 2006, 'Education is your business', *Works Management,* vol. 59, no. 8, pp. 18-21. Retrieved: Nov 2006, from Compendex.

Grisaffe, D 2004, 'A Dozen Problems with Applied Customer Measurement', *Journal of Consumer Satisfaction Dissatisfaction and Complaining Behavior,* vol. 17, p. 1. Retrieved: Mar 2005, from Compendex.

Grunwald, N & Schott, D 2004, 'Gottlob Frege Centre for Engineering Science and Design (GFC)', *Global Journal of Engineering Education,* vol. 8, no. 1, pp. 53-64. Retrieved: May 2005, from Compendex.

Haaijer, R & Rosbergen, E 2005, 'Comment on Market segmentation for customer satisfaction studies via a new latent structure multidimensional scaling model', *Applied Stochastic Models in Business and Industry,* vol. 21, no. 4-5, pp. 313-314.

Haltenhoff, CE 1986, 'Educating Professional Construction Managers', *Journal of Construction Engineering and Management,* vol. 112, no. 2, pp. 153-162. Retrieved: Feb 2005, from Compendex.

Heitmann, G 2005, 'Challenges of engineering education and curriculum development in the context of the Bologna process', *European Journal of Engineering Education,* vol. 30, no. 4, pp. 447-458. Retrieved: Dec 2005, from Compendex.

Herkert, JR 2000, 'Engineering ethics education in the USA: content, pedagogy and curriculum', *European Journal of Engineering Education,* vol. 25, no. 4, pp. 303-313. Retrieved: Dec 2005, from Compendex.

Herkert, JR 2003, 'Professional societies, microethics, and macroethics: product liability as an ethical issue in engineering design', *International Journal of Engineering Education,* vol. 19, no. 1, pp. 163-167. Retrieved: Feb 2005, from Compendex.

Higher Education and Education for All 2005, UNESCO, Paris. Retrieved: 18 Sept 2007, from http://portal.unesco.org/education/en/ev.php-URL_ID=42218&URL_DO=DO_TOPIC&URL_SECTION=201.html.

Higher education summary 2007, Australian Government: Department of Educataion Science and Training, Canberra. Retrieved: 24 Sept 2007, from http://www.dest.gov.au/sectors/higher_education/higher_education_summary.htm.

Higher education: Overview 2007, Wikipedia. Retrieved: 24 Sept 2007, from http://en.wikipedia.org/wiki/Higher_education.

Howell, SL, Saba, F, Lindsay, NK & Williams, PB 2004, 'Seven strategies for enabling faculty success in distance education', *Internet and Higher Education,* vol. 7, no. 1, pp. 33-49. Retrieved: Feb 2005, from Compendex.

Jones, B & Jones, R 2007, 'Quality engineering education for the Arab states region', in *Annual Conference and Exposition*, American Society for Engineering Education, Honolulu, HI, USA, p. 5.

Jordan, W, Elmore, B, Crittenden, K, Wesson, L & Pumphrey, N 2005, 'Assessing changes in student attitudes and knowledge in an engineering for educators class', in *Annual Conference and Exposition*, American Society for Engineering Education, Portland, OR, USA, pp. 795-809.

Kelly, WE 2008, 'Standards in civil engineering design education', *Journal of Professional Issues in Engineering Education and Practice,* vol. 134, no. 1, pp. 59-66. Retrieved: Feb 2009, from Compendex.

Kiili, K 2005, 'Digital game-based learning: Towards an experiential gaming model', *Internet and Higher Education,* vol. 8, no. 1, pp. 13-24. Retrieved: Jun 2005, from Compendex.

King, PH & Fries, R 2003, 'Designing biomedical engineering design courses', *International Journal of Engineering Education,* vol. 19, no. 2, pp. 346-353. Retrieved: Feb 2005, from Compendex.

Knight, PT & Banks, WM 2003, 'The assessment of complex learning outcomes', *Global Journal of Engineering Education,* vol. 7, no. 1, pp. 39-49. Retrieved: Jun 2005, from Compendex.

Knowledge 2008, Wikipedia. Retrieved: 8 Sept 2008, from http://en.wikipedia.org/wiki/Knowledge.

Lang, JD, Cruse, S, Mcvey, FD & Mcmasters, J 1999, 'Industry expectations of new engineers: A survey to assist curriculum designers', *Journal of Engineering Education,* vol. 88, no. 1, pp. 43-51. Retrieved: Feb 2005, from Compendex.

Learning 2008, Wikipedia. Retrieved: 8 Sept 2008, from http://en.wikipedia.org/wiki/Learning.

Lehto, S 2006, 'Transforming engineering education for meeting the requirements of the global industry - Pioneering the use of the systems approach in Europe', in *Annual Conference and Exposition*, American Society for Engineering Education, Chicago, IL, USA, p. 25.

Lemaitre, D, Le Prat, R, De Graaff, E & Bot, L 2006, 'Editorial: focusing on competence', *European Journal of Engineering Education,* vol. 31, no. 1, pp. 45-53. Retrieved: Dec 2006, from Compendex.

Li, H, Scott, D & Love, PED 1999, 'Narrowing the expectation gap of construction information technologies between academic preparation and industrial needs', *Computer Applications in Engineering Education,* vol. 7, no. 4, pp. 244-251. Retrieved: 1 July 2005, from Compendex.

Li, Q, McCoach, DB, Swaminathan, H & Tang, J 2008, 'Development of an Instrument to Measure Perspectives of Engineering Education among College Students', *Journal of Engineering Education,* vol. 97, no. 1, pp. 45-55. Retrieved: Jun 2008, from Compendex.

Liu, X & Fang, D 2002, 'Predicaments and expectations of civil engineering education in China', *European Journal of Engineering Education,* vol. 27, no. 2, p. 219. Retrieved: Feb 2005, from Compendex.

Lohmann, JR, Rollins, HA, Jr. & Hoey, JJ 2006, 'Defining, developing and assessing global competence in engineers', *European Journal of Engineering Education,* vol. 31, no. 1, pp. 119-131. Retrieved: Jul 2006, from Compendex.

Luo, Y-m, Qi, E-s & Mao, Z-f 2005, 'Development of higher education in industrial engineering', *Industrial Engineering Journal,* vol. 8, no. 4, pp. 106-109. Retrieved: Dec 2005, from Compendex.

Lwakabamba, S & Lujara, NK 2003, 'Effective engineering training: the case of Kigali Institute of Science, Technology and Management', *Global Journal of Engineering Education,* vol. 7, no. 1, pp. 71-76. Retrieved: Jul 2005, from Compendex.

Macintyre, K, Kelman, C, McLaughlin, C & Kaluzny, A 1994, *Continuous quality improvement in healthcare: Theory, Implementation and applications*, Aspen Publication, Gaithersburg, Maryland.

Markes, I 2006, 'A review of literature on employability skill needs in engineering', *European Journal of Engineering Education,* vol. 31, no. 6, pp. 637-650. Retrieved: Dec 2006, from Compendex.

Massa, NM, Masciadrelli, GJ & Mullett, GJ 2005, 'Re-engineering technician education for the new millennium', in *Annual Conference and Exposition*, American Society for Engineering Education, Portland, OR, USA, pp. 12005-12019.

Mathew, SS & Earnest, J 2004a, 'Laboratory-based innovative approaches for competence development', *Global Journal of Engineering Education,* vol. 8, no. 2, pp. 167-173. Retrieved: Aug 2005, from Compendex.

Mathew, SS & Earnest, J 2004b, 'Laboratory-based innovative approaches for competence development', *Global Journal of Engineering Education,* vol. 8, no. 2, pp. 167-73.

McAlpine, L, Gandell, T, Winer, L, Gruzleski, J, Mydlarski, L, Nicell, J & Harris, R 2005, 'A collective approach towards enhancing undergraduate engineering education', *European Journal of Engineering Education,* vol. 30, no. 3, pp. 377-384. Retrieved: Dec 2005, from Compendex.

McDermott, KJ, Nafalski, A & Gol, O 2004, 'The quality assurance of engineering programmes at the University of South Australia', *Global Journal of Engineering Education,* vol. 8, no. 2, pp. 159-165. Retrieved: Sep 2005, from Compendex.

McMasters, JH 2004, 'Influencing engineering education: one (aerospace) industry perspective', *International Journal of Engineering Education,* vol. 20, no. 3, pp. 353-371. Retrieved: 2004, from Compendex.

Mead, PF, Stephens, R, Richey, M, Bransford, JD & Weusijana, BKA 2007, 'A test of leadership: Charting engineering education for 2020 and beyond', in *Structures, Structural Dynamics and Materials Conference*, American Institute of Aeronautics and Astronautics, Waikiki, HI, USA, pp. 6406-6417.

Melkert, JA 2003, 'Sustainable development as an integral part of the design and synthesis exercise in Aerospace Engineering', *Global Journal of Engineering Education,* vol. 7, no. 2, pp. 219-225. Retrieved: Oct 2005, from Compendex.

Mgangira, MB 2003, 'Integrating the development of employability skills into a civil engineering core subject through a problem-based learning approach', *International Journal of Engineering Education,* vol. 19, no. 5, pp. 759-761. Retrieved: Mar 2005, from Compendex.

Middleton, A 2005, 'Northumbria University: impact on improving students' confidence and competence in information and IT skills', *Library and Information Research News,* vol. 29, no. 1, pp. 43-45. Retrieved: Dec 2005, from Compendex.

Miles, SW, Styers, FC & Nesbit, CM 2007, 'Setting pipeline rehabilitation priorities to achieve "best" results - A case study using condition and criticality criteria', in *International Conference on Pipeline Engineering and Construction*, American Society of Civil Engineers, Boston, MA, USA, p. 72.

Mischenko, SV, Dvoretsky, SI, Puchkov, NP & Tarov, VP 2003, 'Model of the formation of a technical university students' preparedness for innovative design activity', *Global Journal of Engineering Education,* vol. 7, no. 1, pp. 131-138. Retrieved: Nov 2005, from Compendex.

Mountain, JR & Riddick, AD 2005, 'Determining the age for engineering', in *Annual Frontiers in Education*, 35 edn, IEEE, Indianopolis, IN, USA, p. 1.

Mourtos, NJ, DeJong Okamoto, N & Rhee, J 2004, 'Open-ended problem-solving skills in thermal fluids engineering', *Global Journal of Engineering Education,* vol. 8, no. 2, pp. 189-99. Retrieved: Dec 2005, from Compendex.

Musyafa, A 2003, *Pengaruh Kompetensi Mandor terhadap Kinerja Mutu Pelaksanaan Konstruksi di Jateng-DIY (The Effects of Workers' Competencies to The Quality of The Construction Conducted in The Provinces of Central Java and Yogyakarta)*, Modeling, The University of Indonesia.

Oehlers, DJ 2006, 'Sequential assessment of engineering design projects at university level', *European Journal of Engineering Education,* vol. 31, no. 4, pp. 487-495. Retrieved: Sep 2006, from Compendex.

Paladini, EP 2006, 'A quality management approach of engineering education', *WSEAS Transactions on Advances in Engineering Education,* vol. 3, no. 8, pp. 746-751. Retrieved: Nov 2006, from Compendex.

Pavlov, VL, Boyko, N, Babich, A, Kuchaiev, O & Busygin, S 2007, 'Applying pantomime and reverse engineering techniques in software engineering education', in *Annual Frontiers in Education Conference*, 37 edn, IEEE, Milwaukee, WI, USA, p. 1.

Peide, L 2007, 'Evaluation model of customer satisfaction of B2C E_Commerce based on combination of linguistic variables and fuzzy triangular numbers', in *International Conference on Software Engineering,*

Artificial Intelligence, Networking, and Parallel/Distributed Computing, 8 edn, Institute of Electrical and Electronics Engineers Computer Society, Qingdao, China, pp. 450-454.

Performance 2008, Wiktionary, The free dictionary. Retrieved: 3 April, from http://en.wiktionary.org/wiki/performance.

Pomales-Garcia, C, Liu, Y & Soto, V 2006, 'Excellence in engineering education and educational technology: Views of undergraduate engineering students', in *Annual Conference and Exposition*, American Society for Engineering Education, Chicago, IL, USA, p. 17.

Powell, RA 2005, 'Integrating practice into engineering education', in *Annual Conference and Exposition*, American Society for Engineering Education, Portland, OR, USA, pp. 8437-8449.

Prados, JW, Peterson, GD & Lattuca, LR 2005, 'Quality assurance of engineering education through accreditation: The impact of engineering criteria 2000 and its global influence', *Journal of Engineering Education,* vol. 94, no. 1, pp. 165-183. Retrieved: Jun 2005, from Compendex.

Propositional attitude 2008, Wikipedia. Retrieved: 8 Sept 2008, from http://en.wikipedia.org/wiki/Propositional_attitude.

Ravesteijn, W, De Graaff, E & Kroesen, O 2006, 'Engineering the future: the social necessity of communicative engineers', *European Journal of Engineering Education,* vol. 31, no. 1, pp. 63-71. Retrieved: Mar 2006, from Compendex.

Reforming Higher Education 2005, UNESCO, Paris. Retrieved: 18 Sept 2007, from http://portal.unesco.org/education/en/ev.php-URL_ID=40215&URL_DO=DO_TOPIC&URL_SECTION=201.html.

Richards, LG 2006, 'Work in progress: changing engineering education: stimulating innovation and overcoming resistance', in *Frontiers in Education Annual Conference*, 36 edn, IEEE, San Diego, CA, USA, p. 2.

Richardson, JTE 2006, 'Perceptions of academic quality and approaches to studying', *European Journal of Engineering Education,* vol. 31, no. 4, pp. 421-433. Retrieved: Aug 2006, from Compendex.

Richter, D & Loendorf, W 2007, 'Faculty with industrial experience bring a real world perspective to engineering education', in *Annual Conference and Exposition*, American Society for Engineering Education, Honolulu, HI, USA, p. 10.

Riduwan 2003, *Skala Pengukuran Variabel-variabel Penelitian* Alfabeta, Bandung.

Robson, K 2005, *Marketing Co-operative Education to Increase Customer Satisfaction.* Retrieved: 13 Apr, from http://130.195.95.71:8081/www/ANZMAC1998/Cd_rom/Robson76.pdf.

Rodrigues, S, Oliveira, J & De Souza, JM 2005, 'Competence mining for team formation and virtual community recommendation', in *International Conference on Computer Supported Cooperative Work in Design*, 9 edn, Institute of Electrical and Electronics Engineers Computer Society, Coventry, United Kingdom, pp. 44-49.

Roscino, A & Pollice, A 2004, 'A statistical analysis of the customer satisfaction with car dealers', *Applied Stochastic Models in Business and Industry,* vol. 20, no. 3, pp. 281-289. Compendex.

Roscoe 1992, 'Research Method for Business', in *Sugiyono, 1999, Statistik Nonparametris*, Alfabeta, Bandung, p. 12.

Saeed, KA, Grover, V & Hwang, Y 2005, 'The relationship of e-commerce competence to customer value and firm performance: An empirical investigation', *Journal of Management Information Systems,* vol. 22, no. 1, pp. 223-256. Retrieved: Jul 2005, from Compendex.

Santoso, S 2000, *Buku Latihan SPSS Statistik Parametrik*, Elex Media Komputindo, Jakarta.

Santoso, S 2001, *Buku Latihan SPSS Statistik Non Parametrik*, Elex Media Komputindo, Jakarta.

Satisfaction 2008, Wiktionary, The free dictionary. Retrieved: 3 April, from http://en.wiktionary.org/wiki/satisfaction.

Saunders, LKL & Saunders, JG 2004, 'House of quality assessment of business skills required by manufacturing engineering graduates', *International Journal of Engineering Education,* vol. 20, no. 5, pp. 777-786. Retrieved: Apr 2005, from Compendex.

Savander-Ranne, C & Kolari, S 2003, 'Promoting the conceptual understanding of engineering students through visualisation', *Global Journal of Engineering Education,* vol. 7, no. 2, pp. 189-199. Retrieved: Mar 2005, from Compendex.

Scott, D & Gribble, S 2005, 'Reviewing and reforming a tradition engineering course', in *Global Colloqium on Engineering Education*, Australian Association for Engineering Education.

Short, TD, Garside, JA & Appleton, E 2003, 'Industry and the engineering student: a marriage made in heaven?' *Global Journal of Engineering Education,* vol. 7, no. 1, pp. 77-85. Retrieved: March 2005, from Compendex.

Simple linear regression 2008, Wikipedia. Retrieved: 10 Jan 2009, from http://en.wikipedia.org/wiki/Simple_linear_regression.

Singarimbun, M & Effendi, S 1989, *Metode Penelitian Survai*, LP3ES Jakarta.

Skill 2008, Wikipedia. Retrieved: 8 Sept 2008, from http://en.wikipedia.org/wiki/Skills.

Song, L, Singleton, ES, Hill, JR & Koh, MH 2004, 'Improving online learning: student perceptions of useful and challenging characteristics', *Internet and Higher Education,* vol. 7, no. 1, pp. 59-70. Retrieved: Apr 2005, from Compendex.

Spinks, N, Silburn, N & Birchall, DW 2007, 'Making it all work: the engineering graduate of the future, a UK perspective', in *Technology Management for the Global Future*, IEEE, Istanbul, Turkey, p. 9.

Stansfield, K 2005, 'The role of design in engineering education', *Structural Engineer,* vol. 83, no. 7, pp. 16-17. Retrieved: Dec 2005, from Compendex.

Stewart, BL 2004, 'Online learning: a strategy for social responsibility in educational access', *Internet and Higher Education,* vol. 7, no. 4, pp. 299-310. Retrieved: Oct 2005, from Compendex.

Sugiyono, D 1999, *Statistik Nonparametris*, Alfabeta, Bandung.

Sun, J & Matsui, M 2007, 'A control chart design for supplier in view of quality, due time and cost', in *International Conference on Industrial Engineering and Engineering Management*, Institute of Electrical and Electronics Engineers Computer Society, Singapore, pp. 1639-1643.

Tallent-Runnels, MK, Lan, WY, Fryer, W, Thomas, JA, Cooper, S & Wang, K 2005, 'The relationship between problems with technology and graduate students' evaluations of online teaching', *Internet and Higher Education,* vol. 8, no. 2, pp. 167-174. Retrieved: Apr 2005, from Compendex.

Tryggvason, G & Apelian, D 2006, 'Re-engineering engineering education for the challenges of the 21st century', *JOM,* vol. 58, no. 10, pp. 14-17. Retrieved: Dec 2006, from Compendex.

Turkyilmaz, A & Ozkan, C 2007, 'Development of a customer satisfaction index model: An application to the Turkish mobile phone sector', *Industrial Management and Data Systems,* vol. 107, no. 5, pp. 672-687. Retrieved: Jan 2008, from Compendex.

Tynjala, P, Salminen, RT, Sutela, T, Nuutinen, A & Pitkanen, S 2005, 'Factors related to study success in engineering education', *European Journal of Engineering Education,* vol. 30, no. 2, pp. 221-231. Retrieved: Dec 2005, from Compendex.

Udaipurwala, A & Russell, AD 2002, 'Computer-assisted construction methods knowledge management and selection', *Canadian Journal of Civil Engineering,* vol. 29, no. 3, pp. 499-516. Retrieved: Mar 2005, from Compendex.

UNESCO 2006, *Framework for Priority Action for Change and Development in Higher Education*, Paris. Retrieved: 3 August, from http://portal.unesco.org/education/en/ev.php-URL_ID=19193&URL_DO=DO_TOPIC&URL_SECTION=201.html.

Upadhyay, RK, Gaur, SK, Agrawal, VP & Arora, KC 2007, 'ISM-CMAP-combine (ICMC) for hierarchical knowledge scenario in quality engineering education', *European Journal of Engineering Education,* vol. 32, no. 1, pp. 21-33. Retrieved: Dec 2007, from Compendex.

Wall, PS & Sarver, L 2003, 'Disabled student access in an era of technology', *Internet and Higher Education,* vol. 6, no. 3, pp. 277-284. Retrieved: Apr 2005, from Compendex.

Wani, VP, Garg, TK & Sharma, SK 2003, 'The role of technical institutions in developing a techno-entrepreneurial workforce for sustainable development of SMEs in India', *International Journal of Management and Enterprise Development,* vol. 1, no. 1, pp. 71-88. Retrieved: Aug 2005, from Compendex.

Warnecke, G, Ostermayer, D & Koklu, K 2004, 'Education of engineers by learning in networks', *International Journal of Engineering Education,* vol. 20, no. 4, pp. 521-525. Retrieved: May 2005, from Compendex.

What is Civil Engineering? 2007, Institution of Civil Engineers. Retrieved: 25 Sept 2007, from http://www.ice.org.uk/about_ice/aboutice_wice.asp.

Whitman, L, Malzahn, D, Madhavan, V, Weheba, G & Krishnan, K 2004, 'Virtual reality case study throughout the curriculum to address competency gaps', *International Journal of Engineering Education,* vol. 20, no. 5, pp. 690-702. Retrieved: Jun 2005, from Compendex.

Winkelman, P 2006, 'Frankenstein goes to engineering school', *European Journal of Engineering Education,* vol. 31, no. 4, pp. 449-457. Retrieved: Aug 2006, from Compendex.

Wright, C & O'Neill, M 2002, 'Service Quality Evaluation in the Higher Education Sector: An Empirical Investigation of Students' Perceptions', *Higher Education Research and Development,* vol. 21, no. 1, pp. 23-39. Retrieved: March 2005, from Compendex.

Wu, J & DeSarbo, WS 2005, 'Rejoinder for Market segmentation for customer satisfaction studies via a new latent structure multidimensional scaling model', *Applied Stochastic Models in Business and Industry,* vol. 21, no. 4-5, pp. 317-318. Retrieved: Mar 2007, from Compendex.

Xu, X & Duhovic, M 2004, 'Computer-aided concurrent environment for manufacturing education', *International Journal of Engineering Education,* vol. 20, no. 4, pp. 543-551. Retrieved: Mar 2005, from Compendex.

Yang, J-B & Peng, S-C 2008, 'Development of a customer satisfaction evaluation model for construction project management', *Building and Environment,* vol. 43, no. 4, pp. 458-468. Retrieved: Mar 2007, from Compendex.

Yeo, S 2006, *Outcomes-focused education at Curtin: Interpreting Curtin's Graduate Attributes*, Curtin University of Technology, Perth. Retrieved: Jun 2006, from http://lsn.curtin.edu.au/outcomes/docs/handoutofe2.doc.

Yeung, AT 2006, 'Reappraisal of university-level engineering education', *Journal of Professional Issues in Engineering Education and Practice,* vol. 132, no. 2, pp. 103-111. Retrieved: Jul 2006, from Compendex.

Zualkernan, IA & Sakka, ZI 2005, 'Digital storytelling in higher education: A case study in a civil engineering laboratory', in *International Conference on Advanced Learning Technologies*, 5 edn, Institute of Electrical and Electronics Engineers Computer Society, Kaohsiung, Taiwan, pp. 365-367.