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PREPAREDNESS FOR WORK IN INDUSTRIES OF GRADUATING ENGINEERING STUDENTS IN A STATE UNIVERSITY IN THE PHILIPPINES: IMPACT TO ENGINEERING CURRICULUM DESIGN

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ABSTRACT

The study focused on the assessment of students and industry personnel of graduating engineering students' preparedness for work in industry. It involved the collection of primary data from fifth year electrical engineering undergraduate of the NEUST. A questionnaire was used as data gathering instrument administered to 78 NEUST electrical engineering students who were undergoing OJT course in different industries and thirty one (31) industry personnel. Results showed that graduating electrical engineering students are technically and non-technically competent which means that the skills/competencies needed by a graduating electrical engineer for work in industry were developed but were moderately mastered within the present curriculum. The same study confirmed the importance of technical skills as basis for engineering practice, communication skills, ability to work with teams, awareness of ethical practice and lifelong learning skills in the workplace. And emphasized the complex interactions between the technical and non-technical areas of competencies. Also, there found no significant difference between assessments made by the two sets of respondents.

Keywords: ***Curriculum design, Engineering graduates, Engineering Curriculum, Industries, State Universities.***

INTRODUCTION

Engineering education and the profession in the Philippines are confronting a challenging crossroads with the implementation of the ASEAN integration in 2015. Some see it as a crisis, others as an opportunity to position the Philippine economy and society for the 21st century. For the integration, an ASEAN Economic Community Blueprint and its strategic schedule were adopted. An important goal of the blueprint is to establish the ASEAN as

a single market and production base by 2015 through the free flow of goods, free flow of services, free flow of investment, free flow of capital and the free flow of skilled labor.

The ASEAN integration will result to talent mobility within the region thus it will be easier for Filipino engineers to seek employment. However, Filipino engineers will be benchmarked against the best in the region. It is therefore incumbent upon the educators and trainers to keep the engineers produced by higher education institutions in the Philippines equipped with competencies needed by employers in the workplace.

For an engineering graduate, integrating certain aspects of an educational system with that of other countries may prove to be a curse or a blessing. If an engineering graduate has a good scholastic preparation, he/she will find it easy to take advantage of the various employment opportunities found in ASEAN countries. But if an engineering graduate's educational background was mediocre and lacking in knowledge and skills, as the case of majority of engineering graduates, then it will be a source of a lot of problems.

To be able to cope up with the international standards of foreign universities and colleges, higher education in the Philippines are seeking new ways of designing education to improve the existing educational system of the country to produce workforce ready graduates as well as to prepare students in facing the challenges of the 21st century. Implementation of Outcomes-Based Education (OBE) is the main concern of most higher education institutions in the Philippines today.[4][2] In the Philippines during 2007 and 2008, the Commission on Higher Education (CHED), through the efforts and recommendation of the Technical Panel for Engineering and Technology (TPET), has released a series of memoranda for compliance by all engineering schools offering baccalaureate engineering programs. The CHED Memorandum Order (CMO) [3] mandated engineering schools to follow a new set of policies, standards and guidelines for all baccalaureate engineering programs that defined the needed competencies for the practice of each engineering field, and a set of program outcomes that engineering students in the different fields are expected to possess by the time they graduate. The CMO discussed the mandate to Higher Education Institutions (HEIs) providing engineering educations to adopt the OBE systems by the end of AY 2016 – 2017.

Outcome-Based Education (OBE) is a new paradigm in engineering education that is being pursued in the United States and other countries, including the Philippines. OBE is a student-centered learning philosophy that focuses on empirically measuring student performance called "outcomes". [10]. Motivations for implementing OBE can be "to improve learning or "to meet accreditation needs". [1] [10] The OBE Framework is not an end

but a process of continuously improving education through a continuous accreditation. The outcomes are first defined and then the design of the curriculum including the teaching and learning activities and assessment tasks follows. In defining the outcomes, a hierarchy was followed, with the university vision-mission at the top. The expected graduate attributes (EGA) which are characteristics or qualities of students of a university upon graduation were identified based on the university vision-mission.

For the College of Engineering at the Nueva Ecija University of Science and Technology (NEUST), the move towards OBE as mandated by CHED will be fully implemented by the end of AY 2016-2017. The NEUST implementation of OBE is not only triggered by the CMO released by CHED but also triggered by several factors, namely (1) some prescribed graduate competencies by international professional associations such as Accreditation Board for Engineering and Technology, Inc. (ABET). (2) the direction toward outcomes-based accreditation by the local accrediting agency, the Accrediting Agency of Chartered Colleges and Universities in the Philippines (AACCUP) and (4) the CHED's Institutional Quality Assurance Monitoring and Evaluation (IQUAME).

Before the full implementation of the OBE, the Electrical Engineering department of the NEUST has already begun a process of curricular review, curriculum revision and curricular accreditation in order for the graduates to be more responsive and globally competent. As a result of the continuing improvement for accreditation, the Bachelor of Science in Electrical Engineering program has achieved the status of being Level III accredited and is now readying for Level IV accreditation. Over the past decade, the traditional model of a university education, that focused on the acquisition of discipline specific knowledge and skills have been called into question, in terms of both university and feedback from employers .[12] Employers from the business and industry sector demand that higher educational institutions generate prepared and workplace ready graduates. The institutions of higher education therefore have the role of producing workplace ready engineering graduates. The purpose of this research is to determine the students' and industry personnel's assessments of their preparedness for work in industry. The goal was to identify the gaps in the engineering curriculum based on their assessments and thus ensuring the graduation of well-rounded engineers prepared for the 21st century workforce. The result of this research will provide the faculty an understanding of students' and industry personnel's assessment of how graduate attributes are manifested in the Electrical Engineering program. It will be used to provide feedback at instructor, program and faculty levels as the NEUST Department of Electrical Engineering furthers its efforts towards the full implementation of the OBE curriculum for continuous cycle of improvement.

To determine work preparedness in industry of graduating engineering students as assessed by the students themselves and industry personnel, competencies that are likely to be important to engineers and employers were identified from the key competencies from criteria stated by the Philippine Technological Council (PTC) in the accreditation of engineering programs submitted by HEIs. These criteria are in the form of student outcomes that specify what students are expected to know and be able to do by the time of graduation. These relate to the skills, knowledge, and behaviors that students acquire as they progress through the program. Students', as well as industry personnel's assessments of their competency levels based on the student outcomes can help formulate the courses the program must have and the learning outcome for each course.

Since the NEUST Electrical Engineering department will fully implement OBE, it is very important to determine the graduating engineering students' preparedness for work in industry as assessed by the students themselves and industry personnel. The assessment can guide the university in formulating plans to find solutions on the identified concerns or problems and guide the students to cope up with the new educational approach. The students' and the industry personnel's assessment of how the present engineering program prepares graduating students for work in industry would lead to more effective implementation of OBE in the NEUST.

OBJECTIVES OF THE STUDY

This research was conducted in order to determine the assessment of students and industry personnel of graduating engineering students' preparedness for work in industry. The main objectives in this research are stated as follows:

1. Determine the preparedness for work in industry of graduating engineering students in terms of technical areas of competencies based on the assessment of:
   1.1 Students, and
   1.2 Industry personnel.
2. Determine the preparedness for work in industry of graduating engineering students in terms of non-technical areas of competencies based on the assessment of:
   2.1 Students, and
   2.2 Industry personnel.
3. Determine the difference between the students' and industry personnel's assessment of graduating engineering students' preparedness for work in industry in terms of:

3.1 Technical areas of competencies, and

3.2 Non-technical areas of competencies.

4. Determine the implications of the assessment of students and industry personnel on engineering graduates preparation for work in industry to the proposed implementation of OBE in educating future engineers.

METHODOLOGY

This research was conducted based on the premise that the quality and nature of an engineer's education greatly impacts his effectiveness in the profession. If engineering graduates are not prepared for the challenges that they will encounter as a professional, they will require training by industry. This is often a costly and time-consuming process.

The research was a descriptive survey seeking to determine graduating engineering students' preparedness for work in industry based on the assessment of students and industry personnel. As identified by several researchers (Evans, et.al., 1993; Keenan, 1993), the desirable attributes of an engineering graduate is categorized into two distinct areas, the technical and non-technical areas of competencies. The researcher has described the engineering graduates' preparedness for work in industry in terms of these areas. The student outcomes set forth by the PTC were grouped by the researcher into technical and non-technical areas of competencies. The student outcomes that are categorized into technical competencies include aspects related to the ability to apply knowledge of mathematics and science to solve engineering problem as **analytical knowledge**; aspects related to the ability to design and conduct experiments, as well as to analyze and interpret data as **research skills**; aspects related to the ability to design a system, component, or process to meet the desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability, in accordance to standards as **design skills**; aspects related to the ability to identify, formulate, and solve engineering problems as **problem solving skills**; aspects related to the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context as **transferable knowledge**; aspects related to the knowledge of contemporary issues as **keeping up to date**; aspects related to the ability to use techniques, skills, and modern engineering tools necessary for engineering practice as **technical skills** and aspects related to the knowledge and understanding of engineering and management principles as a member and leader in a team, to manage projects and in multidisciplinary environments as **business and management skills**. The non-technical competencies include aspects related to ability to function

on multidisciplinary teams as **ability to work in teams;** aspects related to the understanding of professional and ethical responsibility as **professional and ethical practice**; aspects related to the ability to communicate effectively as **communication skills**, and finally aspects related to recognition of the need for, and an ability to engage in life-long learning as **life-long learning skills**.

This study involved the collection of primary data from final year electrical engineering undergraduate of the NEUST. The questionnaire was administered in the month of May 2015 to electrical engineering students who were enrolled in the On-the Job Training (OJT) course as part of the requirement for their graduation. The seventy eight (78) electrical engineering students at the NEUST who are undergoing OJT course in different industries and thirty one (31) industry personnel participated in the research. All of these students were eligible for graduation in the Second Semester of Academic Year 2015-2016. Graduating electrical engineering students who are enrolled in the OJT course as part of the requirement for graduation were included as respondents because of the similarities between new engineers and their working environments as on the job trainees. The students' immediate supervisors on their OJT assignments were the industry personnel respondents. The questionnaire was personally administered by the researcher on the month of May, 2015 when the graduating students will finish their OJT course. A 100% retrieval rating was achieved from the 78 students and 31 industry personnel. .The assessment of the students and industry personnel on graduating engineering students' preparedness for work were quantified using the five point Likertscale where 5 means very highly prepared, 4 means highly prepared, 3 means prepared, 2 means moderately prepared, and 1 means not prepared.

The computed weighted means were given verbal interpretation as follows:

Computed Weighted Means	Verbal Interpretation
4.20 – 5.00	Very Highly Prepared
3.40 – 4.19	Highly Prepared
2.60 – 3.39	Prepared
1.80 – 2.59	Moderately Prepared
1.00 – 1.79	Not Prepared

To qualify the obtained ratings and equivalent verbal meanings, the matrix below guided the researcher. The five scales utilized were given corresponding description as follows:

Scale	Descriptions
Very Highly Prepared	The competencies are highly developed and highly mastered within the curriculum.
Highly Prepared	The competencies were developed and mastered within the curriculum.
Prepared	The competencies were developed and moderately mastered within the curriculum.
Moderately Prepared	The competencies were moderately developed but were not mastered within the curriculum.
Not Prepared	The competencies were not developed and not mastered within the curriculum.

The significant difference of the assessment of students and industry personnel on graduating students' preparedness for work in industry was determined using z test of two sample means with level of significance $\alpha = 0.01$ for two tailed test..

RESULTS AND DISCUSSION

1. Students' and industry personnel's assessment of the graduating electrical engineering students' preparedness for work in industry in terms of technical areas of competencies.

Table 1 shows students' assessment of graduating electrical engineering students' preparedness for work in industry in terms of technical areas of competencies.

Table 1: Students' Assessment of Graduating Engineering Students' Work Preparedness in terms of Technical Areas of Competencies

Technical Competencies	Mean Score	Verbal Interpretation
1. Analytical knowledge	3.38	Prepared
2. Research skills	3.27	Prepared
3. Design skills	3.27	Prepared
4. Problem solving skills	3.09	Prepared
5. Transferable knowledge	3.23	Prepared
6. Keeping up to date	3.39	Prepared
7. Technical skills	3.24	Prepared
8. Business and management skills	3.40	Prepared
Average Weighted Mean	**3.28**	**Prepared**

The summary of the industry personnel's assessment of graduating engineering students' preparedness is shown in Table2.

Table 2: Industry Personnel's Assessment of Graduating Students' Preparedness For Work In Industry In Terms of Technical Areas of Competencies

Technical Competencies	Mean Score	Verbal Interpretation
1. Analytical knowledge	3.15	Prepared
2. Research skills	3.06	Prepared
3. Design skills	3.03	Prepared

4. Problem solving skills	3.39	Prepared
5. Transferable knowledge	3.13	Prepared
6. Keeping up to date	2.97	Prepared
7. Technical skills	2.9	Prepared
8. Business and management skills	3.13	Prepared
Average Weighted Mean	**3.09**	**Prepared**

The over-all mean of both students' (3.28) and industry personnel's (3.09) assessments indicated that graduating electrical engineering students are prepared for work in industry in terms of technical areas of competencies. The competencies were developed but were moderately mastered within the present curriculum. The technical competencies include the "hard skills" of engineering. These include the mathematical and scientific tools used to solve engineering problems. If the student acquires competency in this aspect, it will enable the student to recognize and formulate a problem and its solution. Furthermore, preparedness in this area will enable the student to solve problems theoretically and apply theory when solving problems whether situational or written problem solving. The technical areas of competencies were developed within the curriculum because the present curriculum of the Bachelor of Science in Electrical Engineering (BSEE) program passed the minimum requirements set forth by the Commission of Higher Education (CHED). The development of the skills and competencies can be attributed to the students' experiences of completing the courses in engineering programs. However these skills/competencies were moderately mastered within the present engineering curriculum. This can be attributed to the students' limited exposure to manufacturing or industrial plants. The theories that they learned in their classes were not applied to real-life situations.

2. Students' and industry personnel's assessment of graduating engineering students' preparedness for work in industry in terms of non-technical areas of competencies.

Table 3 summarizes the students' assessment of graduating electrical engineering students' preparedness for work in industry in terms of non-technical areas of competencies.

Table 3: Students' Assessment of Graduating Students' Preparedness For Work In Industry In Terms of Non-Technical Areas of Competencies

Non-Technical Competencies	Mean Score	Verbal Interpretation
1. Ability to work in teams	3.38	Prepared
2. Professional and ethical practice	3.23	Prepared
3. Communication skills	2.55	Moderately Prepared
4. Life-long learning skills	3.28	Prepared
Averaged Weighted mean	**3.11**	**Prepared**

Table 4 summarizes the industry personnel's assessment of graduating electrical engineering students' preparedness for work in industry in terms of non-technical areas of competencies.

Table 4: Industry Personnel's Assessment of Graduating Students' Preparedness For Work In Industry In Terms of Non-Technical Areas of Competencies

Non-Technical Competencies	Mean Score	Verbal Interpretation
1. Ability to work in teams	3.1	Prepared
2. Professional and ethical practice	2.88	Prepared
3. Communication skills	2.45	Moderately Prepared
4. Life-long learning skills	3.32	Prepared
Averaged Weighted mean	**2.94**	**Prepared**

The over-all mean of both students' (3.11) and industry personnel's (2.94) assessments with regards to the non-technical areas of competencies indicate that graduating electrical engineering students are prepared for work in industry. This means that the skills/competencies were developed but were not mastered within the present curriculum. The non-technical areas of competencies are considered as the "soft skills" in engineering. Although the non-technical areas of competencies could be considered as related at least partly to a student's personality, the OBE curriculum specifically mandates the development of these competencies and thus obliging the tertiary education institutions to assume the responsibility of adequately developing the students' non-technical skills for use in the workplace. Furthermore, these competencies are explicitly required by agencies accrediting engineering degrees. These non-technical competencies were not mastered by the graduating engineering students because like the case in the technical areas of competencies they were not exposed to manufacturing or industry settings where they can apply these competencies.

One interesting result of the survey is that of the graduating electrical engineering students' preparedness in terms of communication skills. Both the students (2.55) and industry personnel (2.45) assessment indicate that graduating electrical engineering students are moderately prepared in terms of this non-technical area of competency. This means that communication skills were moderately developed and were not mastered within the present engineering curriculum. This finding is similar to those previous industrial recruitment surveys conducted by various researchers (e.g., Lang et. al., 1999); Meier et.al., 2000; Scott and Yates, 2002), indicating that engineering graduates lacked communication skills. The result of this present study affirms the inadequacy of the communication training imbedded within the present curriculum.

3. Difference between the students' and industry personnel's assessment of graduating engineering students ' preparedness for work in industry.

The computed z values at 0.01 level of significance as shown in Table 5 indicate that there is no significant difference between the students' and industry personnel's assessment of graduating electrical engineering students' preparedness for work in industry except in the aspect related to keeping up to date (z=2.810) or students' knowledge of contemporary issues.

Table 5: Difference Between Students' and Industry Personnel's Assessment of Graduating Students' Preparedness for Work in Industry In Terms of Technical Areas of Competencies

Competencies	z- value	Remarks
1. Analytical knowledge	1.914	Not Significant
2. Research skills	1.552	Not Significant
3. Design skills	1.593	Not Significant
4. Problem solving skills	-1.920	Not Significant
5. Transferable knowledge	0.783	Not Significant
6. Keeping up to date	2.810	*Significant
7. Technical skills	2.031	Not Significant
8. Business and management skills	2.031	Not Significant

*Difference is significant at 0.01 level (2-tailed)

With regards to the non-technical areas of competencies shown in Table 6, the computed z values at 0.01 level of significance of each area indicate that there is no significant difference in the assessment of students and industry personnel except in the aspect related to professional and ethical practice (z=-3.27). This is a competency that can be better measured once the students are already graduates and are practicing their profession. The difference in assessment showed that there is difference between what the students learned with regards to ethics instruction and what ethics is when one is already practicing the profession.

Table 6: Difference Between Students' and Industry Personnel's Assessment of Graduating Students' Preparedness for Work in Industry In Terms of Non-Technical Areas of Competencies

Non-Technical Competencies	z- value	Remarks
1. Ability to work in teams	2.03	Not Significant
2. Professional and ethical practice	3.178	*Significant
3. Communication skills	0.643	Not Significant
4. Life-long learning skills	-0.398	Not Significant

*Difference is significant at 0.01 level (2-tailed)

4. Implications of the assessment of students and industry personnel on graduating engineering students' preparedness for work in industry to the proposed implementation of the OBE curriculum in educating future electrical engineers.

The present curriculum of the electrical engineering degree program as implemented by professors prepares the students for stressful projects and deadlines they will experience once they practice their profession. However, although both the technical and non-technical areas of competencies were developed or moderately developed, these competencies were not mastered within the curriculum. The new curriculum design must incorporate new teaching methods and strategies which are grounded on experimental and context oriented framework such as teamwork, case study and individual problem solving, project based learning and other modern tools and equipments to achieve mastery of both the technical and non-technical areas of competencies. The new curriculum design should be able to address the non-mastery issue involving these competencies.

An increased emphasis on the development and mastery of communication skills can improve the university's electrical engineering program. This can be achieved through integration of communication skills across different electrical engineering core courses.

Cooperative education programs and on the job trainings are invaluable experiences for the preparation of students. The efficiency of the transition from an electrical engineering student to an electrical engineer depends on the competencies that the students acquire on graduation day. The OJT provided by industries to engineering

students are difficult to replicate in a college education. Industry experience helps to eliminate the gaps between students' assessment of graduating engineering students' preparedness for work in industry and the assessment of industry personnel. This better prepares students to enter the workforce and decreases the adjustments and trainings that both the employee and their company will have to endure. In the proposed OBE curriculum, the orientation of the engineering program will be shifted from the conventional practice towards OBE which defines qualifications in terms of a set of expected learning outcomes, or desirable graduate attributes. This has presented higher education institutions with significant new challenges. The main requirements for any outcomes-based qualification are a clear understanding of the goals and objectives of the program, and teaching strategies that are able to support the development of the required competencies, coupled with assessment procedures capable of reliably monitoring whether the established targets are being met, or not.

CONCLUSIONS

Based on the results of the study, the following conclusions were derived:

1. Graduating electrical engineering students at the NEUST are prepared to face the challenges of work in industry with respect to both the technical and non-technical areas of competencies based on the assessment of both students and the industry personnel. This indicates that the skills/competencies needed by a graduating electrical engineer for work in industry were developed but were moderately mastered within the present curriculum. This study confirms the importance of technical skills as basis for engineering practice, as well as the need for communication skills, the ability to work with teams, awareness of ethical practice and lifelong learning skills in the workplace. The study also emphasized the complex interactions between the technical and non-technical areas of competencies, specifically that the non-technical skills area built on a technical basis, and a lack of confidence in the technical arena would hamper the development and mastery of skills and competencies in the other areas.

2. There is no significant difference between the students' and industry personnel's assessment on the preparedness of graduating electrical engineering students for work in industry with respect to the technical areas of competencies (e.g. analytical knowledge, research skills, design skills, problem solving skills, transferable knowledge, technical skills and business and management skills). Keeping up to date is a technical area of competency where the assessment of students and industrial personnel significantly differs. There is no significant difference on the assessment of students and industry personnel with

regards to the non-technical areas of competencies while significant difference was found on the professional and ethical practice. The differences or similarities of perceptions of students and industry personnel on the preparedness of electrical engineering graduates for work in industry is not the problem itself, but rather the presence or absence of clearly defined expectations or learning outcomes for each courses taken up by students in the electrical engineering program.

3. This study has highlighted the importance of the technical and non- technical aspects of the engineering curriculum. The implications for curriculum development are that the non-technical skills cannot be taught in isolation from the technical context in which they will be used, and that integrated projects are a crucial tool for achieving such ends. The implementation of the OBE curriculum may help eliminate the competency gaps or the difference between the levels of performance expected from a graduate engineer by their employers and what the engineer actually delivers.

RECOMMENDATIONS

In the light of the findings of the study, the researcher recommends the following:

1. The findings of the study can be used to design studies in this area, and could be used to develop better questionnaires. This is because the discovery of clear links between technical and non-technical competencies could be used to ask questions that will generate more detailed and accuratel results. However, a quantitative study performed using questionnaires will be limited by the need for fixed questions and a small range of predetermined answer categories into which all responses must fit.

2. The findings of the study provided considerable insight about students and their educational experience. If the academe fails to prepare students for their careers as much as possible, industry pays the price. Industry must make a substantial investment to train young engineers in skills that they may easily have learned in college. Collaboration of the academe and industry may be established to provide the engineering students with the needed exposure to industrial settings to make them prepared for work.

3. Although this study focused specifically on NEUST electrical engineering graduates, the global nature of the engineering profession and close alignment of the engineering degree in NEUST with engineering degrees in other parts of the world (as recognized in the Washington Accord), suggest that the findings of this study could well be applicable to other contexts. Thus, research along this line should also be undertaken by other researchers.

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