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OUTCOMES OF MECHANICAL ENGINEERING EDUCATION IN SPECIALIZED PROJECTS WITH RESPECT TO ENTRY LEVEL PRACTICE

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Abstract: The study measured the extent of importance, desired and existing level of competences of seven proposed outcome statements related to specialized project works in Bachelor's Degree in Mechanical Engineering. A structured questionnaire was distributed to three groups of respondents namely employers, graduates, and teachers associated to mechanical engineering. Collected data were analyzed with the help of SPSS technology. The findings showed that all seven outcome statements were very important in the profession indicating the need of the fulfilment of higher level of competencies in these areas by engineering education. On the opposite the study showed significant differences between the mean values of desired and existing level of competences indicating the desire of additional efforts to improve the quality of engineering education.

1. INTRODUCTION

One of the most important areas of mechanical engineering profession is design and implementation of specific projects to solve specific problems in the society [2]. The specific projects which demand highly specialized knowledge and technical skills may be called as specialized project works. Along with general knowledge and skills in overall subjects, mechanical engineers must be able to carry out a limited number of specialized projects based on their own interest and the demand in the profession. Considering the specific problems, the specialist engineers need to conceive the machines, production system or approaches as required. Most of the devices used by consumers and industry are designed and manufactured by specialist mechanical engineers. For example, household appliances, computer hardware, automobiles, plant equipment, spacecraft, airplanes – anything that uses mechanical motion – are all designed by mechanical engineers. These tasks are often performed in close cooperation with other types of engineers and specialists. One of the areas of increased interest in design is medical bio- technology. Mechanical engineers are the motion specialist in this design team which includes doctors and biologists. The design, fabrication and installation of artificial body parts- particularly artificial limbs – demand the knowledge of how things move, how they can be designed to withstand stress, and what materials will provide adequate strength and still be compatible with the human body [1, 2].

Energy sector is one of the important factors in human civilization. Therefore specialized project works in energy engineering may be one of the important areas to be addressed by mechanical engineering education. Mechanical engineers are concerned about the mechanics of energy – how it is generated, stored and moved. In different countries, many mechanical engineers are employed in industries related to electrical power, natural gas and oil. They also develop solar energy, wind energy, and geothermal systems to supplement and eventually replace conventional fuels. In addition to

this, they are concerned with energy use, developing more fuel efficient cars, motors and appliances. Some of the mechanical engineers focus on the effects of heat energy on systems and machines [1, 2, 3].

In general, the entry level engineers are engaged in design and implementation of any specialized projects under senior and experienced mechanical engineers. One of the common sectors of involvement of mechanical engineers in underdeveloped and developing countries are thermo-mechanical projects, electro-mechanical projects, rural technology, and energy engineering projects. In addition to this, the mechanical engineers in developed countries are involved in various projects associated to advanced manufacturing technologies. [3, 4, 5].

With respect to changing context, different countries are preparing mechanical engineers with specialized knowledge and expertise in specific technical projects based on their specific needs. The engineers need to be able to assess the business environment for specific projects. Based on the needs of the society they need to design, develop, and implement specific projects. In addition to this the engineers should be able to evaluate the impact of the project in the society.

In the context of Nepal, it is less obvious regarding the outcomes of mechanical engineering education in relation to specialized projects. It is not clear for the educators and faculty members regarding important outcomes related to specialized projects, desired level of competences to carry out intended projects, and existing level of competences of the graduates in related project areas. The stakeholders want to understand the performance of engineering education system with respect to essential outcomes in specialized projects. Specifically, the engineering educators want to understand how well they are doing in satisfying competency needs for the employers. Therefore the study was focused on the identification of essential outcomes and effectiveness of mechanical engineering education to satisfy competence needs in specialized projects related to mechanical engineering profession.

Purpose of the Study

The purpose of the study was to understand the essential outcomes of mechanical engineering education in specialized projects for entry level practice and determine Competence Effectiveness Index (CEI) of the education system.

Statement of the Problem

The problem of this study was to assess the level of the importance of the proposed outcomes, desired level of competences to achieve proposed outcomes, existing level of competences exhibited by the graduates on proposed outcomes, and competence effectiveness index (CEI) of the engineering education system with respect to specialized knowledge and skills in specific areas of engineering practices. In addition to this, the study determined if a difference exists between the perspectives of different group of respondents.

2. RESEARCH QUESTIONS

- What is the level of importance, desired level of competences, existing level of competences, and competence effectiveness index on proposed outcomes in 'Specialized Projects' for entry-level mechanical engineering practice in view of employers, graduates, and teachers?
- Is there a significant difference between the perspectives of employers, graduates, and teachers related to the level of importance, desired level of competences, and existing level of competences?

Significance of the Study

As engineering educators and planners explore quality initiatives in specialized project works, they will need to identify the experience and perspectives of employers, graduates and teachers. Findings from this study could provide valuable insights into these perceptions. From a practical view point, information obtained in this study may be useful to ptoject design educators, consultants, human resource development officers interested in implementing outcomes assessment program in engineering education. More specifically it may create more dynamic and challenging environment for faculty members who are engaged in designing and implementing specialized project works in mechanical engineering. On the one hand they may understand their existing progress and on the other hand it may encourage them to be more responsible through a systematic involvement in teaching-learning processes.

Various literatures have indicated that the responsibility of the faculties is not just limited to teaching, but it should include a continuous cycle of curriculum revision, development of instructional materials based on new contents, implement the new courses, and evaluate the outcomes as required [6]. Ultimately, the quality of operational system should be of high priority for desired outcomes of engineering education. Therefore the findings of the study may contribute in increasing the responsibilities of faculty members. Asa result, employers would be benefited from higher quality engineers and future engineering students would be benefitted from improved quality of teaching and learning in specialized project works in mechanical engineering course.

3. DEFINITION OF TERMS

Outcomes. Outcomes are what engineering graduates are expected to know and are able to do by the time of graduation [7]. Differently, outcomes are intended results of education system in terms of the required body of knowledge which includes knowledge, skills, attitudes, and modified behaviors. The guiding principles of outcomes are professional and industry associations' practice standards.

Entry level practice. The practice is the application of the knowledge, skills, and attitudes in engineering profession that are based on professional and industry associations' practice standard and ethical guidelines. Entry level practice standards are related to fresh engineering graduates.

Level of importance (LI). It is the extent of importance of specific outcome in the profession with respect to its extent of contribution in the success of professional practice.

Desired level of competence (DLC). It is defined as the ideal level of ability (desired standard) of the graduate which is required to apply knowledge and skills to the job in order to achieve the required outcomes in the workplace. Competency standards define the outcome required. The hierarchy of competency is based on Bloom's Taxonomies of educational objectives. Differently, the competences are assumed as indicators of the outcomes statements for the purpose of this study.

Existing level of competence (ELC). It is defined as the actual level of ability exhibited by the graduate in professional practice with respect to particular outcome.

***Competence Effectiveness Index (CEI*).** It is the calculated ratio obtained when the value of existing level of competence is divided by the value of desired level of competence. The value of CEI less than 1 indicates poor

quality, greater than 1 indicates improving quality, and 1 indicates barely capable system.

Employers. For the purpose of this study, the employers are defined as the representatives of public and private organizations where mechanical engineers graduated from Nepalese universities are employed.

Graduates. Those engineers having Bachelor's Degree in Mechanical Engineering from Nepalese Universities.

Teachers/Educators. For the purpose of this research, engineering teachers or academics or educators are those individuals directly involved in teaching, training and educational management in mechanical engineering course.

Quality of graduate or quality of engineering education. Quality is the totality of features and characteristics of a product or service that bear on its ability to satisfy stated needs [8]. Crosby defined quality as 'conformance to requirements'. For the purpose of this study, quality of the graduate is defined as the extent of competences of the graduates against desired standard. Quality of engineering education is defined as the capacity to produce engineers with desired competences.

4. RESEARCH METHODOLOGY

Survey research methodology selected for this study was descriptive in nature which is one of the methods widely used in the study of social sciences and to investigate educational issues [9.10]. Descriptive research finds out and reports the way things are and replies questions concerning the present status of the area of study. The survey research method has remarkable credibility and widespread acceptance. As indicated by Borg & Gall, the questionnaires are commonly used to determine the experience, attitudes, and perspectives of the major stakeholders related to the study. In survey research strategy and descriptive studies like this the contribution of major stakeholder groups in primary data collection is most important [11]. Bragg, further indicated, knowing how educators/teachers, students, and employers conceptualize outcomes in education could provide several benefits to practitioners and policy makers engaged in the development of engineering education.

The study implemented a structured questionnaire set to collect primary data which included seven specific outcome statements. The questionnaire was pilot tested to increase its reliability before going to actual implementation. Finally approved questionnaire was distributed to 254 respondents among that 191 respondents (53 employers, 105 mechanical engineering graduates, and 33 mechanical engineering teachers) provided accurate information thus maintaining around 75 percent rate of return.

Seven outcome statements were examined to determine the level of importance (LI), desired level of competency (DLC), existing level of competency (ELC) and competence effectiveness index (CEI). The respondents were asked to rate the extent of LI, DLC, and ELC on proposed outcomes using a 1 to 5 scale where 1 meant "not important" and "poor competence" to 5 meant "extremely important" and "excellent competence". Similarly 2 meant "some what important" and "fair competence", 3 meant "important" and "good competence", and 4 meant "very important" and "very good competence". To arrive at the final results, the collected data were entered to a personal computer. SPSS program was implemented for statistical procedures. An alpha level of 0.50 was used for all statistical tests. The significant differences were examined with ANOVA supported by Scheffe's Range Tests.

5. FINDINGS OF THE STUDY

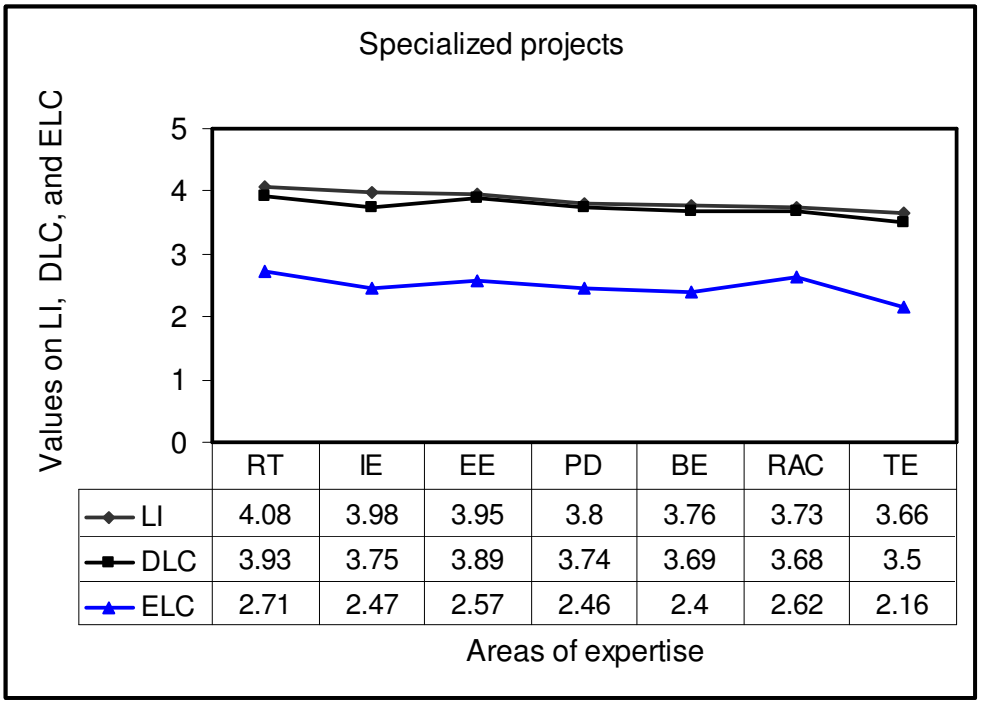
Figure 1 demonstrates the mean values of ratings provided by the respondents. The first, second, and third lines from the top of the figure illustrate the LI, DLC, and ELC respectively with respect to outcome statements examined by the study. The specific outcomes examined and identified from higher to lower order of importance were related to rural technology, impact evaluation, energy engineering, project design, business environment, Refrigeration and Air Conditioning, and transportation engineering.

Level of Importance on Proposed Outcomes

The outcome related to Rural technology (M = 4.08) was extremely important for all respondents. Next to this, all remaining outcomes scored between 3.60 and 4.00, indicating the level of very important. In general, the cluster average obtained 3.85, indicating the outcomes at the level of very important. The first line at the top of the figure 1 represents individual data on the level of importance.

Desired Level of Competences to Achieve Intended Outcomes

All of the outcomes scored between 3.50 and 4.00, indicating the desire of very good competencies to achieve indented results. The cluster average of 3.74 indicated the desire of very good competency as minimum standard. Within this standard, the rural technology was placed in first priority and transportation engineering in lowest priority. The second line from the top of the figure 1 represents individual data on the desired level of competency. From the figure it is obvious that there existed very close relationship between the ratings of the level of importance and desired level of competency.



	RT	IE	EE	PD	BE	RAC	TE
LI	4.08	3.98	3.95	3.8	3.76	3.73	3.66
DLC	3.93	3.75	3.89	3.74	3.69	3.68	3.5
ELC	2.71	2.47	2.57	2.46	2.4	2.62	2.16

Figure 1: Comparative chart on specialized projects

Note: LI = Level of importance, DLC = Desired level of competence, ELC = Existing level of competence, RT = Rural technology, IE = Impact evaluation, EE = Energy engineering, PD = Project design, BE = Business environment, RAC = Refrigeration & Air Conditioning, TE = Transportation engineering

Existing Level of Competences the Graduates Exhibited

All of the outcomes achieved scores between 2.15 and 3.00, indicating that the graduates exhibited good competency level as maximum standard. Within this standard, the graduates were better in rural technology and poor in transportation engineering projects. The third line from the top of the figure 1 represents individual data on the existing level of competency. From the figure it is obvious that there existed considerable gap between desired and existing competencies. The highest gap was found in relation to transportation engineering (1.34), and lowest gap was found in Refrigeration and Air Conditioning (1.06).

Competence Effectiveness Index

The mean value of CEI obtained 0.65, indicating that the graduates achieved 65 percent against desired level of competencies. Specifically, highest achievement was in refrigeration and air conditioning (71%) and lowest achievement was in transportation engineering (61%). The last column of Table 1 demonstrates detail data of CEI with respect to specific outcome statements.

Table 1: comparison between desired and existing level of competencies

Ability to carry out specialized projects in mechanical engineering		Competence levels to be achieved in BE courses	Real achievement (existing competency)	Competence Effectiveness Index
List of specific outcomes		DLC	ELC	CEI
1	Ability to conduct rural technology projects	Very good	Good	0.68
2	Ability to evaluate the impact of specific projects	Very good	Good	0.65
3	Ability to conduct energy engineering projects	Very good	Good	0.66
4	Ability to design specific projects	Very good	Good	0.65
5	Ability to assess the business environment for specific projects	Very good	Good	0.65
6	Ability to conduct Refrigeration and Air Conditioning projects	Very good	Good	0.71
7	Ability to conduct transportation engineering projects	Very good	Good	0.61
	Overall	Very good	Good	0.65
	General interpretations	Higher level of competences desired	Lower level competences existed	Competence gap 35 percent

Note: the number 1 to 7 related to the list of specific outcomes indicates the priority order of outcomes in descending order.

Summary of the Findings in Relation to LI, DLC, ELC, and CEI

Table 1, presents summary of findings related to the level of importance, desired level of competences, existing level of competences, and competence effectiveness index with respect to outcome statements examined by the study. All outcomes were very important. In general the BE course should fulfill the desire of higher level of competencies (analysis, synthesis, and evaluation), but the present capacity of education system is limited to the development of lower level of competencies (knowledge, understanding and application abilities) in graduates with about 35 percent competence gap against desired standard. The specific outcomes related to 'Transportation engineering projects' was found with highest competence gap (39%), indicating the need of higher focus by education in these areas.

Significant Differences among the Mean Values of Employers, Graduates, and Teachers

ANOVA test was conducted to detect mean values with significant differences. But the test found no significant differences between the mean values in relation to the level of importance, desired level of competences and existing level of competences, indicating full consensus of respondents regarding the extent of ratings.

6. CONCLUSIONS AND RECOMMENDATIONS

In general, the outcomes of mechanical engineering education in specialized projects are very important in engineering profession. In the countries like Nepal, the competences of mechanical engineer in rural technology are more important as compared to the competencies in other areas. The engineering education system must be responsible to fulfil the needs of the graduates with higher level of competences (analysis, synthesis, and evaluation) in specialized projects so as to achieve intended results in the workplaces. But the present capacity of engineering education system is limited to the development of lower level of competences (knowledge, understanding, and application) in the graduates. The engineering education system is 65 percent effective in satisfying competence needs related to specialized projects.

So as to produce highly competitive mechanical engineers in this 21st Century dominated by knowledge economy, continuous improvement in engineering education is essential. In specific, it is recommended to give first priority in curricula updating related to: transportation engineering projects, followed by business environment assessment, project design, impact evaluation, and energy engineering projects. Further detail studies to develop number of specific project works in rural technologies, energy engineering, and transportation engineering projects is essential to offer better education and training in these areas which are very important to support economic development of the countries like Nepal.

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