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Training Evaluation of Engineering Students: A Case Study*

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This paper looks at an evaluation of students who are training with the cooperation of the industry. The main objective of such a 'project-cum-training' programme is an improvement in the generic attributes of engineers. The ranking of four such attributes (motivation, attitude, skills and knowledge) is initially considered, both in terms of any improvement effected through training and their ultimate importance in an engineering career. Training evaluation is then carried out by considering improvements in these attributes according to students' self-assessment and assessment by faculty and industry supervisors. Finally, correlations are made among the three groups involved in order to see where there is consensus.

INTRODUCTION

REGULAR MONITORING, evaluation and feedback-based improvement of engineering education have become a necessity now, due to changing needs of employers and students, and wider economic and political changes [1]. Engineering education all over the world is based on the fact that practical learning and application of scientific knowledge in engineering are vital. Although both laboratories and design projects offer opportunities for hands-on work, laboratory projects are more close-ended than the design projects [2]. An open-ended design project may be considered as the ultimate exercise presented to the student before graduation to measure accumulated engineering knowledge and experiences. At the same time, the project itself provides the student with some new skills and information, and strengthens acquired ones [3]. Such a project may take the form of work executed for an industrial client using their resources, or a project performed at the university but with sponsorship from an industrial partner [4].

In all engineering education programmes, students are required to work on a project extending over approximately one semester where they are expected to respond to a complex and open-ended statement [5]. In India, many engineering colleges and institutions run a six-month industrial training programme in the final year. The main objective of the industrial training programme is to engage the students in a relevant project. Industrial problems of low priority, with a time schedule of less than six months and with a low financial volume, are solved by students [6]. The most suitable time for the project is in the final year and, the more the industrial involvement, the better. It is believed that, with proper procedures, industry-sponsored projects can provide key aspects of teaching students a design methodology and development process [7]. Industrial project training introduces the student to real life; either in the summer vacations or as an integrated part of the engineering programme. With resources being administered by both institute and industry, it becomes imperative to evaluate such a student industrial training project, as it cannot be assumed that the results will always be obvious. Therefore, outcomes are regularly assessed and the results are part of a feedback loop to improve student learning.

There are two kinds of assessment: formative and summative [8]. In education literature, summative assessment is conducted for making a final (summative) judgment about the effectiveness of a process. Such assessment is usually formal and ensures that students completing a degree programme have the knowledge and/or skills required of a program [9]. The purpose of formative assessment, on the other hand, is to assess progress in meeting a task's goals, whereas the purpose of summative assessment is to evaluate outcomes. This paper focuses on formative assessment of training of engineering students, which is generally conducted for the specific purpose of improving a process and usually begins before the process is completed. It involves continuous, informal assessment of student learning to achieve the goals of student training projects. It has been convenient to use terms such as internal and external evaluation for formative and summative assessment respectively [10].

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However, we consider that it is better to avoid this dichotomy, especially when attempting to bridge the gap between education and training.

Training, from a management perspective, follows three stages: training need assessment (TNA), implementation and evaluation. Need assessment has been a topic of considerable interest, both in training and education research. We propose to apply a three-stage training analysis, with the involvement of students, faculty and industrial supervisors. A similar study involving students, faculty and industry focused on the essential generic and specialist skills and attributes of an engineer [11, 12]. In most studies reported in the literature, the relevance or effectiveness of training are considered to be synonymous with evaluation. In this study, we differentiate between evaluation and effectiveness (i.e. relevance [13]) of training by considering training evaluation, which is generally an internal matter in the institution.

LITERATURE SURVEY

Over the past few years, there has been ongoing discussion about the specific skills and knowledge a qualified engineer should possess [14]. Evans *et al.* suggested ten attributes that an engineer should possess [15]. Donald R. Woods *et al.*, for their total programme evaluation, looked at improvement in marks in courses, student acceptance of the learning environment, confidence in problem-solving skills, attitude towards lifetime learning, and self-assessment skills [16]. This study was based on alumni, recruiter and employer response, and student and faculty acceptance. Larry D. Benefield *et al.*, after identifying many different constituents, focused on five groups (undergraduates, graduate students, faculty, alumni and industry) for assessing quality of engineering education [17]. Duyen Nguyen presented the results of a survey of academics, industry personnel and students which solicited their views on what the essential generic and specialist skills and attributes should be for a modern engineer [12]. She concluded that all three groups agreed on the generic skills and attributes necessary for the creation of a modern engineer. Industry considered attitude to be of most significance, academics placed more emphasis on technical knowledge and skills, and the students overlapped with both academics and industry for both technical knowledge and skills and attitudes. Therefore, engineering graduates need to assimilate knowledge while simultaneously acquiring skills in experimentation, calculation, troubleshooting, safety, and in thinking to serve all these skills; they also need to have the right attitude [18]. Although many industry groups have specific needs regarding engineering knowledge and skills, a few generic requirements have been identified by many researchers [19]. British and American studies have emphasised the importance of ensuring that these generic requirements should be given adequate coverage in engineering education.

When considering industrial training as a bridge between institution and industry, motivation is the key to running the process, as described in Kolb's cycle of experiential learning [20]. The immediacy of knowledge gained while working in the industry is very motivating and exciting to students. Therefore, to avoid too much complexity, with many attributes, we chose four prominent generic attributes—motivation, attitude, skills and knowledge (MASK)—for training evaluation in the case study. We further chose five sub-elements for motivation: achievement, affiliation, dependence, recognition and activity applicable to student training. Similarly, attitudes were considered for improvement in problem-solving, positive belief, faith and flexibility and resilience.

OBJECTIVES

We shall first analyse how the immediate impact of training can be measured at the end of the six-month training. Considering the attributes selected above for evaluation, the objectives for this case study can be broadly stated as follows:

- training need assessment of four generic attributes of an engineer and their ranking for improvement due to training and their ultimate career importance;
- satisfaction of the motivational needs of students by making comparisons before and after training; and
- improvements in motivation, attitude, skills and knowledge (MASK)—i.e. generic attributes due to training as perceived by students (self-assessment), faculty members and industry supervisors and develop correlations in their assessments.

RESEARCH METHODOLOGY

Data concerning all the 87 students in the Chemical Engineering and Civil Engineering courses in Thapar Institute of Engineering and Technology, Patiala, India, who were undergoing training during July to December 2000 were used for this research. As mentioned above, the students follow *project-based* training, due to the obvious advantages. The faculty members maintain contact with the student and the industry by visiting three times (at the beginning, the middle and the end of training) during training. Our approach uses the existing training system in the institute and a training evaluation model adapted from the work by Kazmi [21], Virmani [22], Verma [23] and others. The impact of training will be studied according to the MASK attributes suitable for job opportunities for newly trained engineers.

In this study, appropriate questionnaires (including one interview schedule) were designed for all the three groups. The initial data was collected from students using a questionnaire before their departure for the respective industry. It was designed to assess training needs, according to the students' perception. It asked them about their perceptions, attitudes, motivations and expectations from training. In addition, they were also asked to provide an interim assessment in the middle of the training and their reactions and a self-evaluation at the end. The first questionnaire for supervisors was designed primarily to assess training needs from the industry's point of view. This requirement, when analysed, forms the basis of the training evaluation exercise. We put questions to them regarding improvement and importance of the four main MASK attributes (motivation, attitude, technical skills and theoretical knowledge), both during training and ultimately in one's career. For assessment of the training by the faculty members, the interview approach was used.

Scores of items measured on a five-point scale were added and additive scales were obtained. Such additive scales were studied through the mean and standard deviation of such scales. Scores (1, 2, 3, etc.) were used to analyse ranking of various items by the respondents, with '1' as the best choice. For evaluation of improvements in attributes, five options (No improvement to Very High improvement) were provided for each element or sub-element due to training. The respondents were asked to mark the appropriate choice for each student. The results were obtained in five categories of improvements, expresses as percentages of students. The value of students' self-assessment as a formative exercise is unquestioned [24]. Therefore, in this study, students' self-assessments were considered equally with those of the faculty or industrial supervisors. Spearman's rank correlation coefficient (r_s) values were obtained for establishing agreement between two groups (e.g. supervisors and faculty members) and a t-test was applied for testing the hypothesis with a 95% level of significance. For evaluation analysis from the three groups (students, faculty members and supervisors), the results obtained in percentages have been converted to ranks, with the highest percentage ranked as '1' and the lowest as '5'. The ranking correlations are then obtained in a similar way as above for correlating the two groups (student–supervisor, supervisor–faculty and student–faculty).

TRAINING NEEDS ASSESSMENT (TNA)

The main objective of the TNA for engineering students is to obtain a consensus from institution members and training supervisors on the general 'needs' of an engineering degree. Four attributes of an engineer (motivation, attitude, skills and knowledge) were chosen for ranking, to be provided by the faculty members. They were to be ranked (using 1 to 4, 1 being the highest) according to *improvement due to training* and *ultimate importance in the career*. Table 1a finds that, for the former, the top rank is given to attitude, while motivation and technical skills take second and third place. Since theoretical knowledge is not expected to be provided by the training industry, it has been ranked in the fourth position. The results also show that, ultimately, *for the career*, with minor differences, the ranks by mean scores are as follows: motivation, technical skills, theoretical knowledge and attitude. One faculty member explained that motivation is most important, since it makes one want to work. Although the number of faculty members was small, the results revealed broadly *equal importance* (2.5) of all the factors. Ultimately, therefore,

Table 1a. Faculty members' ranking of four MASK attributes for an engineer

	Improvement due to training			Ultimate importance in the career		
Attributes	Mean Score	Standard Deviation	Ranking by Mean	Mean Score	Standard Deviation	Ranking by Mean
Motivation	2.33	0.89	2nd	2.37	1.29	1st
Attitude	1.92	1.08	1st	2.64	1.12	4th
Technical Skills	2.42	0.9	3rd	2.45	1.03	2nd
Knowledge	3.33	1.23	4th	2.54	1.21	3rd

Table 1b. Supervisors' ranking of four MASK attributes for an engineer

	Improvement due to training			Ultimate importance in the career		
Attributes	Mean Score	Standard Deviation	Ranking by Mean	Mean Score	Standard Deviation	Ranking by Mean
Motivation	1.97	0.79	2nd	2.19	1.03	3rd
Attitude	2.46	1.16	3rd	1.58	0.86	1st
Technical Skills	1.78	1.13	1st	1.80	0.78	2nd
Theoretical Knowledge	3.12	3.12	4th	3.17	1.16	4th

Table 2. Comparison of motivational needs

Motivational need	Mean score	
	Before training	After training
Concern for establishing warm and affectionate relations	4.38	4.11
Concern for excellence	4.16	3.97
Need to be recognised	3.87	3.41
Desire to be constantly busy	3.82	3.52
Need to consult others when making decisions	3.01	3.01

all the attributes are clearly equally important for the career. The standard deviations in both cases do not show any alarming exceptions to these conclusions.

The same exercise was repeated with training supervisors and the results are given in Table 1b. From the table, we can see that there is a considerable difference between the two rankings and the effect of training on their improvement does not much correlate with the ultimate importance for the career. From these results, it can be seen that training improves technical skills and motivation, while it is clearly attitude and technical skills that are ultimately important. However, the training undoubtedly aims at improving technical skills and these skills are ultimately important in one's career. This shows the importance of the training for improving the technical skills required in an engineer's career. On the other hand, we find a large standard deviation in the ranking for theoretical knowledge improvement during training. This shows considerable variation in the opinions of supervisors as to whether theoretical knowledge is improved during training.

An attempt to compare the results obtained from faculty members and training supervisors follows. As far as the MASK improvements *due to training* are concerned, there is a good consensus on the fact that the training does not improve the students' theoretical knowledge when compared to other attributes. The training supervisors believe that technical skills are improved most by them, and motivation and attitude take second and third place respectively. Faculty members, on the other hand, find that attitude and motivation are visibly improved after training. When comparing the two groups' opinions on *ultimate importance in career*, faculty members seem to have a very abstract view attributing nearly equal importance to all the MASK attributes. Training supervisors are of the opinion that attitude plays the major role, with technical skills in second place. Motivation comes lower and theoretical knowledge is least important.

TRAINING EVALUATION

Here we consider the improvements in four major MASK attributes for the students due to training. We received responses from supervisors and teachers regarding these improvements. In addition, we also asked students to provide a self-assessment of improvements in the MASK attributes. The conventional method of finding the differences in these attributes pre-training or post-training was difficult, due to the complexity of quantifying all these parameters.

Comparison of motivational needs before and after training (students' opinion)

First, the satisfaction of motivational needs is considered here for assessment of training evaluation. Table 2 gives the weighted results of the various motivational needs before and after training using the two questionnaires. Here weights (5, 4, 3, 2, 1) were given to the responses *always, mostly, sometimes, rarely, not at all*, respectively. The mean score was obtained based on the

Table 3. Students' self-assessment of improvement in MASK attributes after training

Attributes	Improvement				
	No	Small	Reasonable	High	Very High
Technical Skills	0%	4.5%	38.8%	43.3%	9.0%
Theoretical Knowledge	3.0%	22.4%	40.3%	23.9%	6.0%
Motivation					
Achievement	0%	7.5%	22.4%	43.3%	20.9%
Affiliation	1.5%	7.5%	34.3%	37.3%	6.0%
Dependence	3.0%	16.4%	34.3%	25.4%	7.5%
Recognition	3.0%	13.4%	28.4%	40.3%	6.0%
Activity Level	0%	1.5%	22.4%	50.7%	11.9%
Attitude					
Problem-solving	0%	1.5%	20.9%	49.3%	23.9%
Positive Belief	1.5%	3.0%	17.9%	43.3%	29.9%
Faith	6.0%	10.4%	28.4%	31.3%	19.4%
Flexibility and Resilience	1.5%	6.0%	28.4%	40.3%	19.4%

responses in both cases. The weighted results show that the various values are clearly still high (> 3) but there is a slight downward trend in the concerns and needs. Some of the results may be explained by a more developed sense of maturity or balanced approach after the training. However, the desire to be constantly busy and concern for excellence are also reduced, which suggests a loss of some enthusiasm as the price of this maturity.

Improvement in MASK attributes

For a complete quantitative improvement in MASK and sub-variables in motivation and attitude, we asked supervisors, faculty members and even students to make an assessment of improvements during training, keeping the pre-training levels for these variables in mind. This self-assessment approach could provide a quantitative result without making comparisons of results before and after training. This approach maintains objectivity as far as faculty members and supervisors are concerned. In addition, it is not complex and some results can be obtained from students themselves as well. For example, it was possible to obtain the results given in Table 3 from students' (63) self-assessment of improvements, keeping in mind their levels initially.

From the table, we can see that most (43.3%) students felt that there was high improvement in their technical skills and, for 38.8% of students, this improvement was reasonable. For improvements in theoretical knowledge, the results indicate that most students (40.3%) showed reasonable improvement. There was reasonable or high improvement as far as achievement and activity levels of students are concerned. Nearly all students showed improvement in their attitude, from reasonable to very high.

The same format as above was used for obtaining results from supervisors and faculty members. The results obtained for 43 students are presented in Table 4a. The results obtained from supervisors have some degree of central tendency with most students showing reasonable improvement. Here also, some commonality appears, with supervisors reporting that, for some students, achievement and activity level improvements were very high. Table 4b also shows the assessment of improvement in MASK attributes as assessed by the faculty members for 83 students. Here also, the data obtained from faculty members has central tendencies, with the highest number of students having reasonable to high improvements.

To obtain more insight, all the three combinations of Spearman's correlation among the three communities (students, faculty members and

Table 4a. Supervisors' assessment of improvement in MASK attributes after training

	Improvement				
Attributes	No	Small	Reasonable	High	V. High
Technical Skills	0%	25.6%	44.2%	25.6%	4.7%
Theoretical Knowledge	0%	23.3%	48.8%	20.9%	7.0%
Motivation					
Achievement	4.7%	14.0%	44.2%	25.6%	11.6%
Affiliation	2.3%	23.3%	39.5%	30.2%	4.7%
Dependence	11.6%	4.7%	51.2%	27.9%	4.7%
Recognition	0%	14.0%	44.2%	37.2%	4.7%
Activity Level	0%	18.6%	30.2%	32.6%	18.6%
Attitude					
Problem-solving	0%	11.6%	39.5%	34.9%	14.0%
Positive Belief	0%	9.3%	44.2%	34.9%	11.6%
Faith	0%	18.6%	37.2%	27.9%	14.0%
Flexibility and Resilience	14.0%	4.7%	37.2%	25.6%	18.6%

Table 4b. Faculty's assessment of improvement in MASK attributes after training

	Improvement				
Attributes	No	Small	Reasonable	High	V. High
Technical Skills	7.2%	27.7%	21.7%	37.3%	6.0%
Theoretical Knowledge	6.0%	25.3%	32.5%	32.5%	3.6%
Motivation					
Achievement	7.2%	13.3%	42.2%	30.1%	7.2%
Affiliation	8.4%	16.9%	44.6%	25.3%	4.8%
Dependence	4.8%	30.1%	25.3%	33.7%	6.0%
Recognition	7.2%	20.5%	30.1%	28.9%	7.2%
Activity Level	7.2%	25.3%	21.7%	37.3%	6.0%
Attitude					
Problem-solving	6.0%	25.3%	20.5%	42.2%	6.0%
Positive Belief	7.2%	19.3%	24.1%	37.3%	6.0%
Faith	8.4%	18.1%	31.3%	30.1%	4.8%
Flexibility and Resilience	10.8%	16.9%	34.9%	31.3%	6.0%

supervisors) were computed by ranking the percentage results for improvements in four MASK attributes. The statistic results are shown in Table 5. Further, *t*-values are computed to verify the hypothesis that the two groups agree as far as the ranking of improvements in a MASK variable is concerned. The results show that there are variations in the consensus for each attribute or sub-variable. For example, in the case of improvement in skills, dependence motivation, problem-solving attitude and positive belief attitude, hardly any conclusions can be drawn. On the other hand, for recognition motivation, all three are in perfect agreement, with significantly high correlations. Similarly, improvements in knowledge and affiliation motivation show a consensus in two out of three combinations. In most other cases, the table shows one or two correlations with acceptable confidence level.

CONCLUSIONS

Engineering education programmes need regular monitoring, evaluation and feedback-based improvement due to changing needs of employers and students, and wider economic and political changes. Industrial training projects, in which students work for open design projects and interact with industry, are one way of preparing the students to join the industry. The evaluation exercise presented here required goals to be achieved, such as improvement of some chosen generic attributes due to industrial training. Technical knowledge, skills and attitude are the generic attributes found most appropriate in all previous studies and have found consensus among various professional groups. The involvement of students in an open problem, experimentation and exposure during training all influence their motivation. So we chose four generic attributes—motivation, attitude, skills and knowledge—as a vehicle for training evaluation. To make the exercise more relevant, we considered improvement due to training and their ultimate importance in an engineer's career.

It was possible to make comparisons of motivational needs by comparing students' responses before and after training. Students after training are more mature and balanced but lack the enthusiasm they had before training. Quantifiable results were obtained from students (self-assessment), supervisors and faculty members for improvements in MASK attributes and sub-variables. There are difficulties in making generalisations from data obtained regarding improvements. These were sorted by correlating the responses of the students, supervisors and faculty members. Despite the difficulties in forming a consensus between all the three groups, there is a general feeling that the training results in reasonable to high improvements in many attributes and sub-variables.

Table 5. Spearman's correlations, *t*-values and resulting confidence by correlating between students, supervisors and faculty members' assessment of improvement in MASK attributes

Correlation between	r_s	t	Resulting Confidence	r_s	t	Resulting Confidence
		Improvement assessment of MASK variable due to training				
		Skills			**Knowledge**	
Student–Supervisor	0.675	1.5846	Insignificant	0.9	3.5762	98%
Student–Faculty	0.5	1	Insignificant	0.875	3.1305	95%
Supervisor–Faculty	0.575	1.2173	Insignificant	0.725	1.8232	Insignificant
		Motivation: Achievement			**Motivation: Affiliation**	
Student–Supervisor	0.8	2.3094	90%	0.9	3.5762	98%
Student–Faculty	0.725	1.8232	Insignificant	0.8	2.3094	90%
Supervisor–Faculty	0.975	7.6	98%	0.9	3.5762	98%
		Motivation: Dependence			**Motivation: Recognition**	
Student–Supervisor	0.675	1.5846	Insignificant	0.9	3.5762	98%
Student–Faculty	0.7	1.6977	Insignificant	0.875	3.1305	95%
Supervisor–Faculty	0.225	0.4	Insignificant	0.975	7.6	98%
		Motivation: Activity				
Student–Supervisor	0.975	7.6	98%			
Student–Faculty	0.5	1	Insignificant			
Supervisor–Faculty	0.675	1.5846	Insignificant			
		Attitude: Problem-Solving			**Attitude: Positive Belief**	
Student–Supervisor	0.7	1.6977	Insignificant	0.7	1.6977	Insignificant
Student–Faculty	0.475	0.9349	Insignificant	0.4	0.7559	Insignificant
Supervisor–Faculty	0.425	0.8132	Insignificant	0.6	1.299	Insignificant
		Attitude: Faith			**Attitude: Flexibility and Resilience**	
Student–Supervisor	0.8	2.3094	90%	0.8	2.3094	90%
Student–Faculty	0.6	1.299	Insignificant	0.6	1.299	Insignificant
Supervisor–Faculty	0.9	3.5762	98%	0.6	1.299	Insignificant

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