Outcomes and Assessment of Engineering Projects: An Example

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ABSTRACT

The engineering curriculum usually includes Basic Science, Basic Engineering, Humanities, Core Course, Elective Courses and the project. In this structure of the curriculum, the Engineering project is about 10% of the credit distribution. Hence, the project in the engineering curriculum plays an important role in developing the essential attributes of the graduating engineer. The next essential step is the series of assessments that accompany the Project Evaluation. Usually projects are implemented by a group of students, with guidance from a faculty guide and sometimes with additional support by industry experts. At the end of the semester, the program has a number of engineering projects prepared by different groups of students with continuous guidance from different (independent) faculty. The challenge one faces during the project evaluation is to ensure uniform and unbiased evaluation of various engineering projects. In this work, we commence by defining the outcomes of the project and then present the rubrics together with a sample evaluation sheet. The aim of this work is to ensure fair evaluation of engineering projects.

Keywords: Course Outcomes, Program Outcomes, Project Rubrics, Project Assessment.

INTRODUCTION

The project work integrated in the engineering curriculum plays an important role in developing the essential attributes of the graduating engineer. The minimum set of skills to be processed by the graduating engineer is defined through the Program Outcomes (POs), and is measured at the time of graduation [1]. The POs are addressed through the outcomes of the course. Hence, all courses in the curriculum have 4-6 course outcomes (COs), with every CO mapping to PO(s). The engineering project being an integral part of the curriculum also needs to have outcomes, with suitable mapping to the PO(s). It is possible to embed most of the Program Outcomes (POs), through the outcomes associated with the course on Project work, and constitutes the first step towards ensuring quality [1-5]. The next essential step is the series of assessments that accompany the Project Evaluation. Defining COs for the project together with the evaluation rubrics leads to implementation of quality projects and a fair evaluation.

There are two components associated with project evaluation: (i) every project being evaluated by different faculty of the department, (ii) every project being implemented by a group of students. With these components, if there exists' a need to identify three best projects, it becomes an

extremely difficult task, as every faculty feels the project by their students is the best. Similarly, all students from a group expect equal marks, as they have jointly implemented the project. To resolve these issues, we have defined outcomes for the project, mapped every outcome to PO, defined rubrics for every parameter, and also prepared an evaluation sheet. In this work we present the method we have implemented for evaluating engineering projects.

THE OUTCOMES OF THE PROJECT

The first step towards defining and ensuring quality projects is through defining the course outcomes, and mapping to the program outcomes. Since the engineering program usually culminates in a project, and contributes to about 10% of the credits, it is possible to define the outcomes of the project to develop most of the global attributes [1-5]. In Table I, we present a possible COs for the Engineering Project, together with the mapping to the POs, defined by National Board of Accreditation [1]. It can be observed that through the defined outcomes, all the POs are being addressed. We would like to emphasize that this is just one sample set, and every program may define the COs of the project based on the emphasis to be provided for an attribute.

Table 1: The Course Outcomes (COs) with Mapping to Program Outcomes (POs)

CO#	*Course Outcome*	*PO#*
CO1	Ability to engage in independent study to research literature in the identified domain	**PO 12**
CO2	Ability to consolidate the literature search to identify and formulate the engineering problem	**PO 2**
CO3	Ability to identify the community that shall benefit through the solution to the identified engineering problem and also demonstrate concern for environment	**PO 6PO 7**
CO4	Ability to demonstrate compliance to the prescribed standards/ safety norms through implementation of the identified engineering problem	**PO 8**
CO5	Ability to prepare the Gantt Chart for scheduling the project work and designate responsibility of every member in the team	**PO 11**
CO6	Ability to engage in independent study to identify the mathematical concepts, science concepts, engineering concepts and management principles necessary to solve the identified engineering problem	**PO 12**
CO7	Ability to engage in independent study to arrive at an exhaustive list of available engineering tools that may be used for solving the identified engineering problem	**PO 12PO 5**
CO8	Ability to select the engineering tools/components for solving the identified engineering problem	**PO 5**
CO9	Ability to apply the identified concepts and engineering tools to arrive at design solution(s) for the identified engineering problem	**PO 1PO 3**
C010	Ability to analyze and interpret results of experiments conducted on the designed solution(s) to arrive at valid conclusions	**PO 4**
C011	Ability to perform the budget analysis of the project through the utilization of resources (finance, power, area, bandwidth, weight, size, any other)	**PO 11**
C012	Ability to engage in effective written communication through the project report, four-page IEEE paper format and the one-page poster presentation of the project work	**PO 10**
C013	Ability to engage in effective oral communication through presentation of the project work, demonstration of the project and preparation of the video about the project	**PO 10**
C014	Ability to perform in the team, contribute to the team and mentor/lead the team	**PO 9**
C015	Ability to abide by the norms of professional ethics	**PO 8**

RUBRICS FOR PROJECT EVALUATION

The second step towards defining and ensuring quality projects is through defining rubrics that accompany the defined outcomes of the project. The rubrics provide the expectations from every outcome, and a broad guideline for distribution of marks. In Table II, we present a sample rubric that has been used with the project outcomes defined in Table I. This is again a sample and based on the emphasis to be provided for every attribute, and the expectations from the project outcome, the rubrics can be suitably defined.

Table 2: RUBRICS for Project Evaluation

Parameter	*>70%*	*40 to 70%*	*< 40%*
Literature Survey	Referred to more than TEN articles; appropriately summarized; includes recent references	Referred to more than SIX articles; appropriately summarized; NO recent references	NO references included
Problem statement	Problem statement is clear, can be implemented and tested, and addresses one of the Engineering Grand Challenge	Problem statement clear, NOT feasible for implementation, and does NOT address the Engineering Grand Challenge	Problem statement NOT clear
Contribution to society, concern for environment	The community that shall benefit clearly specified; ensures safety to environment	Community clearly specified; however safety measures not specified	Hazard to society and to environment
Compliance to Standards	Clear statement of existing Standards/ Norms, with compliance	Clear statement, but does not include compliance	Standards/Norms NOT stated
Project Scheduling and work delegation	Proposed and implemented Gantt chart included; with clear distribution of workload among the team members	Proposed Gantt chart included; without clear distribution of workload	Gantt chart NOT provided; NO distribution of workload
Identification of essential concepts	Clear list, description and justification of MOST essential Mathematical, Science, Engineering and Management Concepts included	SOME essential Mathematical, Science, Engineering and Management Concepts included, without necessary details/ justification	There is NO mention of any of the essential Concepts
Preparing the equipment/ component list	An Exhaustive list of possible Modern Tools/Components that may be used to implement the project is provided, together with a brief comparative study	A list of possible Modern Tools/Components that may be used to implement the project is provided, without the brief comparative study	Only list of modern tool(s) and components being used is provided
The Modern Tool	Clear justification in selecting the TOOL/Components being used is provided	There is no justification for the tool/components being used	--
Design(s)	More than ONE design solution provided and implemented, with a comparative study	Only ONE design solution implemented	NO design included

Parameter	*>70%*	*40 to 70%*	*< 40%*
Analyze the results	Included clear analysis, along with advantages and disadvantages	Included analysis, without the advantages and disadvantages	NO analysis
Budget Analysis	Budget analysis provided for most of the resources	Budget analysis restricted to finance	NO budget analysis included
The Project Report	well organized, clear objectives and outcomes for every chapter	NOT well organized	NOT submitted by the deadline
The Poster Presentation	The Poster is well designed and includes the aim, the outcome, the results and conclusion	The Poster is NOT well organized, and includes few details	The Poster is NOT included
Originality score	Plagiarism check (using a software) is less than 60%	Originality score more than 40% and less than 60%	Originality is less than 40%
Oral Presentation	well organized, clear presentation, all members have equal participation	Slides are not well organized, presentation not clear	Poor organization, ALL members do not have a role
Video Presentation	well organized, demo included, clear presentation, allocated time well utilized	Not well organized, demo not included, poor utilization of allocated time	Video not submitted
Viva-Voce	Fair knowledge of MOST concepts related to the project	Demonstrates fair knowledge of SOME concepts	NO knowledge of any of the concepts
Performance in the Team	Contributes to the team, cooperates in the team, and mentors/leads the team	cooperates in the team, but does NOT contribute to the team	Does NOT cooperate in the team

THE PROJECT EVALUATION SHEET

The third and most important step towards defining and ensuring quality projects is through defining the evaluation matrix that is related to the defined rubrics corresponding to the outcomes of the project. We need to ensure fair, unbiased evaluation of every project, and every individual in the project group. Every faculty member usually guides one or two student projects. When the evaluation of the project is performed by the solely by the faculty guide, there is no room for relative performance, and it becomes difficult to arrive at the best projects of the program. To ensure uniformity and an unbiased evaluation of the project it is suggested to constitute a Project Evaluation Committee (PEC), that shall comprise of about three faculty members (who do not guide any student projects).

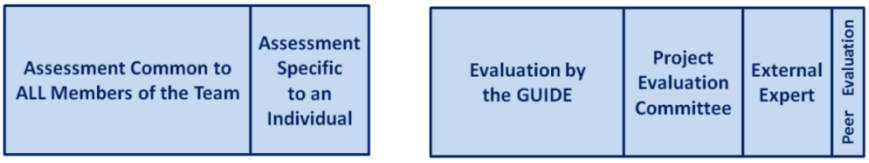

Fig. 1: The Components that Contribute to Evaluation of the Project

In addition, we may include evaluation by external expert during the final stages of the project. A component of the evaluation may also include peer group evaluation. This component may contribute to a small percentage of the marks, but ensures the students learn, comprehend and analyze the projects of other groups. We also need to ensure that there some parameters are evaluated for the group while some are evaluated for every member in the group. These components are presented in Figure 1. All these are purely suggestive and may be changed based on the emphasis for each component.

With the components for project evaluation being clear, we arrive at the evaluation matrix through Table III, which has possible distribution of marks. The evaluation of each of these parameters is based on the RUBRICS given in Table II. It can be observed that some parameters are evaluated only by the guide, while few parameters are not evaluated by the peer student group. The weightage given to peer-evaluation is low. The final score for each parameter is a weighted average. The distribution of marks is purely suggestive and can be changed based on the significance of the attribute being assessed, through a collective decision arrived at through a series of discussions held with the relevant stake holders of the program.

Table 3: Project Evaluation Sheet

	Parameter	*CO Mapped*	*Maximum Marks*	*Guide (>50%)*	*PEC (30%)*	*External (15%)*	*Peer (5%)*	*Total*	*Remark*
Evaluation Common to all members of the Group	Literature Search	CO1	5						
	Problem statement	CO2	3						
	Society, environment	CO3	2						
	Standards/Norms	CO4	3						
	Project Scheduling and work delegation	CO5	5						
	Identification of essential concepts	CO6	3						
	Equipment/ component list	CO7	2						
	Effective utilization of the Modern Tool	CO8	3						
	Design(s)	CO9	12						
	Analyze the results	CO10	5						
	Budget Analysis	CO11	2						
	The Project Report	CO12	12						
	IEEE paper format	CO12	5						
	The Poster Presentation	CO12	3						
	Originality score	CO15	10						
An individual	Oral Presentation	CO13	10						
	Video Presentation	CO13	5						
	Viva-Voce (Technical Knowledge)	CO6	5						
	Performance in the Team	CO14	5						

CONCLUSION

In this work, we have presented the outcomes, the rubrics and corresponding assessment pattern for evaluating the engineering projects. All parameters are purely suggestive, and may be suitably modified based on the suggestions of the relevant stakeholders. The aim of this process is to ensure

fair evaluation of the engineering project. This has been implemented during the recent semester (August to December 2015), and the project internal evaluation resulted in marks ranging from a minimum of 65% to a maximum of 98%, without any complaints from either the student group or the faculty guides. The proposed evaluation matrix, the rubrics and the outcomes shall continuously evolve based on feedback and suggestions from various stake holders.

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