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Enhancing Quality of Teaching-Learning through Knowledge, Research and Experience: A case study

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Abstract: An attempt has been made to present a case study for enhancing quality of teaching-learning process, where a structured approach has been adopted, putting emphasis on the factors 'knowledge', 'research' and 'experience' for teaching the subject 'Embedded Real time operating systems' to PG (Post graduate) students. Our aim is not only to enhance quality of teaching-learning, but also to strengthen the knowledge domain of the students, augment their research quality and skillsets through experiences in diversified ways. It has been proved that our structured approach not only addresses maximum program outcomes (those were, otherwise, not mapped through course outcomes), but also has motivated our students to acquire many skills required for their employability and enhance their global mobility.

Keywords: Teaching Learning (T/L), Course outcomes (CO), Program Outcomes (PO), Outcome based Education (OBE), Graduate attributes (GA)

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1. Introduction

Outcomes based Education (OBE) has motivated us to bring significant changes in teaching-learning process. It provides a comprehensive approachto evaluate performance in terms of attributes in most focused way through systematic approaches and appropriate assessment tools. Our institute, Yeshwantrao Chavan College of Engineering (YCCE), Nagpur, has acquired autonomous status in 2010. The autonomy has offered us freedom to bring necessary reforms andwe can implement the plans to incorporate the procedures to bring transformations in teaching-learning process and overall academic environment to grow and survive in competitive world, to cope with the changing expectations of the industries, R&D(research & development) sectors and academics in the respective engineering disciplines. We have designed our curriculum relevant to the global needs, set new frameworks to bring transformations in traditional teaching-learning process, deliver the courses and also define the assessment tools. Being a part of outcome based education system, we are committed to ensure highest quality assurance standards to be implemented in ourtechnical and engineering programs. Our basic aim is to generate groomed learners through techniques to enrich their knowledge, skills and attitudes.

Industry expectations from engineering graduates are increasing day by day. Emerging technological areas and new career options have provided excellent

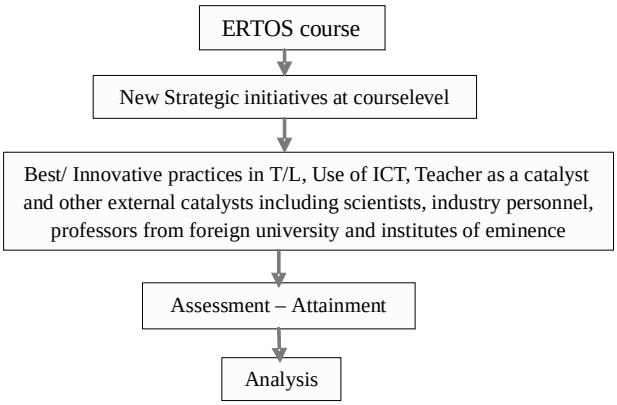
opportunities to the engineering graduates; however, it has become essential to check the intricacies in the approaches employed for overall teaching learning and bring relevancy in technical education system.

In order to strengthen outcome based system at course level, we have undertaken innovative methods to make T/L more effective and student centric, and made effective use of ICT by adopting modern techniques to enhance competency in the context, beneficial from learner's perspective.

A case study is presented which highlights a structured approach in T-L process for the subject 'Embedded real time operating systems' (ERTOS), a course offered to postgraduate students of electronics engineering, which is to be taught through theory sessions only.

Our efforts through which graduates acquire competence to endure and succeed in professional world at appropriate level can be viewed through the impact analysis.

A student centric transformation model for T/L (For 'ERTOS' course at PG level) is shown in Flowchart-1



Flowchart-1: A simple transformation model at course level

Prior to actual delivery of every theory session, session plan/template is uploaded on the departmental Moodle i.e. modular object oriented dynamic learning environment, from which students come to know about session objectives, learning outcomes and precisely acquire adequate knowledge in consistence with the course goals. This activity helps some of the learners to come prepared with preliminary reading from the course material, textbook or reference book.

For demonstrating concepts given in initial assignments, students can perform some other group activities like quiz, Role Play, open book activities, etc. It has been observed that the students can understand group dynamics in better way, contribute more to collaborative research, demonstrate capacity of self-management and teamwork, and perform rationale analysis to achieve common goals in competitive way with positive thinking. Group activity also strengthens management principles and groom leadership qualities among them. Competition level can further be raised, so that team members are motivated to improve communication skills, prepare proper documents, demonstrate complex engineering activities through effective presentation and adhere to appropriate standards as required in global context. Gardener's principle of multiple-intelligence can also be incorporated through various exercises.

In our transformation model, we have concentrated on three factors, develop logical thinking of students, enable them undergoing research pertaining to industry and societal needs and to carry out intellectual analysis to arrive at meaningful solution. This is in line with mission statement of our department.

From industry perspective, engineering graduates must be capable of addressing problems that have unknown or multiple solutions. Instead of delivering only theorysessions for ERTOS course, for better understanding of the subject, we have used blendedteaching approach. We have made effective use of ICT for implementing innovative practices including inquiry-basedlearning through laboratory approach. Based on the pre-requisite knowledge and also from knowledge gained by the students through first two units of course, students were asked to design the experiments/mini-projects. In last three years, this activity resulted in setting new lab set-upsfor undergraduate students. They were also motivated to design many new experiments in ERTOS lab, in addition to 10-12 experiments listed by the UG course teacher. Some of the Innovative mini-projects were shortlisted for filing the patent applications. Students demonstrated responsible attitudein demonstrating the concepts, since they were involved in actual design process. This approach helped us a lot in working in a supervisory role and in engagingourselves in rubric development, and carrying out assessment/ attainment.

Development of student centric T/L transformation model for the course 'Embedded& Real Time Operating System', i.e. ERTOS begins at realization of Vision–Mission statements of our department. Our vision is'to become a department imparting quality technical education and to provide a platform for research and development to fulfil needs of industry and society'. Our mission is'to prepare professional through quality Teaching-Learning, imbibing research culture and lifelong learning'.

We have defined 4 COs for ERTOS course, with each CO addressing one or more POs. Since the COs describes the knowledge and the skill-sets possessed by the student at the end of the course, we have to develop maximum attributes of the students through additional efforts in T/L, so as to enhance competency of the student to make them employable, which is our ultimate aim.

Our PEOs i.e. Program Educational Objectivesareto prepare students to succeed in employment, profession and to pursue research in electronics engineering discipline, to provide students with scholarly knowledge so as to formula teanalyze and design novel systems for solving electronics engineering problems, to inculcate in students professional and ethical attitude, effective communication skills, resource management and teamwork to become successful professional and to provide students with academic environment to work independently through reflective and life-long learning.

It is our regular practice to provide the handouts in the beginning of every session to the students through the Department Moodle, through which the students come to know about syllabus, prerequisites, course objectives, course outcomes, teaching plan, list of text books and reference books, distribution of marks, activities planned, etc.

COs defined for the ERTOS course are:

CO1: Students will be able to understand and learn the concepts, architecture, programming, addressing modes for various embedded systems.

CO2: Students will be acquainted with the new concepts related to design of embedded systems, introspect themselves for applying their previous knowledge for various parameters, especially, selection of operating systems, processors, controllers, memory, IO devices, etc.

CO3: Students will be able to establish link for hardware-software interaction for embedded systems, develop build process for signal / data processing through related software and hardware set up.

CO4: Students will be acquainted with task scheduling, interrupt mechanisms and various managements related to embedded real time operating systems, and will be able to discuss / deliver presentation on contemporary issues related to system on chip and system on slice.

While performing CO-PO mapping, it was observed that the POs addressed were 'a' and 'd', and the level of attainment was 'H' and 'M', since PO-a stating, 'An ability to demonstrate in-depth knowledge of embedded system, signal processing, VLSI design and allied electronics engineering fields' was attained at high level through significant practice and PO-d, i.e. 'an ability to think critically to identify, conceive, analyze and solve complex engineering problems in core areas of electronics' was attained moderately, since initially, no experimentation part was included as it was only a theory course.

Secondly, POs 'an ability to carry out research with independent and introspective learning', 'an ability to apply appropriate modern engineering techniques, EDA tools and related software', 'an ability to accept and adapt to the technological changes for lifelong learning with enthusiasm and commitment to improve knowledge and competence continuously', and 'an ability to demonstrate capacity for self-management, decision making, project & finance management to achieve common goals' were either not addressed or addressed by a small degree.

Though some of the POs were not addressed through traditional methods, it was possible for us to develop the graduate attributes, e.g. 'communication skill', 'professional ethics', 'project management', of the graduating engineer through innovative practices in T/L, use of ICT and strengthening the knowledge domain, research skills and experimental work.

2. Incorporation of innovative practices in T/L:

Keys to successful delivery of session are proper planning and preparation. In our transformation model, we have defined diversified roles of ERTOS Course teacher. The course teacher is expected to

prepare the handouts, course plan in the beginning. For every session, objectives are defined. It was observed that a structured session plan described with time required to carry out sub-activity, contents, methodology, faculty approach, learner's activity and objectives enable the course teacher to accommodate the subject matter in stipulated time. He can also design adequate active learning methodologies and equip each session with the necessary arrangements in advance. The teacher should also organize sessions by inviting experts from industry side and institutes of eminence. It has been observed that many experts acted like catalyst. They initiated the process of developing new ideas (e.g. application specific embedded systems) during workshops/expert sessions they were sure that the process has initiated successfully, they just took one or two follow ups. Students were motivated to work on several ideas and started linking themselves with external world (academicians, scientists and industry persons).

In order to make our instructional strategies 'student centric', as a part of pre-instructional activity, every lecture plan is made with different learning activities (in-line with innovative teaching methods including quiz, Role Play, demonstration, etc.), learner's assessment and regular follow-ups. Efforts were taken to promote thinking process of students. Bloom's taxonomy was referred, Gardner's principle of multiple intelligence was utilized,and innovative practices were implemented for enhancing their attention and their involvement in T/L.

It was planned in the beginning to assign internal marks on the basis of 100 points evaluation for each innovative practice implemented in T/L and continuous assessment based on which the students would gain points through a series of activities planned.

For direct assessment of 100 marks for ERTOS, the distribution of marks is

Mid-semester Exam-1: 15 Marks

Mid-semester Exam-2: 15 Marks

Teacher's assessment: 10 Marks

End-semester Exam: 60 Marks

Normal trend of distribution of marks in Teacher's assessment initially was

Home assignments: 6 Marks

Regularity in class/Attendance: 4 Marks

In order to strengthen effectiveness in the process of T/L and make it more and more students centric, so as to support OBE system, our strategy was to apply various innovative practices, make all the sessions interactive, enable PG students to get involved in developing scholarship of knowledge, critical thinking, problem solving&research skill, usage of modern tools, collaborative & multidisciplinary work, project management and finance, communication skill, life-long learning, ethical practices and social responsibilities, independent and reflective learning through self-learning approach.

Distribution of Teacher's assessment marks:

Role Play (100 points evaluation): 3 Marks

Experiment/Project based learning (100 points evaluation): 4 Marks

Activity through Self-learning approach (100 points evaluation): 3 Marks

A. Activity 1: Role Play

When students were assigned group activity, i.e. Role Play, and they were told that this would be a competition and winner groups would be given reward in the form of opportunities in organizing an event, they started working with competitive spirit. This resulted in quality script writing, quality performance and good group dynamics. They also acquired higher levels of Bloom's taxonomy.

For the 'Role Play activity', the groups were expected to select the themes, preferably 'task scheduling', 'interrupt handling mechanism', 'data transfer processes', 'handshaking', 'mode 1 operation of PPI (Programmable Peripheral Interface) 8255 'DMA i.e. Direct Memory Access', etc.

After the performance, student's satisfaction survey was carried out. They also wrote feedback/remarks. Some observations through survey analysis of students, who performed on the theme 'interrupt handling mechanism', pertaining to Bloom's taxonomy:

The students were able to

1. recall classifications and categories of interrupts including vectored and non-vectored, maskable and non- maskable, interrupt mechanism, terminologies and specific facts (knowledge),

2. understand and express their ideas (comprehension),

3. describe the interrupt concepts as applicable to peripherals,

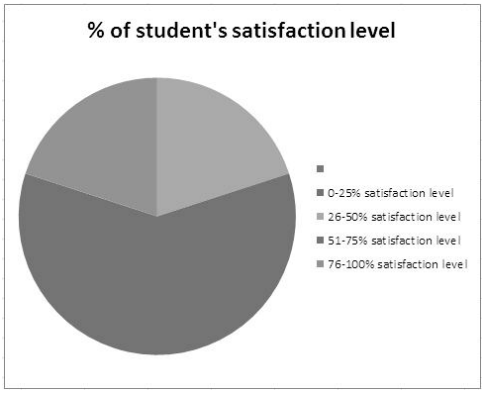
4. apply abstractions and demonstrate interrupt principles (application).

5. Analyse various handshaking operations, specific signals to be exchanged by examining the concepts and timing diagrams by separation of complex concepts into constituent parts, i.e. breaking the information into parts as IO operations and making inferences and finding evidence (analysis).

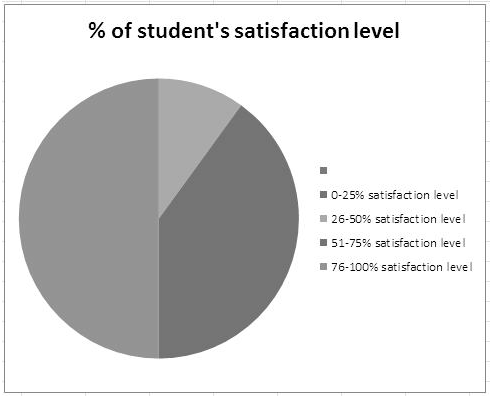
6. apply creative and constructive ideas to demonstrate complex concept using special skills which resulted into a new, integrated, and meaningful way for examining insights to given constraints (synthesis).

Impact analysis of Students satisfaction survey &Self-analysis of students pertaining to graduate attributes/program outcomes is given as,

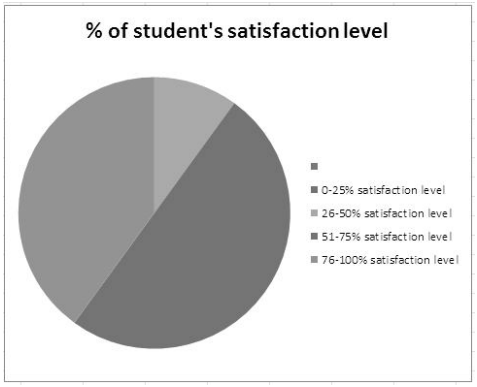
a) Rubric pertaining to Attribute: An ability to demonstrate in-depth knowledge of ERTOS through Role Play



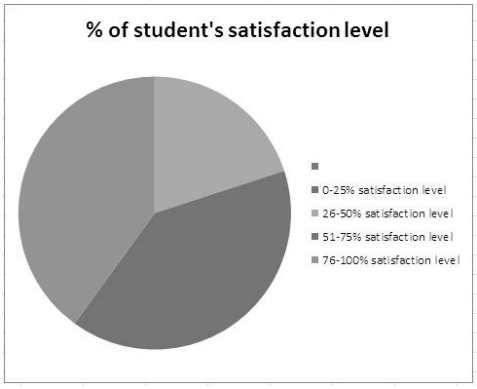
b) Rubric pertaining to Attribute: An ability to carry out research with independent and introspective learning for ERTOS while writing script for Role Play and preparing costumes and other material required for Role Play



c) Rubric pertaining to Attribute: An ability to apply appropriate modern engineering techniques and ICT (Information and Communication Technology) tools, while demonstrating special effects while presenting Role Play



d) Rubric pertaining to Attribute: An ability to communicate effectively, comprehend & prepare report and acquire professional, ethical and responsible attitude towards sustainable development of the society



e) Rubric pertaining to Attribute: An ability to accept and adapt to the technological changes for lifelong learning with enthusiasm and commitment to improve knowledge and competence continuously

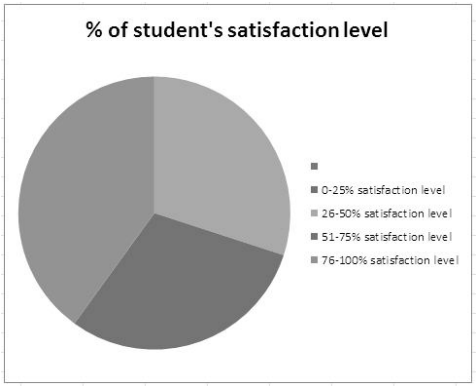


Table 1: Attainment calculation by group of teachers

Sr. No.	Attribute of the students assessed by teacher	POs addressed	Level of PO attained (1-10)	
			Group A	Group B
1.	An ability to demonstrate in-depth knowledge of ERTOS through presentations of Design experiment/Mini-project	PO-a,b,c,d,e,f,g	9	9
2.	An ability to carry out research with independent and introspective learning for ER TOS while selecting Design experiment/Mini-project	PO- b,f	8	7
3.	An ability to apply appropriate modern engineering techniques and ICT (Information and Communication Technology) tools, while selecting Design experiment/Mini-project and demonstrating spec ial effects while presenting PPTs	PO-b,c,d	8	8
4.	An ability to communicate effectively, comprehend & prepare report and acquire professional, ethical and responsible attitude towards sustainable development of the society	PO-a,e	9	7
5.	An ability to acc ept and adapt to the technological changes for lifelong learning with enthusiasm and commitment to improve knowledge and competence continuously	PO-f,g	7	7

Details of CourseTeacher's assessment (Rubrics based) for 100 points evaluation is given as,

The Role Play activity was assessed by 5 teachers. For the expert team, evaluating student's performance, Evaluation sheets was given individually with list of GA, POs was given for reference. The team evaluated the team performancei.e. group wise (not the individual). PO attainment was calculated group-wise, and marks were assigned equally among the group. (Ref. Table 1). Additional outcome of this evaluation practice was that, every student realized his individual responsibility to contribute best in the group. Secondly, they could contribute in diversified way based on their individual talent, e.g. understanding concepts, writing technical script, use of modern ICT tools for presentation and bringing special effects, acting (playing a role), selecting costumes, stage arrangement, anchoring, etc. Since, there was a competition between the two groups, both performed extremely well.Every Role Play ended with meaningful conclusion, which proved the fact that students are capable of making judgements about information, they can present and defend opinions for validity of their ideas (evaluation).

Table2: Attainment calculation by course teacher

Rubric	Points awarded and description
Script:	0: No script written
	4: Less Relevant Script
	8: Relevant Script
	12: Relevant, meaningful, appropriate, concise Script with proper, technical dialogues
	16: Relevant, meaningful, appropriate, more concise Script with proper, technical dialogues
	20: Relevant, meaningful, appropriate, more concise, innovative Script with proper, technical dialogues
Goals set: knowledge-based, skills"based, and affective goals (affective: values, attitudes, and interests)	0: No goals set
	4: knowledge-based goals reflected through script with less relevance
	8: knowledge-based goals reflected through script with relevance
	12: knowledge based and skill based goals set with less relevance
	16: knowledge based and skill based goals set with more relevance
	20: Concise, appropriate and innovative knowledge based, affective and skill based goals set with relevance
Levels of Bloom's taxonomy: Knowledge, Comprehension, Application, Analysis, Synthesis, Evaluation	0: No participation
	4: Knowledge, Comprehension,
	8: Knowledge, Comprehension, Application
	12: Knowledge, Comprehension, Application, Analysis
	16: Knowledge, Comprehension, Application, Analysis, Synthesis
	20: Knowledge, Comprehension, Application, Analysis, Synthesis, Evaluation
Presentation (individual, Group)	0: No participation
	5: Bad presentation
	10: Good presentation
	15: Better presentation
	20: Best and innovative presentation
Overall Performance	0: No participation
	5: Bad performance
	10: Good performance
	15: Better performance
	20: Best performance

In the feedback, students wrote that most of them had not performed on the stage, and Role Play activity has provided them opportunity which they would never forget. They will be energized by the experiences, which they have shared together. Some of the students expressed that they were introvert and this activity has changed their personality altogether.

B. Activity 2: Experiment/project based learning

Students were assigned to develop mini-project/experiment, which was an open-ended assignment. It was observed that the students were enthusiastically involved in identifying problems based on societal needs and developing solutions using combination of the pre-requisite knowledge and concepts which they learnt in their ERTOS course of PG.Since the exercise was open ended, the students were liberalized to select contexts related to public safety, medical related, societal and environmental issues also. They specified the objectives, selected appropriate hardware platform and started developing the solutions. They came across various difficulties in scheduling the tasks, studying interrupt driven mechanisms, interfacing and establishing hardware-software interactions.Students were evaluated through rubrics based on quality of selection of project or problem. Since the studentsrecognize that the evaluation is done contemptuously, they start thinking critically, they identify and analyze complex engineering problem through intellectual literature survey, apply independent judgement or synthesis. Rubrics were designed for evaluating their ability to work on modern tools, design level, research methodology, justification of conclusions and experimental results, STEM analysis, etc.

Rubrics designed for 100 pointsevaluations of students and the assessment can be described and summarized as (Ref. Table 3)

Table 3: Rubrics details for activity 2

Particular	Points	Rubric details
Title of Open ended experiment	0	Title not defined
	4	Title are not relevant to Embedded Real time operating system
	8	Objectives defined are relevant to ERTOS, but are conceptually less correct
	12	Objectives defined are relevant to ERTOS, and are conceptually correct
	16	Objectives defined are complete, conceptually correct, and concise
	20	Objectives defined are complete, conceptually correct, concise, and innovative
Objectives set	0	Objectives not defined
	4	Objectives defined are not relevant to Embedded Real time operating system
	8	Objectives defined are relevant to ERTOS, but are conceptually less correct
	12	Objectives defined are relevant to ERTOS, and are conceptually correct
	16	Objectives defined are complete, conceptually correct, and concise
	20	Objectives defined are complete, conceptually correct, concise, and innovative
Ability to demonstrate the experiment	0	No participation
	4	Bad style of demonstration
	8	Good way of demonstration
	12	Better way of demonstration
	16	Best way of demonstration
	20	Best and innovative way of demonstration
Quality of Result and conclusions	0	No participation
	4	Bad style of drawing result and conclusion
	8	Good way of drawing result and conclusion
	12	Better way of drawing result and conclusion
	16	Best way of drawing result and conclusion
	20	Best and innovative way of drawing result and conclusion
Ability to Justify the conclusions	0	No participation
	4	Bad style of drawing result and justifying the conclusion
	8	Good way of drawing result and justifying the conclusion
	12	Better way of drawing result and justifying the conclusion
	16	Best way of drawing result and justifying the conclusion
	20	Best and innovative way of drawing result and justifying the conclusion

We are implementing this activity from last 6-7 years, and every year PG students develop 9-10 experiments/4-5 mini-projects. The outcome of this practice is development of 'Student's Driven Laboratory'. Some of the projects are also displayed in 'Innovation Gallery' of our institute.

C. Activity 3: Self-learning approach

Introducing 'Self Learning' in the T/L processmotivates introspective and independent learning capability of students. For ERTOS subject taught at PG level, it is expected that the students learn at least 5-10% of the syllabus, prepare PPTs and present it in the form of seminars. This activity not only improves their presentation/communication skill, but also inculcate professional ethics among them. (Ref. Table 4)

Table 4: Rubrics details for activity 3

10 pts. Define Title of the Seminar

Points	Rubric
0	No appropriate title
2	Title given but is not relevant to embedded system
4	Title given and is somewhat related to embedded system
6	Title given and is related to embedded system
8	Appropriate title
10	Innovative title

10 pts. Seminar Outline

Points	Rubric
0	Improper
2	Incorrect / Not Justifiable
4	Correct but with less justification
6	Correct with proper justification
8	Perfect
10	Perfect and Innovative

As expected, major Outcomes of the various innovative practices incorporated in T/L are:

20 pts. Define Session Objectives

Points	Rubric
0	No objectives identified
4	Objective identified but not relevant to Seminar topic
8	Objective identified but Contains technical or conceptual errors
12	Objective is conceptually correct and uses correct technical terminology but may be incomplete in scope.
16	Objective is complete, conceptually correct, concise, specific and clear but with incorrect technical terminology and grammar
20	Objective is complete, conceptually correct, concise, specific and clear, and uses correct technical terminology and grammar

20 pts.Descriptive slides & Level of Presentation

Points	Rubric
0	No description
4	Description OK but substandard and less relevant to Embedded system
8	Description OK but substandard but just relevant to Embedded system
12	Description relevant to Embedded system
16	Description: complete, conceptually correct, concise, specific and clear
20	Description: complete, conceptually correct, concise, specific, clear and innovative

20 pts. Clarity of diagrams/ Block diagrams

Points	Rubric
0	No
4	Less Clarity, less relevance
8	Good clarity, less relevance
12	Good clarity, good relevance
16	Perfect
20	Innovative

20 pts. Seminar Report: Including Conclusion, References

Points	Rubric
0	No
4	Incorrect
8	Weak
12	Precise
16	Very precise
20	Innovative, precise and perfect

- Students are able to solve open ended problems.
- The students are adept at the analysis and develop the process solution.
- The students are able to address problems that have unknown or multiple possible solutions.
- The students are able to design and conduct experiment.
- The students are able to demonstrate the concepts in most effective way, and communicate effectively because of their involvement from beginning in the design experiment.
- The students are able to demonstrate their leadership qualities in various aspects.
- The students are able toanalyze and interpret the data.
- The students are able to learn laboratory techniques and operation of various equipments.
- The students are able to students driven inquiry lab can be developed.
- Free reign to implement a focussed, innovative and unique experiment.
- Enrichment of laboratory culture with dynamic and innovative ideas, interactive environment and research.
- The students were able to learn how to present the results and articulate the interpretation of the outcomes in the report and the presentation which are very helpful skills in seeking their employment.
- The students were able to analyse the concepts, processes, procedures and principles rather than just remembering the facts.

It was also observed that, ICT has provided great opportunities to enhance student's learning abilities and also in developing different skills. Students store and recall the information from specific content areas and transform their knowledge in new ideas and applications. We can develop laboratories and their classroom as place for collaboration and discovery where we can integrate ICTs into learning processes. We have made extensive use of Moodle for conducting online tests, submitting online assignments, making handouts, course plan, question papers of previous years, model answers, notes, DTEL material available for students.

In second phase, ERTOS teacher can start delivering new concepts. To link new knowledge with previous one, again session plans can be prepared for objectives set with knowledge based goals (to be

achieved through six levels in Bloom's taxonomy namely knowledge, comprehension, application, analysis, synthesis and evaluation), skill based goals (through various levels of expertise–perception, set, guided response, mechanism, complex overt response, adaptation and organization) and affective goals (through receiving, responding valuing, organizing and characterizing). Students can acquire new knowledge in new domains, and are able to discriminate, analyze, evaluate and synthesize existing and new knowledge through this activity.

From the assessment of open ended experiment and project activity, it was observed that the students were able to apply the knowledge of mathematics, science, engineering fundamentals while designing the experiment and developing the project. They were also capable of implementing their knowledge related to their specialization for developing solution of complex problems. They were adept at problem analysis to identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions.

They were able to design solutions for complex engineering problems and some groups were also able to design system components for the processes that meet the specified needs with appropriate consideration for the public health and safety and environmental considerations. They were able to conduct investigations of complex problems for which they utilize research-based knowledge, including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. They were adept to fast technological changes and up-gradations in software and firmware, and were eager to get acquainted with modern tools.

As a matter of fact, engineering graduates were able to get groomed to apply contextual knowledge. They followed commitment for professional ethics and responsibilities, while writing the scripts, reports and submission.

Students functioned effectively as an individual, and as a team member or as a leader in multidisciplinary settings. They were able to communicate effectively, comprehend and write effective reports and presentations, give and receive clear instructions. They were able to demonstrate knowledge and get engaged in independent and life-long learning in the broadest context of technological change.

As a part of prerequisite for ERTOS course designed for PG, students are expected to know basic concepts of programming and interfacing of microprocessors and microcontrollers, C and C++ programming, data and signal processing. ERTOS teacher is expected to prepare activity schedule for students and proper time activity lecture plans, so that students can recall the concepts related to ERTOS which they have learnt at UG level prior to learning of advanced concepts at PG level.

One example of the session plan is discussed. To recall the concepts of Interrupts and interrupt driven mechanisms in microprocessor, students were asked to present Role Play on the next day. Session template is developed as, (Ref. Table 5)

Table 5: Sample session template

Time	Contents	Methodology	Faculty approach	Learner's activity	Learner's Outcomes
10 minutes	Introduction of the theme 'Interrupt mechanisms' Introduction of teams	Innovative introduction (Dramatic approach)	Facilitator	Participates Observes Comments	Applying
40 minutes	'Interrupt mechanisms'	Role Play	Facilitator	Participates Observes Comments	Applying Interpersonal Intrapersonal Kinaesthetic Linguistic Spacial
10 minutes	Concluding remarks	Evaluation sheets	Subject expert	Evaluates, Comments	Understands

A teacher should act as a catalyst, and should prepare students to be competent participatory citizens in the 21st century with ability to provide engineering solution to handle complexities of contemporary life. A catalyst triggers the process, which would have not been taken place without involvement of the catalyst. Once the process gets instigated successfully, catalyst comes out of the process. In the similar way, we have conducted the activities like Role Play, Experimental Learning and Self Learning, the practices which were not implemented before, in our institution. Expert sessions and workshops conducted by prominent academicians, scientists and industry persons has also proved to be inculcating novel and patentable ideas and innovative concepts in student's mind.

This is how, we can apply structured teaching approach for improving teaching/learning and making it student centric by maximizing incorporation of graduate attributes.

Following discussion would demonstrate, how GAs are addressed through all the innovative practices undertaken by us.

1) Scholarship of Knowledge:

It is the primary responsibility of teachers to impart subject knowledge to the students. However, efforts are required to develop scholarly attitude among the students to gain the knowledge and apply it in different contexts. Methodology is to be development so as to properly assess whether they acquire in-depth knowledge of specific discipline through the courses offered to them. Here, it is expected that they should demonstrate their scholarly engineering knowledge of the related discipline and attitude for providing solutions to problems pertaining to global perspective. They should also come up with an ability to appraise, analyze and synthesize the engineering in depth knowledge by incorporating practical implementations, through research orientation, so that they would also devise new theory, mathematical formulations resulting in enhancement of knowledge. Through presentations made through Self Learning approach, Role Play and Inquiry based learning, and also through the research papers, the students can exhibit this attribute.

2) Critical Thinking:

Through all the innovative practices implemented, as mentioned in the paper, students at PG level had to think critically to arrive at appropriate solution. e.g. in the design of embedded system, their critical thinking is required regarding selection of proper hardware platform, software environment, operating system and appropriate knowledge of task scheduling, memory management, etc. They have to analyze complex engineering problems critically; apply independent judgment for synthesizing information to make intellectual decisions for conducting research in a wider perspective.

3) Problem Solving:

For the activity 'Inquiry based learning' and 'Experiment based / Project based learning' students were expected to have problem definition based on public health and safety, cultural, societal and environmental issues in the core areas of expertise, think laterally, originally, conceptualize and provide engineering solutions. The students demonstrated this attribute through mini-projects, which were specially designed for blind, old aged and citizens from special category. These projects were innovative and patentable.

4) Research Skill:

All the innovative T/L methods, especially 'Self-learning approach' has proved to be excellent approaches to develop Research skill among the students. They were able to extract information pertinent to unfamiliar problems through literature survey and experiments, apply appropriate research methodologies, techniques and tools, design, conduct experiments, analyze and interpret data, demonstrate higher order skill and view things in a broader perspective, contribute individually/in group(s) to the development of scientific / technological knowledge in one or more domains of engineering.

5) Usage of modern tools:

The students were able to use modern tools for all the innovative practices used by us in T/L. For open ended design project activity, they used various microcontroller based boards, fuzzy controller, DSP controller etc. They also developed various apps. Focus of some of the students was IoT. In the feedback, the students wrote that they were highly motivated by the open-ended design project activity through which they were able to create, select, learn and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to provide engineering solution to complex societal problems. Through presentations also, the students demonstrated innovative way of use of ICT tools. Teachers, who were acting as faculty mentors for design projects, and evaluating the performance of students were also surprised to see the effective use of modern tools made by the students, especially when the students developed app for slide progression and the special effects given in the PPT presentations.

6) Collaborative and Multidisciplinary work:

Main project at PG level is assigned individually, and it has been observed that PG students do not possess knowledge and understanding of group dynamics. To develop this attribute, the activity 'Role Play' and interdisciplinary projects assigned group-wise helped them to recognize opportunities to act/lead in groups, contribute positively to collaborative-multidisciplinary scientific research,

demonstrate a capacity for self-management and teamwork, decision-making based on open-mindedness, objectivity and rational analysis in order to achieve common goals and further the learning of themselves as well as others.

7) Project Management and Finance:

This attribute was strengthened by all the innovative practices implemented for our PG students and they were able to demonstrate knowledge and understanding of engineering and management principles as a member and leader in a team, manage projects efficiently.

8) Communication skill:

This attribute is very imperative, in every aspect. We had taken efforts through presentations of all innovative activities, to develop our students to communicate confidently and effectively. The students were also mentored for drafting reports of all activities, and it was observed that they were able to comprehend and write effective reports and design documentation by adhering to appropriate standards, make effective presentations, and give and receive clear instructions.

9) Life-long Learning:

The attribute 'Life-long learning' relates to ability to engage in 'self-study', or 'independent-study', 'introspective learning' so that the student can apply acquaintance, experience, 'life-long'. For all the innovative practices implemented for PG class, students were engaged in self-learning mode and independent study for carrying out related literature survey. From the analysis, it was clear that this competency was developed to high degree through 'Role Play activity', thereafter 'open ended design experiment' and 'seminars'. The students were trying to correlate engineering concepts with day to day real life experiences. They were listening to webinars, getting acquainted with modern tools, reading technical lab manuals, research articles, watching videos, etc. and getting more and more involved in 'life-long learning' independently, with a high level of enthusiasm and commitment to improve knowledge and competence continuously.

10) Ethical Practices and Social Responsibility:

Mostly this attribute is not covered by the technical courses offered to the engineering students. It is required to make the students to realize the ethical responsibility towards society beyond profit. to review some of the concepts, research and practice that have come to characterize this developing idea. Professional ethics encompass the personal, organizational, and corporate standards of behavior expected by professionals including honesty, integrity, transparency, accountability, confidentiality, objectivity, respect, loyalty. acquire professional and intellectual integrity, professional code of conduct, ethics of research and scholarship, consideration of the impact of research outcomes on professional practices and an understanding of responsibility to contribute to the community for sustainable development of society.

11) Independent and Reflective Learning:

It was quite obvious that the students learn independently by observing and examining critically the outcomes of one's actions and make corrective measures subsequently, and learn from mistakes without depending on external feedback. In Role Play activity, in practice sessions, the students were observing performance of other groups, and were taking care that some of the common mistakes would be avoided. While designing experiment/project, they were comparing their projects with others and were addingmore and more ideas in their project through competitive spirit.

3. Conclusion

We have applied a structured teaching approach for improving teaching/learning and making it student centric. We have also developed assessment techniques for measuring student outcomes and. We have designed rubrics for evaluating the effectiveness of the activity planned for learners. From the improved percentage of the campus placement of students and also from the feedback and survey analysis, it can be concluded that all the sessions were planned, informative and interesting. Various innovative techniques enhanced quality of teaching-learningand strengthened knowledge domain of the students, augmented their research quality and skillsets through experiences through diversified ways. It has been proved that our structured approach not only addresses maximum program outcomes (those were, otherwise, not mapped through course outcomes), but also has motivated our students to acquire many skills required for their employability.