Journal of Engineering Education Transformations,
Volume 30, No. 3, January 2017, ISSN 2349-2473, eISSN 2394-1707

Imbibing Research Component in the Energy Systems Engineering Graduate Programme

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Abstract: Engineering education in unison with societal needs forms the bedrock to developmental activities and progress of human race. The transient nature of real world demands innovative solutions that makes it imperative for continuous knowledge exploration in science and technology. Engineering curriculum must sensitize graduates to be inquisitive to evolve solutions through application of their domain knowledge and exploration of new frontiers. Engineering research involves a systematic investigative approach to enhance the knowledge domain directed towards solution of existing problems. The research at graduate schools can be categorized as Basic research and Applied research depending on whether it establishes the "proof of concept" or delivers new processes, products or techniques. Government of India has initiated several measures for import substitution and indigenous technology development through financial assistance to research activities at academic institutions and industry. The graduate programme in Energy Systems Engineering with focus on renewable energy conversion has taken initiatives to imbibe research component into its curriculum.

The theory courses in the programme have adopted a component that gives an exposure to the research trends in the respective areas through review of research articles. The project work course during the second year of the programme was meticulously designed to provide a mechanism that generated interest to pursue research activities. The periodic assessment through well-defined rubrics to incorporate the good mix of experimentation and computation segments helped in better execution of the project work. The strategy encouraged use of open source hardware tools like Raspberry Pi and Arduino along with software tools like Scilab and Open-foam in the project courses. This work summarizes instillation of research component for attainment of the Graduate Attributes PO4, PO5, PO6 and PO8 through execution of project work at different levels of the Programme. The results have shown that experiential learning strategy in project work has brought a positive change in the learning styles of students indicating their enthusiastic contributions.

Keywords: Research in Engineering, Graduate Attributes, Project work, Open source.

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1. Introduction

Research is a delineated piece of creative effort systematized to elevate the stock of knowledge. The thirst of knowledge forms the driving vector to carry out directed research in selected domain of expertise. Research that leads to knowledge exploration should

be an indispensable part of education in identified domain owing to societal needs that demand transformations.

Research in the engineering education plays an important role of elucidating pupils to explore the stupendous knowledge in their domain and to elicit the inquisitiveness to learn beyond the academic prospectus. These outbursts of inquiry in pupils induce the exquisite nature of seeking truth in form of scientific evidences that imbibe lifelong learning mindset fuelled by perseverance and hard toil. Engineering education involves theories with mathematical justifications that prepare graduates to model real world problems and arrive to optimal solutions that benefit the society at large.

Transformations in the engineering education has been pragmatic in the recent decades through outcome based education model laying emphasis on student centric learning against teacher centric learning. Research in engineering education dispenses the essence of systematic methodologies to elevate the explorative instinct to provide solution for real world problems. Thus imbibing of research in engineering education delivers positive impact in upbringing future engineers who would exhibit pragmatic and more practical outlook against the basket of theoretical know-how.

Imbibing research initiatives into PG Programme in Energy Systems Engineering has been discussed in the present work based on blend of various strategies like Experiential learning, Project based learning and Active learning. These strategies implemented throughout the length of the Programme contributed to address various graduate attributes that include PO4, PO6, and PO8. Project based learning was brought into the context by mini, minor and major project components where students actively participated in multidisciplinary teams. As part of the learning strategy student were made to work through the phases of survey, identification and analysis of real world situations to be systematically chunked into feasible research challenges.

Literature survey

The salient contributions of research component in engineering education have been briefed in this section.

The advanced computational and data handling capabilities of computers lead the researchers to depend more on it for scientific and technological breakthroughs.

Case et al., have investigated impact of non-conventional teaching strategy to transform traditional pencil-paper engineering design through use of computer graphics adopting solid modeling designer's package to catalyze student learning through innovative pedagogy to address requirements of twenty-first century.[1]

The modern day educational transformations stresses on experiential learning shedding out rote learning practices. In the current context, anything other than experiential learning is considered a mere store of information that makes the least contribution in evolving creative solutions for real world problems. Ashok Kumbar et al., have reported on the learning experience in outcome-based approach applied to curriculum design and delivery. The student performance was primary goal in this approach adopted for group of interdisciplinary streams. As part of the experience based teaching learning process domain specific projects were assigned and executed to promote peer learning and imbibing research element. The challenges introduced in the theory and laboratory courses were tackled by cross discipline concepts in the curriculum. [2]

Modern computational tools with capabilities to solve multi-physics problems offer effective platform to the otherwise complex time consuming formulations. Madival et al., have discussed pedagogical approach in Computational Fluid Dynamics (CFD) laboratory course to overcome challenges in delivery due to constituent multidisciplinary team. The bridge course, think-pair-share model and ACE (Analytical, Computational and Experimental) approach were adopted to motivate students form multidisciplinary teams. The contemporary industry trends strongly indicate the need for multi-domain integration towards the evolution of feasible solutions. Therefore, the reported work emphasized on synergizing capabilities of different streams of engineering towards research solutions.[3]

Research in engineering education forms the vital link to connect existing problem and feasible solution. The arduous process of imbibing research has a major role played by the conducive environment over the bank of information available to students. Therefore it

is imperative to create research ambience that draws interests students to opt for research based career options. Farooq Mughal et al., have analyzed Kolb's experiential learning model with reference to four influencing parameters that include psychoanalytic, situative, critical cultural and enactivist. The study indicated adoption of Kolb's experiential learning model with its short comings addressed through Fenwick's theory. [5]

2. Methodology

Different pedagogical approaches have been implemented in the Energy Systems Engineering and practiced for achieving improved academic and research outcomes.

Experiential learning

Experiential learning can be defined as the learning from the one's experience by undergoing the process of problem solving. It's basically learning through reflections by experiences. This model of learning was proposed by David Kolb in 1984 popularly known as Kolb's experiential learning theory which is primarily focused on learner's internal cognitive processes [4]. Experiential learning is one of the strategies implemented in the Energy Systems Engineering programme where students are subjected to experience the constraints in developing the technology.

Projects taken up by the students are on the social relevant issue where they need to get on the field and primarily do the survey before they begin the project. On field survey build the competence among the students to interact with local community in order to fetch required inputs for generating customized solutions.

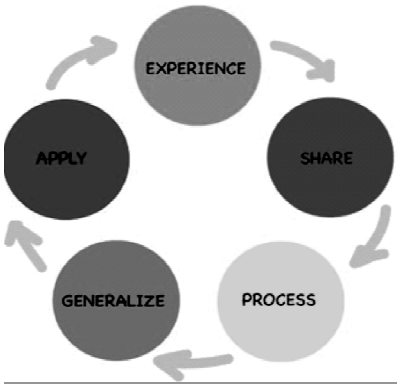

Fig 1. Experiential Learning Model [6]

Experiential learning involves continuous internal evaluation based on experience where students share their experience with the interdisciplinary groups initiating the thought process. This process is framed into generalized concepts which are then applied for g solving the problem statement. This is repetitive and iterated until desired convergence for the solution is observed.

Project based learning

Project based learning basically focuses on the strategy of defining the problem statement in form of project and assigning to the students. Here the real time model is laid out in mathematical model and simulated for desired solution which are necessary for the practical set up, design and execution. Primarily approach of transformation of real world constraints into mathematical forms associates the theoretical knowledge with practical relevance.

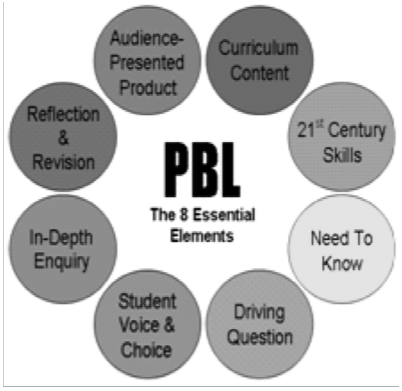

Fig 2. Elements of Project Based Learning [13]

Active learning

Active learning is achieved by involvement of student in various activities such as reading, writing and group discussion resulting in the improved problem solving competency, problem analysis and better understanding of concepts.

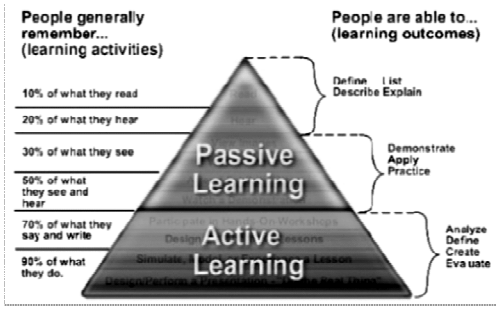

Fig 3. Comparison Active and Passive Learning [14]

As shown in the figure 3 majority of the learning is achieved through framing, planning and executing things rather than assimilation of facts. Active learning involves the promotion and enhancement of student capability through various activities such as reading, writing, analyzing, synthesizing of incorporated content as a part of curriculum. Theme of active learning is to engage students in two levels namely doing things and thinking about what they are doing. The course project involved in the college level promotes and uplifts the concept of active learning. Each theoretical subject in the curriculum is attached with the course project which allows students to practically work on the concepts learnt in the theory course which is the whole essence of active learning strategy.

Mini, Minor and Major Project

The teaching and learning process is enhanced through espousal of above strategies in the academics and imbibing practical approach in learning through incremental semesters of curriculum. The initial two semesters of PG programme are more focused on the learning facts, figures, simulation tools addressing PO5, introduction to research methodologies where the students learn the art of research addressing PO4 in the systematic approach followed by the implementation in the next successive two semesters covering the entire length of four semesters of PG programme.

The curriculum of the higher semester primarily designed to motivate students to involve more practically in the form of mini, minor and major projects which hold 2, 10 and 30 credits respectively. The projects are executed in the interdisciplinary teams comprising Electrical and Mechanical PG scholars addressing PO8.

Impact of implementation

The introduction of the discussed strategies involving research components in the academic prospectus has led to the encouraging results in terms of technical publications, participation in conferences and registration of patent. Few outstanding projects are discussed in brief to elaborate the outcomes. One of the project undertaken by the Post Graduate student has been escalated for filing the patent and has been successfully registered. Many of the research works are published in the reputed international journals and were presented in the conferences.

Solar Wind Integrator

Research in the field of energy integration focuses on the optimal energy extraction and integration of different renewable energy sources viz. solar photovoltaic and wind energy systems. The project emphasizes the efficient energy utilization to charge the battery bank as well as cater the electrical load connected.

Fig.4 Solar Wind Integrator

The intelligent algorithm developed senses the state of charge in the battery bank and load demand which is optimally fed with the differential power generated from the renewable sources at that particular instant, this strategy reduces the number of charging and discharging cycles of the battery bank which results in the enhancement of its life. Algorithm along with the application is under the process of filing a patent for its exclusive functionality.

Solar wireless insolation sensor

This research project has led to the development of a measuring instrument capable of monitoring and logging solar insolation wirelessly. Developed instrument and its algorithm has been successfully registered under Indian Patent. System consists of the photovoltaic cell as insolation sensor that produces electrical signal which is conditioned and calibrated to be interpreted as insolation in terms of Wm-2. Research of six month duration was invested to evolve in successful registration of patent. [7]

Fig. 5 Solar wireless insolation sensor

Biomass based Cook stove

Rural community needs were surveyed which was assigned as the major project of one-year duration which led to the product level development of the biomass based cook stove. The prototype is deployed at the nearby village which is under testing and evaluation phase. The reviews and feedbacks of the users were collected which was helpful to develop second and third version of the cook stove resulting in phases of technical and economical optimization.

Fig. 6 Biomass based cook stove

Collaboration with NGO has created the platform for commercial marketing of the prototype transforming into product. [8,9]

Solar electrification of rural community

Off grid centralized power generation for the un-electrified village has been modelled. The preliminary site survey carried out by the team of interdisciplinary students assigned with the mini project for the duration of three months has shown the potential of renewable energy at the site are favorable for the installation of the power plant [10]. Energy efficient illumination systems based on solar photovoltaic systems are developed and substantiated [11]. The feasibility of the developed modelled is simulated using software computational tool such as PVSyst. The DC grid with solar photovoltaic generation scheme seems to be feasible for electrifying 18 homes, 1 school and 3 street lights.

Drying Agri products using solar energy

This research has been carried out for last three years on various crops to obtain its drying characteristics. Some of the charge under test were chili, potato, grapes etc. The drying characteristics help to derive the development of solar thermal system for drying agri products.

The prototype is now used as the experimental setup in the department for studying drying characteristics of agricultural products. [12].

Fig. 7 Solar crop dryer collector

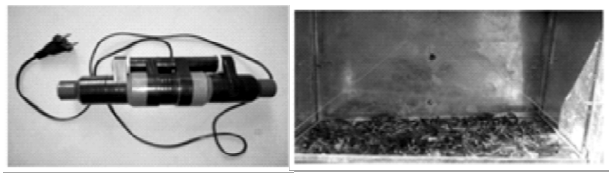

Fig.8 Auxiliary heater with dried chili in the chamber

Various other projects were competent to get published in research journals which are summarized as below

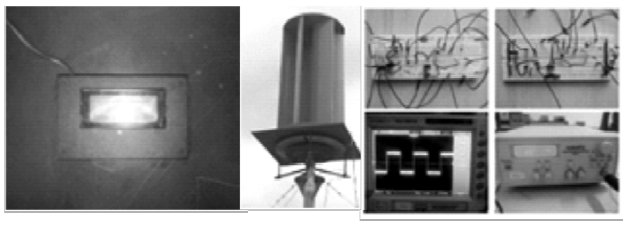

Fig.9 Weather DAQ, Vertical WECS, Solar Charge Controller.

3. Research outcomes

Imbibing research in the curriculum has brought a constructive change in the PG studies enabling lifelong learning among students yielding in responsible engineers of future. Various papers have been presented in the conferences, journals and some have scored for filing patent. Students have been employed under diversified domains such as Information technology (INFOSYS), Engineering design (QUEST), Government public services (KPTCL) and research jobs (INFOSYS R&D) which was possible because of the domain specific electives offered in lower semesters and various projects undertaken in the higher semester. Statistics of results obtained by the pilot batch students in the PG Programme are as below.

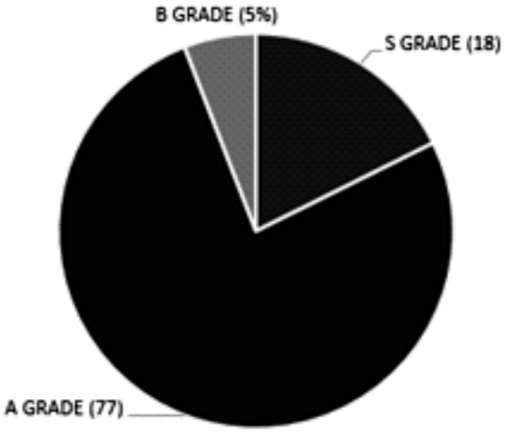

Fig. 10. Employment distribution for last two years

Statistics of employability of the students for last two years has been graphically represented below.

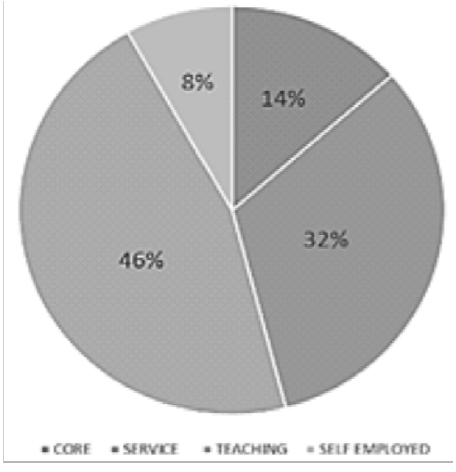

Fig. 11. Employment distribution for last two years

4. Conclusions

Imbibing research in the PG studies have addressed various graduate attributes which have uplifted the programme objectives in educating engineers to serve the society in responsible and professional approach.

- Imbibing research components through the course project linked to theory courses has conceptualization of theory and thereby gaining practical relevance of the theoretical concepts. The graduate attribute related to research component (PO4) was thereby addressed.
- The Computational tools form the bedrock for design activity as they offer effective means to minimize the design lead time. In this context the graduate attribute PO5 was addressed through extensive use of computational tools for activities related to data analysis, parametric simulations and optimization.
- Project based learning has played an important role in addressing PO6 through the execution of Mini and Minor projects in multidisciplinary teams. The think pair and share strategy augmented by Analysis-Computation-Experiment (ACE) adopted during the activities promoted to bridge the knowledge gap between participating disciplines.
- The communication in written and oral format constitutes a vital functional element for the practicing professional identified as Graduate attribute-PO8. The curriculum provided ample scope for imbibing communication skill-sets through all theory course related activities and specific course on Technical report writing. The attainment of PO8 is also reflected in placement records.
- The overall statistics of Programme alumni has strongly indicated a substantial segment to have pursued the doctoral research evidencing the imbibed research component.

Acknowledgement

The authors express their gratitude to the Management KLE Society Belagavi, honorable Vice-Chancellor (KLE Tech. University Hubballi), TEQIP funding agency and all other individuals and Departments for their support provided during this study.

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