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Pedagogical Reforms in Delivery of Undergraduate Heat and Mass Transfer Course towards Enhancements in Student Learning

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Abstract: The new genre learners need tech-savvy Teaching-Learning procedureto initiate dialogue between the instructor and pupils. The course at Graduate level was envisaged based on employment statistics that indicated sizable segment of graduates opting teaching profession. The need for this course was also strongly supported by potential employer expectations in new recruits to possess better professional skills of team work and communication. The reported pedagogical initiative streams a non-conventional approach in imparting concepts on essentials of engineering education at Graduate level. The ordeal aims at providing a hands-on experience on broad principles of engineering education to Graduate students from multiple disciplines in Engineering. The course delivery involvedoral and written presentations using conventional modes blended with Moodle-platform. The Course delivery and Assessment strategies were meticulously executed to foster interactive learning that lead to attainment of higher levels in Graduate attributes PO3 and PO5.The pedagogical impact of the course presented in form of statistical data strongly portrayed affirmative catalysistowards improved team work culture and communication skills.

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1. Introduction

The present technology driven era has madeavailable at user's fingertips the scientific and technical information empowering him address various issues confronting mankind. Education sector that plays a significant role in the society, in recent years has been driven by new technology innovations.

The Engineering education involves a methodological identification of skill sets or attributes that potential employers in society would demand from a student pursuing the Programme. The purview of this emerging stream of knowledge and practice extends towards bringing reforms in design-delivery and assessment of course-ware to equip effective student learning. The transformation in engineering education involves emotional change variables unlike the conventional thought that perceived on course content, curriculum or pedagogy as the directive variables.

The work reported on the five pillars of transformation as the trend setter for authentic changes based on the simpli?edformulation of Trust, Courage, Initiative, Failure and Authentic learning. The emphasis was laid on transformations that happened through newer approaches of learning interpreted as active, experiential or project-based pedagogy. The work highlights the transition from "I know" to "I trust" that hints the authentic education reform with educators to wear the cap of a 'coach' rather than an 'expert'. Today's web has hit both classroom and laboratory expertise in unparalleled way to marginalize role of expertise. The expert's role transition to the coach who trusts creativity and learning capacity of learner was arduous task and needed executive coaching to faculty members to make this shift.[1]

The pedagogical interventions in different streams of education showed the importance of changing the education methodology from conventional way of teaching to elevated levels. The core courses of the domain should be taught to understand the basics of the subject and to ensure that students can apply the basic knowledge to application related issues. Heat and Mass transfer theory subject is one of the influencing core subjects in the mechanical engineering field which has applications in wide range of the areas. The course finds application in diverse fields of engineering that involves use of heat energy to run machinery and generate power through energy conversion devices. The modern world uses myriad energy transformation devices wherein heat energy changes to other forms as in Internal combustion engines, Air conditioners, steam turbines, cryogenic devices and domestic cooking appliances. The thorough knowledge of heat transfer process constitutes important element of a mechanical engineers skill-set to address many engineering problems confronting our daily life activities. The course offers ample opportunity to impart methodological learning that target many of technical and professional Graduate attributes formulated for existing engineering education.

2. Literature Review

The ever increasing demand of vital resources like water, food and energy for human consumption has led to devising newer and cost competitive alternatives. The need to transform engineering education for the new millennium global needs has however not shown encouraging results at a faster pace despite of a multitude of novel pedagogical being proposed and implemented by the Academia worldwide. There have been considerable efforts to diagnose the lethargy in implementing path-breaking transformation in engineering education through trans-disciplinary studies on a systems perspective. The study reported on challenges towards educating students towards realizing engineering professional for 2020 through four institutional case studies practicing active learning initiatives. It was identified that the deterrent parameter for change was the "faculty commitment" to switch over from existing work-culture towards innovative education [2].

The transformations in engineering education towards developing congenial teaching-learning environs depend greatly on self-efficacy of teacher and student involvement. The reported work highlights the correlation between pre-service and in-service states of teachers towards their commitment to deliver the intended roles as educators in terms of theoretical and methodological issues. The reported 33 qualified case studies that included 16,122 pre-service and in-service teachers indicated that self-efficacy beliefs influenced their commitment to teaching profession [3].

The ability to engage in collaborative team learning and research has been identified as a essential ingredient for successful teaching profession. The 82 studies on collaboration attribute amongst teachers based upon narrative review aimed at quantifying terminological framework in previous research along with the focus and depth in collaborative research. The study also identified vital issues that facilitated collaborative research quantifying the overall gain to teacher, student and Institution as a whole. The study concluded that future schools of engineering should be role models to student community that would be contributing to overall growth of society at large [4].

The inquiry based learning has steadily gained popularity on account of electronic gadget support and inquiry-based learning frameworks strengths. The reported literature indicated Orientation, Conceptualization, Investigation, Conclusion and Discussion as five distinct phases of Inquiry learning, with certain sub-phases too. The categorized sub-phases included: Questioning and Hypothesis Generation (Conceptualization), Exploration/ Experimentation and Data Interpretation (Investigation), Reflection and Communication (Discussion) [5].

The solution exploration to Grand Challenges of 21stcentury demands unique attributes in engineering community, this has necessitated global changes in engineering education. The graduate attributes of transformed engineering lays emphasis on multidisciplinary teams, thinking and problem solving and communication. The engineering education research was a precursor to quality engineering education that prepared graduates to face new challenges. The engineering pedagogy must take a complete overhaul to meet demands of its stakeholders locally as well as globally taking a stand to adopt innovative teaching practices to meet future needs [6].

The web based learning (e-learning) offers several advantages to engineering education, however on account of poor infrastructure and lack of competent human resource its implementation in developing nations has been minimal as per the reported survey. The implementation of e-learning improved educational efficiency in engineering either offered to traditional delivery mode or through emerging pedagogy reformed approach as reported by several educational research findings. The implementation of e-learning had challenges like dispositional, learning style, instructional, situational, organizational, content suitability and technological [7].

The rapid pace of technological advancements in today's world demands practicing engineers to keep themselves updated with changes witnessed. The human resource graduating from engineering institutes unfortunately does not quite match to Industry that demands faster learn-ability in the new-recruits. The declining engineering education standard leads to huge economic losses and undermines occupational safety at work place. There is an urgent need to motivate to opt for career in Industry or pursue research oriented higher studies to add to the pool of teaching faculty in engineering education [8].

3. Methodology of Course Delivery

The Heat and Mass transfer course was taught at the third year of undergraduate program in Mechanical Engineering with the details on course outcomes defined through Table 1. The assessment plan for the course included a continuous internal assessment (CIE) and Semester End Assessment (SEE) based on the curriculum content. The CIE and SEE segments had uniform weight-age to decide the student performance for this 3 credit theory course spread over a 40 hour student contact. The details of the assessment and the mapping of course outcomes with Program outcomes are detailed out by Table 2 and Table 3 respectively.

Table 1: Identified Course Outcomes (co)

1. Apply concepts of conduction, convection, radiation and mass transfer to practical engineering applications
2. Apply steady and transient heat conduction to insulation sizing, fin selection and temperature measurements. 1.
3. Analyze laminar and turbulent boundary layer flow on internal and external regions.
4. Design shell and tube type heat exchangers for convective heat transfer applications
5. Analyze phase change heat transfer processes to process-heat applications
6. Apply fundamental laws of radiation heat transfer to engineering problems.
7. Analyze design calculations of thermal equipments and prepare technical report

Table 2: Assessment Scheme

Assessment	Marks
Minor Exam 1	20
Minor Exam 2	20
Course Seminar/Project	10
SEE Assessment	50
Total	100

Table 3: Mapping of Cos With Pos

CO Asse	PO1 Engineering knowledge	PO2 Problem analysis	PO3 Design/Development of Solutions	PO5 Modern tool usage
1.	M	H		
2.	M	M		
3.		M	M	
4.		M	M	
5.		M		
6.		M		
7.		M	M	M

The Fig. 1 indicates marks distribution in terms of Blooms learning levels for the Heat and Mass transfer course in the two segments of assessment that included CIE and SEE. The details of course delivery indicated that 80% of marks focused L3 or higher.

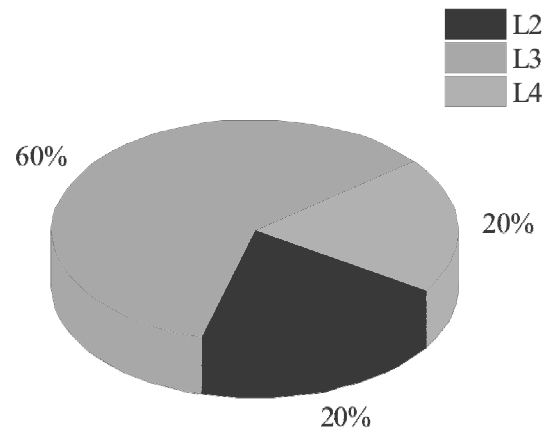

Fig. 1. Blooms Leveldistribution of assessment marks

The seven COs as defined in Table 1 were mapped to the chapter-wise course content amongst which CO7 was assessed through Course seminar/ Project. Each CO defined for the course was segregated to topic level outcomes (TLOs) that addressed micro-levels of the CO. The sample TLOs defined for the CO7 has been indicated in Table 4 clearly revealing that student activity performed as part of the Course Seminar and Project motivated them to apply computational tool to heat transfer problem thereby addressing PO5.

Table 4: Tlo For Course Seminar/project

TLO for CO7
1. Analyze current research publication on heat transfer to evolve a suitable model for solution of proposed problem
2. Analyze the existing literature to draw conclusive statements on the proposed heat transfer problem
3. Prepare a technical document on the heat transfer problem identifying alternate designs for specified application
4. Use computational tool for solution of heat tran sfer problem

The course seminar intended to give a holistic view of application and research needs in heat transfer with reference to Mechanical Engineering. The student was expected to perform following inquisitive study related heat transfer equipments such as Solar water heating system, Vapour compression refrigeration system, Steam power plant or any other such device that incorporates all three modes of heat transfer.

Expected outcomes: Explain working principle, basic component level design calculations, current trends available in market, Research avenues related to thermal equipment.

The overall course delivery was designed to cater to better teaching-learning process with adequate scope for student to explore the contemporary domains of heat transfer.

The overall transformations aimed through OBE based approach was prepared with student learning into the focus. The details of the pedagogical reforms were evolved over several iterations of course delivery over a period of more than five to six years. The students were briefed on the details of the assessment plan for the CIE as well as the SEE segments. The design of the question paper for assessment of student performance was meticulous tracked based on a well tailored distribution of marks that covered all the COs defined for the course. The student performance in the CIE and SEE components were tracked through statistical based software that gave valuable inputs on areas of concern in the course delivery. The overall exercise of course delivery and assessment followed the OBE frame work with use of active learning techniques to keep the students engaged in the class room deliberations. The students also were motivated to work on the course beyond the four wall of the class room.

4. Results And Discussions

The overall analysis of teaching-learning was based on consolidated student performance with sample size of 150. The fig.2 indicates student performance as grade points on a scale of 10: S(Outstanding-10), A(Excellent-9), B(very good-8), C(good-7), D(Fair-6), E(Satisfactory-5) and F(Fail-0). The student securing a F-grade was made to repeat the course as it was a grade equivalent to being in-eligible in the specified course. The observations from the results indicated in fig. 2 showed peak grade for the course to be B-grade with close to 50% of student securing this grade. The students scoring A or higher grade was 24%, grades between C to E accounted for 16% while 10% of the students secured F-grade in the course.

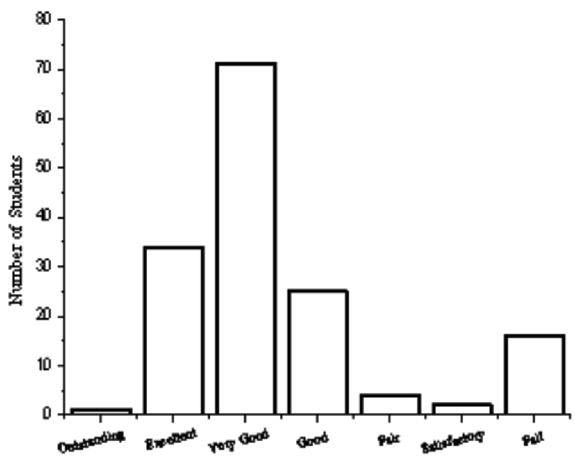

Fig 2: Quantitative assessment of student performance

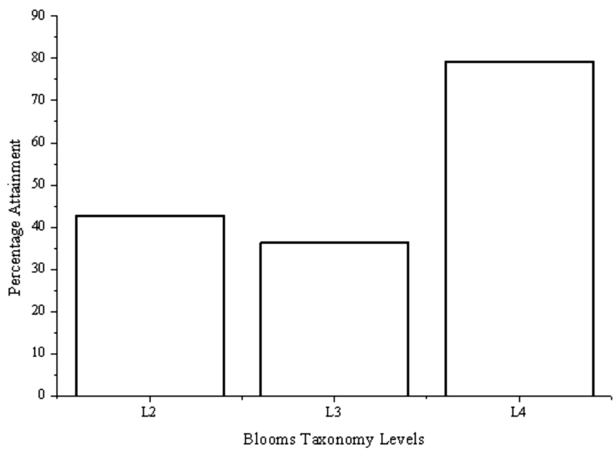

Fig 3: Attainment in terms of Blooms learning levels

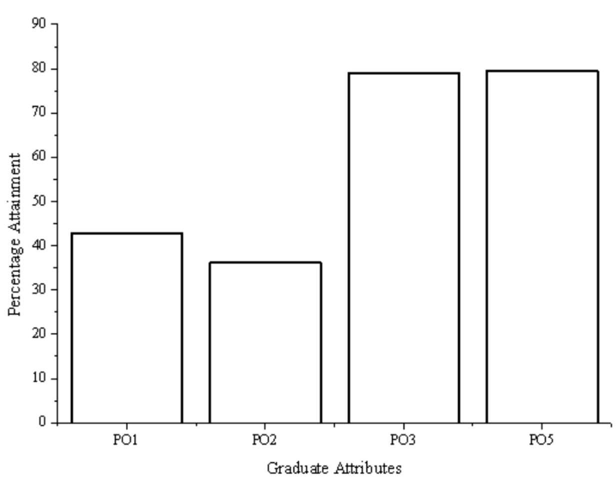

Fig 4: PO attainment levels for the course

The trend exhibited in fig. 3 shows the relative performance of students with respect to the Bloom'slearning levels (L2-Understanding, L3-Applying and L4-Analysing) described by the assessment process for the Heat and Mass transfer course. The attainment in L4 level assessment has been observed to be relatively higher (80%) as against the L2 and L3 levels that respectively recorded 43% and 35% attainment. The higher level of performance in the L4 segment was attributed to the fact that majority of the assessment done in the L4 level was restricted to the CO7 course outcome that was based on active learning concepts. On the contrary the assessment in L2 and L3 level questions were designed to assess the remaining course outcomes CO1 to CO6 that were based on the conventional assessment methodology that included written question and answer type. The lower attainment in the L3 level assessment questions was attributed to difficulty faced by students in analyzing heat transfer related problems. On the other-hand the L2 questions were well received by students as they were involving lower levels of thinking capabilities. Thus it can be observed that students performed well in newer methods of assessment that were challenging to their skill-sets while they were not very open to conventional based assessment that questioned their fundamental skill-sets.

The results indicated by fig. 4 speak on student appreciation for assessment methodologies that take them to real life situations in terms of using concepts for designing thermal systems and use of computational tools. The assessment of PO3 and PO5 were linked to greater extent with the CO7 course outcome, while the program outcomes PO1 and PO3 were tracked through the course outcomes CO1 to CO6. The observations made through fig. 4 strengthen the remarks made in the preceding discussion on the student choice to newer methods of assessment and exposure to the practical aspects of the course.

5. Conclusions

The conclusions drawn through the study indicated that,

- The inclusion of practical concepts and research element in the course content motivated students to explore more on the heat transfer course taught. The newer teaching methodologies like Problem based learning or Project based learning gave ample scope for enticing student interest thereby motivating them to research.

 The performance of students in Heatand Mass transfer theory course indicated 70% of students securing pointer of 8 or higher on the 10 point scale. The poor performance of other 30% reflected their aversion to analytical approach that was essential segment of the course. It was therefore cited that there was imminent need to adopt alternate approaches to generate interest in students albeit to their aversion for mathematical concepts.

 Assessment that involved real world situations like reviewing research paper or designing a thermal system sustained student interest in course despite possible disconnect with mathematical or high level physics. This has been evidenced through an attainment level of 80% for PO3 and PO4 against 45% for PO1 and PO2.The same trend was observed with respect to higher level of student scoring for L4 assessments over L2 and L3 questions.

 The new genera of learners correlated concepts better through practice than theoretical illustrations as indicated through relative performance between theory oriented and practice oriented tasks performed in the assessment. Therefore a proper combination of theory and practical sessions make a better integrated approach that can help student understand the concepts better. The seminar/course project component was well received by students as compared to assessment based on conventional written tests.

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References

[1] David E.Goldberg, Mark Somerville, The Making of A Whole New Engineer: Four Unexpected Lessons for Engineering Educators and Education Researchers, Journal of Engineering Education January 2015, Vol. 104, No. 1, pp. 2-6

[2] Junaid Abdul Wahid Siddiqui, Transformation of engineering education: Taking a perspective for the challenges of change, Ph.D Thesis, ProQuest, Purdue University, 2014

[3] Steven Randall Chesnut, Hansel Burley, Self-efficacy as a predictor of commitment to the teaching profession: A meta-analysis, Educational Research Review, Volume 15, June 2015, Pages 1-16

[4] KatrienVangrieken, Filip Dochy, Elisabeth Raes, Eva Kyndt, Teacher collaboration: A systematic review, Educational Research Review, Volume 15, June 2015, Pages 17-40

[5] MargusPedaste , Mario Mäeots , Leo A. Siiman , Ton de Jong ,Siswa A.N. van Riesen, Ellen T. Kamp , Constantinos C. Manoli, Zacharias C. Zacharia , EleftheriaTsourlidaki, Phases of inquiry-based learning: Definitions and the inquiry cycle, Educational Research Review 14 (2015) 47-61

[6] M. Tariq Banday , Musavir Ahmed , Tariq R. Jan, Applications of e-Learning in engineering education: A case study, Procedia - Social and Behavioral Sciences 123 (2014) 406 - 413

[7] FatinAliahPhang, KhairiyahMohdYusof, Taking the "Guess-work" Out of Engineering Education:Establishing the Virtuous Cycle of Research, Procedia - Social and Behavioral Sciences 102 (2013) 212 - 220

[8] Murat Sonmez, The Role of Technology Faculties in Engineering Education, Procedia - Social and Behavioral Sciences 141 (2014) 35 - 44