

Tipping Point Leadership Theory to Improve Research Culture in Engineering Education

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Abstract—Indian government is aggressively promoting research culture in universities and institutes across nation. Research and innovation is the most important key for sustainable national growth. This paper presents a case study of tipping point leadership theory to improve research culture in engineering education. Paper presents the steps of problem identification, root cause analysis and process established to improve research culture in CS&IT department. All these points are presented from tipping point leadership perspective. Proposed processes and results are beneficial and roadmap for any higher education department or institute. The analysis shows that the main hurdle to increase research and innovation in higher education institute is cognitive hurdles and motivational hurdles among faculty and students. There is need to promote need and importance of research in academics.

Keywords— Cognitive hurdles; Engineering education; Research policy; Tipping point leadership.

JEET Category—Research

I. INTRODUCTION

According to Indian national educational policy 2020 knowledge creation and research are important for sustainable economic growth of nation and uplifting society. Western universities have created to excellent research and innovation culture. It gave birth to new business models and technologies. Technology products and services contribution to their GDP is significant. Ranking of Indian universities are average or below average. Research and innovation investment in India is only 0.69% of GDP. Climate change, population, biotechnology, digital marketplace and the rise of artificial intelligence created need for research and innovation culture in India. There is strong need to inculcate research culture in Indian universities and higher institutes. This is a challenge to government and institute leaders. Indian government is planning to establish a National Research Foundation (NRF) that will coordinate research funding with other funding agencies. NEP 2020 includes identifying student interests, promoting research in universities by inclusion of research and internships in the undergraduate curriculum, faculty career management systems.

In literature, tipping point leadership theory is used in different organizations. Kim and Mauborgne (2003) presented the application of TPL theory by William Bratton police commissioner of New York City. With this theory,

William Bratton made New York safest large city in the USA. Ganapathy (2018) presented the need of applying tipping point leadership in bringing in business schools in India. This paper presents tipping point leadership theory and its effective application to higher education institutes for improving research and innovation culture.

The objectives are,

1. Application of tipping point leadership theory to improve research culture in engineering education
2. Design the processes based on tipping point leadership theory to improve research

The main contributions of the paper are,

1. To the best of our knowledge, the tipping point leadership theory is not applied to improve the research and innovation culture in higher education institutes.
2. Paper presents the main hurdles for poor research activates in engineering institutes
3. A roadmap to strengthen the research culture is presented.
4. A case study of the proposed road is presented with results.
5. The proposed roadmap is general and applicable to other engineering departments.

The remaining paper is divided into following sections. Section II is about identification of reasons to improve research culture. Section III presents the methodology used to apply tipping point leadership theory. Section IV discusses the result and the conclusion is given in section V.

II. REASONS IDENTIFICATION TO IMPROVE RESEARCH CULTURE

In literature, the three main general challenges for research in India reported are, (a) Less number of research-focused institutions (b) Lack of funds and laboratories availability (c) Focus is on expansion than quality.

The problem is identified using the current research status at CS&IT department, Rajarambapu Institute of Technology, Rajaramnagar, Sangli, MS, India. We collected previous year's faculty publications, student publications and funding proposals. Faculty and student survey is conducted to take their feedback and understand their views about research and innovation.

A. Publications and Funding proposals

The collected data is analysed from different perspectives namely number of publications in Scopus journals, peer reviewed journals, conferences and number of faculty members involved in research publication. Publications in quality journals like Scopus indexed, h-index journals and web of science-indexed journals are less. Only few faculty members are involvement in research activities.

Few project groups of final year are involved in research-based projects. The student's publication data shows that few students are involved in conference research publication. The data shows that only final year are students are writing the research articles based on project implementation. The second year and third year students are not involved in research work.

Only few proposals are submitted for funding agencies. The granted funding projects are very marginal. Approximately 15-20 percent faculty members are doing in-house see funding projects.

B. Research interest feedback

The research interest feedback was collected from all the students of the department and the statistics are as shown in Table I.

TABLE I
STUDENT SURVEY

Survey questions	Options	
I know about research methodology	Yes or No	
Participation in research is important		
I am interested in software development than writing research paper.	Yes, Always	Sometimes,
I am familiar with my teacher's research work.		
Like to interact with researchers in the community/institute.		
The research culture in institute encourages my learning process	Strongly Disagree,	Disagree, Neutral,
I know the recent developments in the research field	Agree, Strongly agree	
Courses that I am studying encourages enthusiasm and personal interest about research		

Following are the observations based on the analysis:

1. Majority students are not involved in the research work.
2. 49% of students have a research interest but unaware of the process and methodologies
3. Students are not exposed to the recent research developments and the research work carried in the department.
4. Students are facing difficulty in writing research papers.
5. Students are not opting for the research track.

To understand the perception of faculty members, a survey is conducted shown in Fig. 1. More number of faculty

members feels that research is secondary after teaching activities. In majority of faculty members, focus is on teaching activities and they are not able to correlate teaching with research activity.

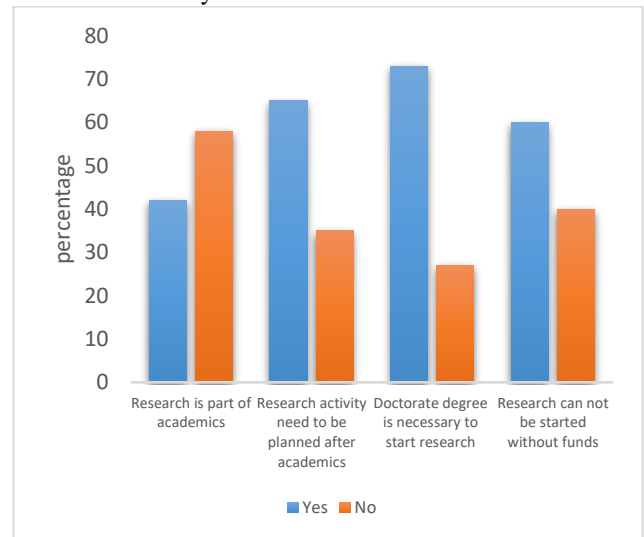


Fig. 1. Faculty survey

C. Finding the Root causes

A Fishbone diagram (Ishikawa diagram) is used to see cause and effect. It is used in various applications to identify the root causes. Sheng-lei (2009) used Fishbone diagram for identification of causes in project management. Luo et al. (2007) used for operation management, Reilly et al. (2014) used for analysing diagnostic errors and Shinde et al. (2018) used for the staff and student-related problems in technical education. The reasons with respect to identifying poor performance in research and consultancy of CS&IT department are expressed through the cause and effect diagram in Fig. 2. The WHY-WHY analysis is applied on the overall causes/phases identified during the problem analysis. It was found that the following are the root causes for the poor performance in research and consultancy of the CS&IT department. The WHY-WHY analysis is performed by the team members, with the assistance of head of the department, other faculty members of the department. It is shown in Fig. 3.

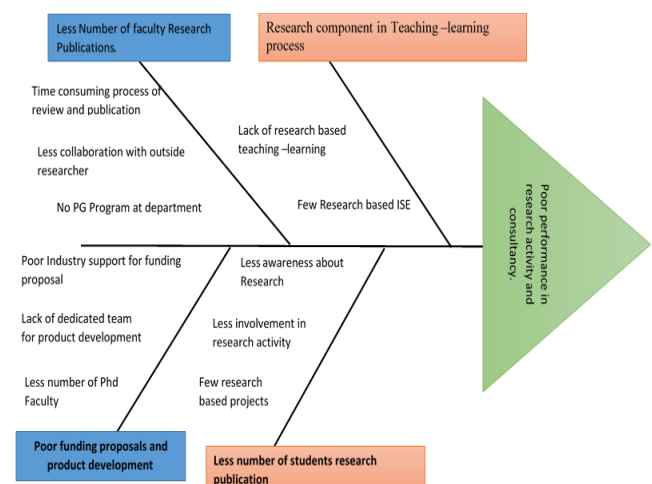


Fig. 2. Fishbone diagram (cause-effect diagram)

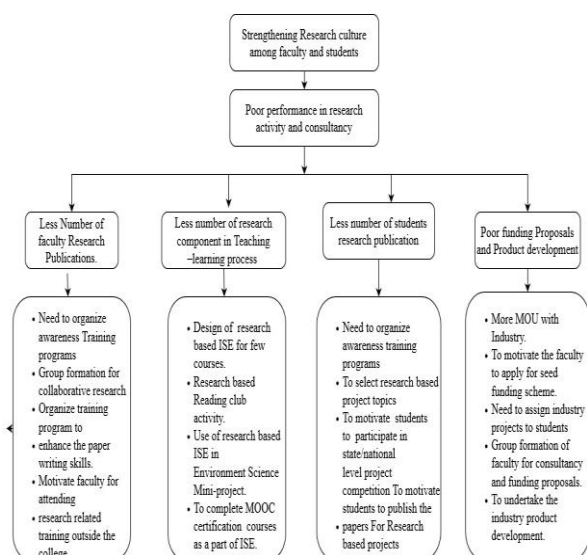


Fig. 3. WHY-WHY analysis

Hurdles for research in academic institutions

1. Our undergraduate students read a lot, but they have always been traditionally taught to read textbooks. There is no initiative to prime them for reading journal articles.
2. Assessment methods focus on remembering level questions
3. Lack of recognition in society for research work
4. Lack of incentives
5. Low self-motivation and interest for research

III. APPLICATION OF TIPPING POINT LEADERSHIP THEORY

Knowledge, skills and positive attitude (KSAs) play a vital role in affecting the choice and inclination towards research or teaching. Competency drives one to make selection between research and teaching or both. Normative social influence affects the decision of the faculty to increase or decrease the level of their inclination towards research or teaching or both. The influence of university or institution, peer pressure, expectation of doctoral students working under them, competition and urge to be ahead in industry in terms of grants and publication do influence the preference for research or teaching.

Tipping point leadership theory provides framework and methodology to overcome the issues in implementing projects with specific objectives. The theory presents the

main hurdles that block the project execution namely cognitive, resource, motivational, and political hurdles as shown in Fig. 4.

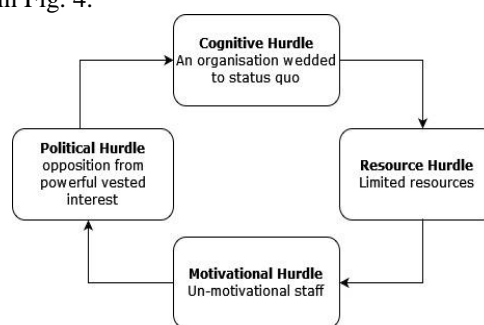


Fig. 4. Tipping point leadership theory

To achieve the excellence in research activity we did the work breakdown and project activities as shown in Fig. 5 and Fig. 6 respectively. Faculty groups are formed based on training need analysis with respective area of interest. The workshops and training are organized as per the need of groups. The standard operating procedure are set for increasing research publication, funding proposals, to increase the involvement of faculty as well as students.

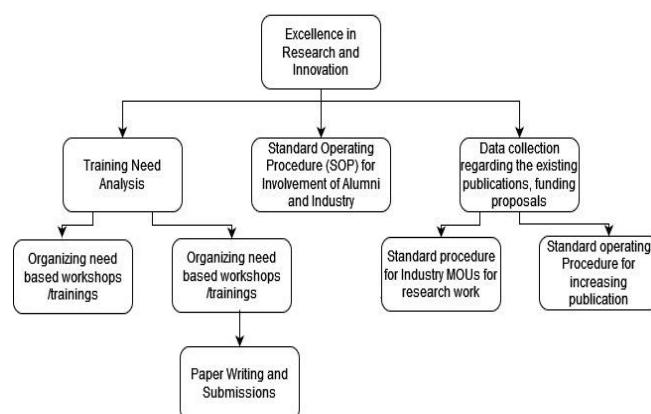


Fig. 5. Work breakdown structure of project

The project activities are scheduled with the help of Gantt chart. It is useful to control a large number of activities, and to ensure that they are completed on schedule.

Activity	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12
Faculty training need analysis (TNA)												
Designing student and faculty survey												
Conducting survey												
Survey and data analysis												
Faculty research publications												
Faculty team formation												
Organizing training programs as per faculty research interest												
Research problem identification												
Conducting research												
Organizing training program on research paper writing.												

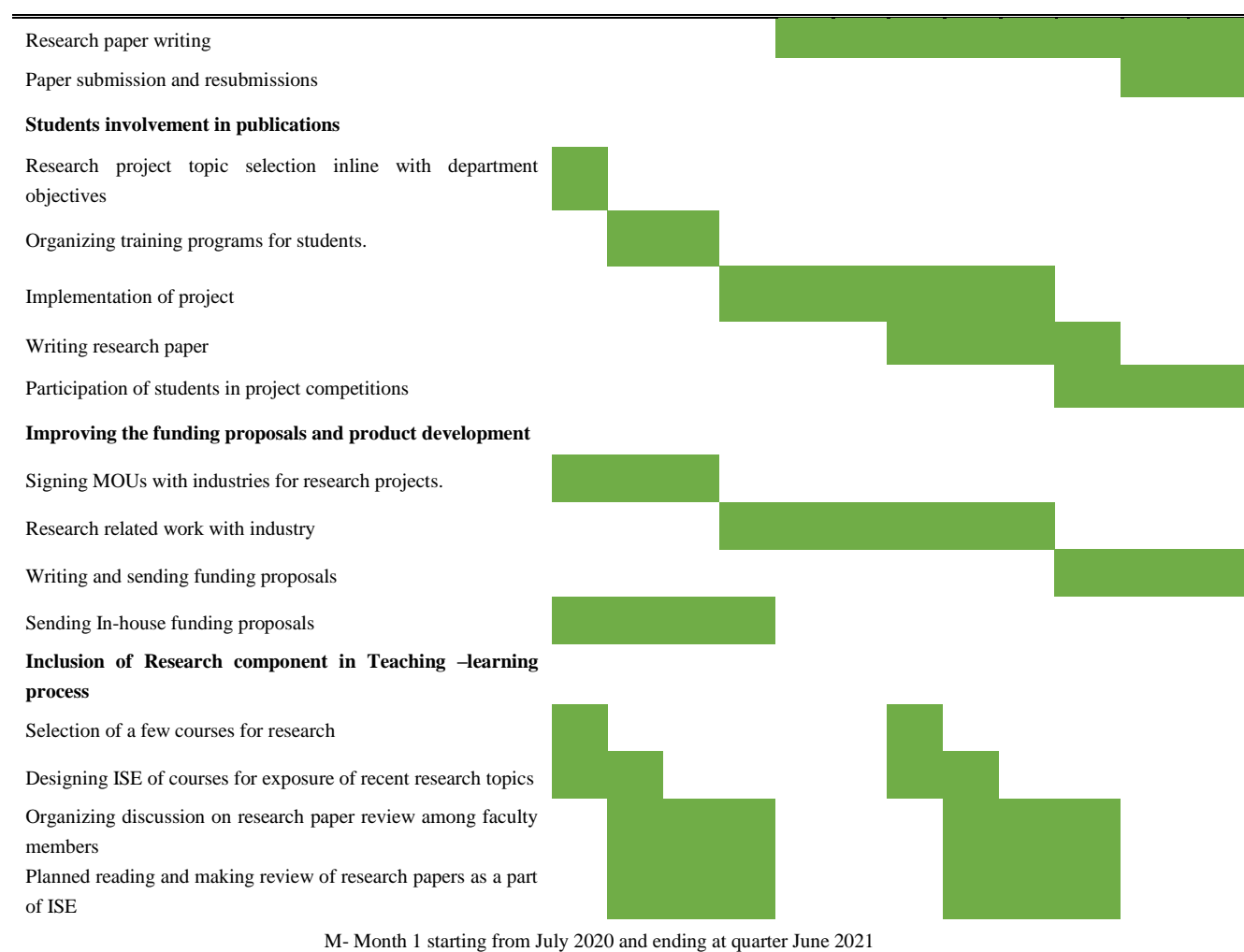


Fig. 6. Project activities

To improve the understanding of project management, we used metrics as shown in Table II. The used project metrics helps to minimize the uncertainty in project.

TABLE II
PROJECT METRICS

	Level 1	Level 2	Level 3
Objectives	Increasing research paper publication	Increasing funding Proposals	Including research in Teaching – Learning process
Deliverables	SOP of research paper publication	SOP of funding proposals	Student's publication count and number of students
Schedule	First draft completion of SOP in three small teams	Permission from institute authorities	Brainstorming and acceptance by stakeholders
Cost	Provision in department budget	Institute level budget allocation	NA

The measures used for metrics using different levels for each deliverables as shown in Table III.

TABLE III
MEASURES FOR PROJECT METRICS

Deliverables	Level 1	Level 2	Level 3
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Research Paper	5% increase in number of publications	8% increase in number of publications	15% increase in number of publications
Funding Proposals	Tie up to industry	Involvement of all faculty in writing funding proposal	5% increase in number of funding proposals
Research in Teaching – Learning	Designing ISE	5% increase in number of students for writing paper	10% increase in student's publications

We have identified some causes, which may incur delay in the progress of our objective of improving the research activity and found some remedy to avoid the delay. Table IV presents the causes of delay and remedies.

TABLE IV
CAUSES OF DELAY AND REMEDIES

Deliverables	Cause of delay	How to overcome
Research Paper	Availability of resources, delay in review process	Provision in budget for R&D procurement
Funding proposals	- No novelty in idea - Insufficient funds, - Less expertise in technology	-Brainstorming with experts -External funding, - Tie up with industry/research organization
Research in	No proper design of	-Timely review

Teaching – Learning	ISE	-Organizing expert sessions
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A. Cognitive Hurdles

This is a difficult hurdle in any organization to make the team members agree that the problem exists and there is need to change. Project leaders need to take efforts to change the people's beliefs and convince for change.

We conducted different activities to improve involvement of more number of faculty members and students in research activities. The objective is to improve the research publications, funding proposal submissions and research based projects. To overcome the cognitive hurdles the following activities are planned and completed during the academic year 2020-21.

1. Each individual faculty's area of interest is taken.
2. Identified department thrust areas from market study, expert interactions and national educational policy 2020 guidelines. The identified research areas are machine learning, deep learning, Internet of things and cyber security. Outcome based learning is common investigation area for all faculty members.
3. Prepared training need analysis based on above two steps.
4. Faculty groups are formed as per their interest in the research area for collaborative research (see table V).

TABLE V
FACULTY RESEARCH AREA

Identified area	Identified sub-areas
Machine Learning	- Text and image classification - Natural language processing - Data analytics - Computer Vision
Internet of Things	- Smart agriculture - Smart city
Teaching-Learning Methodology	Problem based learning Employability Technology adoption

5. To promote the research in outcome-based education, department level reading club activity is implemented. In this activity, the faculty groups are formed based on the course they involve. Three groups are formed namely programming courses, core computer engineering courses and advanced technologies as shown in Table VI. The objectives of reading club activity is to do the literature review of teaching learning techniques used for selected course. Outcome of literature review is taken for planning the teaching learning and evaluation for academic year 2021-22.
6. Student's project topic selection is done based on the focused research area of faculty.
7. For few research-based projects, research paper publication is planned as a part of in-semester evaluation.
8. For a few advanced technology courses, we designed

in-semester evaluation (ISE) where students have to read a research paper and complete the case study by reviewing the number of research papers to understand the problem definitions, implementation methodologies, datasets etc. Table VII shows the course selected for research based ISE.

TABLE VI
GROUPS FOR READING CLUB

Group	Courses
Programming courses	C, python, Java programming, Web technology
Core computer engineering courses	Automata theory, Digital Electronics & Microprocessor
Advanced technologies	Advanced database system, Computer graphics, Big data, Data analytics, Cyber security

TABLE VII
COURSES FOR RESEARCH BASED ISE

Courses	Class
Cloud Computing	Final Year
Business Intelligence	Final Year
Biology for Engineers	Third Year
Machine Learning Algorithms	Third Year

B. Resource hurdles

Limited resources is next important hurdle for successful execution of project. Project leader need to provide the extra resources and schedule the available resources in an effective way.

1. Faculty and student trainings: Organized training programs/webinars related to the interested research areas of faculty. Organized training program on research paper writing.
2. Laboratory development: To provide resources for the research work we provided physical resources like high performance computer, IOT kits and sensors.
3. Collaboration with outside experts: In the CS&IT department three MOUs have signed in year 2020-21 with industries for research projects shown in Table VIII.

TABLE VIII
MOU SIGNED WITH INDUSTRIES

Name of the Industry	Area/ field	Purpose
EXPERTEZE, USA	Bioinformatics	Provide training in bioinformatics and computational neural network
XENSTACK LLC, USA Xenstack Solutions India Pvt. Ltd.	DevOps, Cloud Automation	Centre of excellence

JSR Private Limited, Pune	Conference, FDP	Organizing IEEE Conference
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C. Motivational hurdles

Alerting employees for change and identify ways to achieve it is next challenge. Leaders need to motivate team with moral support, incentives etc.

The people in academics find it difficult to do research due to busy schedules in teaching activity and administrative work. Due to lack of time, they get frustrated about the research, as research requires dedication of time and effort. Because of this, their own research is lagging and involvement of students does not happen. We planned many activities to motivate the faculty as well as students to improve the research activity. The activities are as follows,

1. Teamwork and collaboration: Teams are formed as per training need analysis shown in Table V.
2. We provided financial support for the research work under college's in-house seed funding scheme for research work. In addition, funds are provided for attending and organizing faculty development programs and conferences.
3. We motivated faculty to send in-house funding proposals, total four proposal were sent out of these three were sanctioned.
4. We motivated faculty to attend more training programs related to respective research areas outside the organization.
5. To appreciate and recognize the research work college has announced best researcher award to boost R & D activities and to engage faculty in research work. Publications in Scopus and SCI indexed journals is promoted.
6. Faculty evaluation: In faculty appraisal System like KRA (Key Result Area) and API more weightage is given for quality.
7. Teaching course allocations as per area of interest. The faculty choice was taken before the allocation of courses. Most probably, courses are assigned related to their research interest area.
8. Motivated students to participate in project competitions. Some weightage was given in In-semester evaluation of projects for participation in project competitions.

D. Political hurdles

Business and organizational politics in next important hurdle. We do not find any political hurdles in inculcating research culture in department.

IV. RESULTS AND DISCUSSION

We organized more number of workshop/training/webinars for faculty and students to motivate for participation in research activities such as project competitions, conferences and journal publications. We observed that the participation of students in project competition has increased significantly as shown in Table IX.

TABLE IX
STUDENT PARTICIPATION

	2019-20	2020-21
Webinars	3	5
Workshops	2	3
Hackathons	1	5
Product development projects	2	2

To include the research component in teaching –learning process the reading club activity was organized where faculty groups formed based on their teaching course mentioned in Table VI. All groups have started their research related to their assigned area. Every group-reviewed papers to take review of teaching methods adopted, evaluation method adopted for the courses under assigned group and suggestions given by author for further improvements. The report is formed to make the summary.

Table X shows advanced technology courses, for which we designed ISE where students has to read research paper and complete the case study by reviewing the number of research papers to understand the problem definitions, implementation methodologies, datasets etc.

V. CONCLUSIONS

Tipping point leadership theory has its roots in Epidemiology. It focuses on the root cause of organization progress by addressing the beliefs and energies of a people within organization. This paper presents a case study of applying tipping point leadership theory to improve research culture in engineering institute. Paper presents how the hurdles are identified and addressed with new processes.

To inculcate research culture at the department it is necessary to arrange special training for research trends, research methodology and writing research papers. Students' involvement in the research projects would be encouraged in the department. The factors affecting the students' performance are less research interest, no collaborative research and less product development. Paper presents detailed project activity to improve the publications, funding and improvement in teaching learning using research perception. Project breakdown, activities, deliverables, metrics, risk management steps are presented which can easily replicated for any department. Results show that perception of teachers and students changed about research during the project period. If teachers include research activity as a part of teaching learning process then involvement of students increased significantly. If the faculty tries to involve a group of undergraduate students in small research projects then it will help a lot. Even if students are involved in simple literature review projects, they will be exposed to read journal articles and formulate reviews.

TABLE X
RESEARCH BASED ISE

Course	Activities conducted	In semester evaluation	Outcomes
Cloud Computing	The research paper reading methods discussed by course in-charge during the lectures. Some sample conference papers reading is done in front of students and identified different research directions in cloud computing. The research paper summary preparation is discussed in a classroom.	Case study and report writing. Each student has to select one IEEE conference paper. He/she has to read it thoroughly and present the review of the paper with a review report.	Students have submitted 2-3 page reports on the given research paper.
Business Intelligence	The research papers are discussed by course in-charge during the lectures	Case study. Students have to select real time business problems. Define the problem and study the related dataset. Implementation of machine learning algorithm and preparing the detailed report.	Students have identified real time problems and problem formulation is done. Implemented machine learning algorithm on selected dataset and results are presented with detailed reports.
Biology for Engineers	Group discussion	Students need to select any biomedical instrument/device of the latest version. Then they have to perform a detailed analysis of the working of the instrument and examine how and where the engineering is applied.	Students have done analysis of selected instruments and presented.
Mini-project	Session arranged for literature review and writing research paper.	Research based topic selection. Writing research paper.	Every group done literature review based on 10 recent papers. Few groups submitted papers.
Machine Learning Algorithms	Group discussion	Students are asked to search and study use of machine learning by well-known companies like Facebook, twitter, Netflix, Whatsapp, amazon, yahoo.	During ISE work students analyzed how machine learning is used by the various companies and how it is beneficial to them.

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