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Educating IT-Engineering Theory Courses using BLOOMS Taxonomy(TC-BT)as a Tool and Practical Courses using Magic of Making Mistakes (PC-MoMM): An Innovative Pedagogy.

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Abstract: This paper expounds a novel pedagogical approach used to teach engineering theory coursesby using BLOOMS TAXONOMY(TC-BT) as a tool and practical coursesusing Magic of Making Mistakes (PC-MoMM) in Information Technology programme. The instructions and activitiesfor the theory course being taught are planned in accordance with the cognitive levels of complexity. For each unit being taught, assessment methods are planned to check whether the cognitive levels ofBLOOMS Taxonomy are attained or not. The practical course is planned using MoMM pedagogical approach which alsointegrates collaborative learning activities and peer-to-peer assistance during the laboratory slots. During the implementation of this approach Information and Communication Technology (ICT) tools are used to evaluate students' performance to obtain immediate feedback. Based on the results and feedback, appropriate measures are taken to enhance the learning of students. The results are analyzed and had shown great improvements in the learning of the students. The MoMM approach seemed to be very effective for the programming courses. Designing instructions and assessment as per cognitive levels also directed faculty in the course improvement.

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1. Introduction

Engineering education globally has shifted towards Outcomes Based Education (OBE) paradigm. Kasegaon Education Society's Rajarambapu Institute of Technology (RIT) was established in 1983 in an elfin village Sakharale and was awarded academic and administrative autonomy in 2011-12. RIT is exploring the wings of academic autonomy in the design of curriculum, instruction and evaluation and assessment methods for the courses offered: by considerably incorporating new educational settings with a goal to improve the cognitive ability of students.

Educators have their own pedagogy while delivering education. The common objective of any educator or pedagogy is to give systematic instructions that provides skills and knowledge to the students which can be exhi-bited to accomplish their jobs. In traditional education systems the pedagogy is Teacher-Centered: where teacher is the only source of information and Teacher-Dominated: where only teacher speaks and students listen. This system neither could help the community to effectively demon-stration or apply the learning nor formulated and used any method to measure the outcomes. An outcome is a ending demonstration of learning. The failures of the traditional education system resulted in the paradigm shift towards Outcome Based Education (OBE). OBE is a process that involves the restructuring of curriculum, assessment and reporting practices in education to reflect the achievement of high order learning and mastery rather than the accumulation of course credits (Tucker, 2004).

BLOOMS TAXONOMY the well-known model that classifies the forms and levels of learning was created in 1956 by psychologist Dr. Benjamin Bloom to promote higher forms of thinking in education. According to ABET, Bloom's Taxonomy is a multi-tiered model of classifying thinking according to six cognitive levels of complexity.A framework that characterizes complexity and higher-order thinking.Educators use Bloom's taxonomy to guide the development of assessments and evaluations of student learningand instructional methods such as questioning strategies.

This paper discusses a novel engineering instructional pedagogy that is devisedand practiced for the course "In-ternetworking Protocols" which is in the curriculum of pre final year students of IT department at RIT. The following sections are reserved for discussing: related work done in design and adoption of pedagogy in to disciplinesin second section, motivation behind this work in third section, PC-BT pedagogy used for theory course in fourth section and PC-MoMM pedagogy used for practical course in fifth sectionand conclusion& future workin sixth section.

2. Related Work

This section discusses the research work done by educators ondifferent pedagogical approaches.

In [1], the authors have identified the Key concepts of differentiated instruction like: qualitative & Quantitative work, assessment to determine the needs of individuals, student centered learning and a blend of whole-class, group and individual instruction. Identified the key con-cepts, they designed a pedagogy that includes the differen-tiated instructions throughactive strategies to address the different learning styles of students.

In [2], the author used Learning through Writing (LtW) pedagogical approach to observe and measure improve-ment in students' writing in the discipline, and record stu-dent responses to the effects on their learning, by imple-menting LtW pedagogy in a laboratory course. The learn-ing outcomes required to demonstrate the writing skills are identified and initiatives like workshops and design of action projects are taken to improve the outcomes. The pedagogy is implemented by clearly identifying the grade components, and assessed through RUBRICS. The seven-teen survey questions mentioned provided insights into what communication skills an educator must have. It would of great useful if the authors had provided the res-ponses of LtW Student Survey mentioned in appendix 4 of their paper.

In [3], the authors present a project based pedagogy for energy and environment course. The course provided a list of topics the students can choose for the project work. The course pedagogy used the RUBRICS to evaluate the stu-dents' project work. The evidences of student evaluation shows that the teaching and learning for that course was enhanced to greater extent.

In [4], the authors presented their efforts taken in the department of IT at RIT, to improve the placement of students. They have identified the most important skills an IT graduate must have and devised strategies that will improve the programming skills, project making skills and professional skills of the students. They have started a Placement Club where the professional skills are practiced by the students on their own without any faculty's supervision to enhance the self-learning amongst the students: by creating a friendly environment to make mistakes and learn from the mistakes. This papers makes use of this "making mistakes" concept and applies this method during the laboratory hours of programming courses for improving the programming skills.

3. Motivation

The second section provided several pedagogical in-structions adaptedby authors to suite their disciplines with a goal to achieve higher order thinking. With several changes that have taken place in the way students learn and educators teach, the 21st century educators must be sensitive to the needs of individual students. ICT literacy is the basic need and has become a basic tool to meet the learning needs and must adapt to a student centered peda-gogy for extending the learning beyond classroom. To promote the higher order thinking among the students, the educators needed a suitable eco system. But the greatest challenge the educators face is with the dynamics of class-room and the factors like:

traditional classroom having large number of students, fixed classroom timings, differ-ent learning needs of students with different backgrounds, limited resources and student's attitude expecting the fa-culty to teach everything. To overcome these challenges and promote higher order learning, we designed a pedago-gy that best suits by considering the classroom dynamics, learning goals, assessment methods and teaching-learning activities by identifying the situational factors.

This motivated us to device a customized pedagogy for the IT courses at our department. The pedagogy discussed in this paper is experimented on the course titled "Inter-networking Protocols", which is both theoretical and prac-tical course.The sections below discuss the pedagogies used for theory and practical course. The results of Com-puter Networks course is used for comparison.

4. Pedagogy for theory courses using Blooms taxono-my (TC-BT) as a tool.

On defining the goals of the curriculum, the subject specific content to be learned by the student is assisted through teaching activities, assessment methods and learning activities.How do students know the pedagogy designed for the course? This is done by distributing a course plan which is designedthat consists of the course description, prerequisites for the course, course learning outcomes, ground rules, evaluation schemes, assessment activities and teaching learning activities.Both formative and summative assessment activities are designed and comprised for the course. The pedagogy of the IP course is planned as follows:

A. Course Plan: The course plan consists of course details, description, prerequisites, outcomes and evaluation plan and ground rules.

B. Multiple Choice Questions (MCQ) Tests: MCQ tests are designed for every unit to assess the previously learned information.

C. Definitions: A document containing all the definitions of each unit is provided to the students and a test is conducted and is peer evaluated by the students to as-sess the comprehension skills of the students.

D. Assignments: List of assignments for each lecture are provided to the students. This is a summative assess-ment to assess whether the students are able to apply the knowledge to the actual situations.

E. Case Studies: Few case studies are provided to the students to improve the analytical skills.

F. Collaborative Activities: Few activities are planned to promote active learning amongst the students.

Designing the course delivery in this way facilitated the students to learn step by step, get feedback on their lear-ningandenhanced the student'slower levels of learning.

The "Internetworking Protocols" course is about mak-ing practical application of knowledge of sciences/ sub-jects like Data Communication, Computer Networks and Internet Technology in the design and implementation of protocols to provide specific services over Net-work/Internet. The goal of the course is to make students aware about Client server model & socket interface, Next Generation IPv6 and ICMPv6, BOOTP, Dynamic Host Configuration Protocol, Domain name system, TELNET, File Transfer Protocols, Electronic mail protocols and other Internet Protocols. Lab work includes implementing client/ Server programs for few services and introduction to packet analyzers and Network Simulator (NS-2) with their installation and configuration. The prerequisites for the Subject are:

- Basic knowledge of data Communication
- Good knowledge over Computer Networks
- Basic knowledge of Socket Programming using Berkely Sockets

The Course Learning Outcomes are given below. After completion of the course the students must be able to:

- Demonstrate the working knowledge of Berkely socket programming for the given requirements.
- Identify the features of next generation addressing and protocols.
- Use protocols like DNS, FTP and TELNET to access/provide the services over the network.
- " Explain the concepts of protocols like IP, FTP, TFTP, Remote Login and TELNET services along with their packet formats.
- Practice the HTTP, SMTP protocols, Packet analyzers and Network Simulators (NS-2) and illustrate the same for a given scenario.

The pedagogy used for the courseis provided to the stu-dents through the course plan. To achieve the higher levels of thinking the students must be good at the lower levels of thinking like knowledge, comprehension and application. Remembering previously learned informationand grasping the meaning of information is required to achieve higher order levels of thinking. Hence formative assessments are designed for the first two levels and for application level lecture wise assignments are designed which are of summative type. To check whether the students remembered the previously learned information, Multiple Choice Questions (MCQ) test is conducted during the last ten minutes of lecture after discussing the facts, terminology and concepts of each topic. Though this MCQ test conducted by displaying the questionson the screen could provide some feedback, it could not provide all students a chance to respond and was also time consuming. Hence to overcome this online MCQ tests are planned for each portion of lessons. The students are asked to take the tests at their convenient place and time before attending the next class making it a Flipped Formative Assessments (FFA). The average scores of the tenFFA testswhich were for 15 marks are shown in the table 1.

The average scores of the students had provided an im-mediate feedback on how much students remembered previous concepts. An informal feedback from the stu-dentsstatedthat they are not revising the concepts after the lecture. This shows that the students should be motivated to practice continuous learning skill because they are refer-ring to the concepts only before or during the exams. To partially address this problem and promote continuous learning, Think-Pair-Share activity was performed during the last ten minutes of each lecture. Here an MCQ is asked to the students. Instead of single student answering, he/she can think, discuss with the bench mates and answer the MCQ. During this activity the students felt responsible and were also prepared for the next class to answer the MCQs. Asking any student of a bench to answer the question not only motivated students to think and share the concepts but also addressed the inferiority complex issues of students to stand up and answer. The results of whether this activity motivated the students for continuous and self-learning is shown in Course feedback in figure 11with scores in third row of table 6.

Table 1: Average scores of each MCQ quiz & remarks.

Quiz No	Average Score (15)	Student Remarks
1.	9.2	Not revised after lecture
2.	6.0	Not revised after lecture
3.	7.6	Not revised after lecture
4.	6.9	Not revised after lecture, repeat topics
5.	7.9	understood
6.	4.4	Topics are difficult and needs to repeat
7.	9.6	Understood well
8.	9.3	Very well understood
9.	7.3	Understood well
10.	6.3	Should slow down the teaching

The MCQ activity in the class room and using ICT helped to assess the knowledge: remember previously learned information of students.To evaluate the compre-hensionlevels:demonstrate an understanding of the facts of students, peer evaluation activity was designed and practiced. All the resources in the form of power point presentations, videos and text books, question bank and a separate document containing all possible definitions is made available to the students on the MOODLE server available in the IT department. Using the document containing the definitions, peer evaluation activity is conducted after completion of each unit of the IP course. During the peer evaluation activity each student is given a sheet with ten questions and a blank space provided for the students to give their answers as shown in table 2. Later the answer sheet of one student is assessed by the other during the same lecturewhile the definitions are displayed using compujector. This provided the student with the mistakes her/she made and also the mistakes of others. This is designed to be a formative assessment where it is providing the feedback to students and faculty on the ability of students to demonstrate the understanding of facts and their continuous learning skills.

Table 2: Assessment sheet for comprehension level.

Topic: Client Server Paradigm		
Sr. No	*Question*	*Answer*
1.	Client Server Paradigm.	
2.	Client	
3.	Server	
4.	Standard application service	

The lecture wise assessments/activities are used for summative assessment and check the ability of students to apply the knowledge to actual situations. As these assessments are evaluated through student presentations, poster designs, mind map charts, concept map charts, demonstrations etc.; they were also useful to assess the other cognitive skills of students like presentation, thinking, logical and auditory skills. All the assignments are listed and provided to the students. Around fifty six such assignments/activities were designed and made available to the students through MOODLE. Students with a team of two must choose one among the list and apply the knowledge to complete the task. The students can submit their assignments by implementing programs or by poster designs or presentations or by using tools. Table 3 shows a list of few assignments designed. The lecture wise assignments are revised each time to make sure that they are useful to assess the student'sability to apply the knowledge in solving the problems.

Table 3: Assessment sheet for comprehension level.

Topic: Client Server Paradigm

Topic: Client Server Paradigm	
Sr. No	***assignment***
1.	Which of your local implementations of standard application clients are fully parameterized? Why is fully parameterized needed.
2.	Write a sever program using Berkely sockets that will display the clients end point address.
3.	Provide authentication to client at server using the Berkely sockets.
4.	Write parameterized clientserver programs that will read IP address, Port numbers from the command line arguments.
5.	Design the RIT network using CISCO Packet Tracer Virtual Router Configuration tool

Apart from the above three activities: MCQ, Peer eval-uation of definitions and lecture wise assignments, colla-borative activities are planned to improve the learning by doing and teaching. One of the activity conducted is JIGSAW. The following instructions give a step-by-step account of how to conduct this activity and are explained to the students.

1. Five protocols are used to implement the Collabora-tive activity (JIGSAW method with few assump-tions).
2. Five groups are chosen from a class with 4 students from each group.
3. Each group is allocated 30 minutes of time during the regular lecture to demonstrate the protocol using role plays and posters.
4. The group members should act as nodes and dem-onstrate the protocol with the help of chits and cards.
5. The other groups and the student audience are al-lowed to pose questions for which the group mem-bers should answer.
6. The actual demonstration is also allowed with the real setup (if possible; use of tools like NS-2 or computers)

The students are assigned to four-member teams having different levels of Cumulative Performance Index (CPI) scores as shown below.

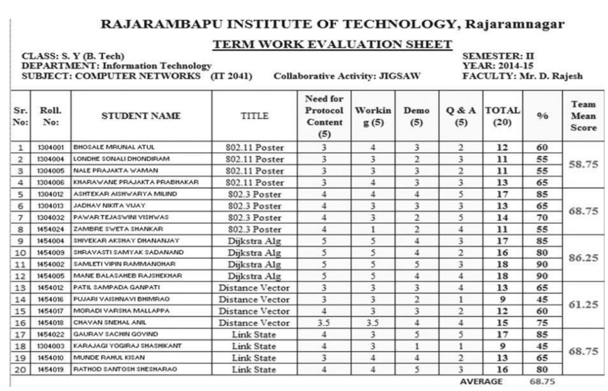
Member 1:CPI > 8
Member 2 & 3:CPI <8 & CPI >7
Member 4:CPI <7

Table 4 shows the section of the protocol the members work and which are also used to access students. When this activity was for the first time conducted to this class, most of the students were participating as presenters and listeners. But very few students were observed as non-participating. So to motivate the non-participating mem-bers, they were informed that they should ask at least two questions at the end of the activity.

Table 4: section of protocol students' work.

Sr. No	Section of protocol	Description
1.	Content developme nt	Here the student should learn and explain the need for the protocol and the types of messages the protocol uses to communicate and explain its format.
2.	Working of Protocol	Here the student should learn and explain the different types of messages the protocol contains, the request and response or send and receive messages.
3.	Demonstrat ion	Here the student should learn and demonstrate the protocol with the help of role play or computers
4.	Q & A	The student must be able to answer the questions posed by the other students.

Figure 1 shows the results of the JIGSAW activity for the Computer Networks (CN) course which is in the third year first semester curriculum of IT program. Also Figure 2shows the results of the same activity with the same stu-dent groups for the Internetworking Protocols (IP) course which is in the third year first semester curriculum of IT program.


RAJARAMBAPU INSTITUTE OF TECHNOLOGY, Rajaramnagar

TERM WORK EVALUATION SHEET

CLASS: S. Y (B. Tech) SEMESTER: II
DEPARTMENT: Information Technology YEAR: 2014-15
SUBJECT: COMPUTER NETWORKS (IT 2041) Collaborative Activity: JIGSAW FACULTY: Mr. D. Rajesh

Sr. No:	Roll. No:	STUDENT NAME	TITLE	Need for Protocol Content (5)	Workin g (5)	Demo (5)	Q & A (5)	TOTAL (20)	%	Team Mean Score
1	1304001	BHOSALE MRUNAL ATUL	802.11 Poster	3	4	3	2	12	60	58.75
2	1304004	LONDHE SONALI DHONDIRAM	802.11 Poster	3	3	2	3	11	55	
3	1304005	NALE PRAJAKTA WAMAN	802.11 Poster	3	3	3	2	11	55	
4	1304006	KHARAWANE PRAJAKTA PRABHAKAR	802.11 Poster	3	4	3	3	13	65	
5	1304012	ASHTEKAR AISHWARYA MILIND	802.3 Poster	4	4	4	5	17	85	68.75
6	1304013	JADHAV NIKITA VIJAY	802.3 Poster	4	3	3	3	13	65	
7	1304032	PAWAR TEJASWINI VISHWAS	802.3 Poster	4	3	2	5	14	70	
8	1454024	ZAMBRE SWETA SHANKAR	802.3 Poster	4	1	2	4	11	55	
9	1454004	SHIVEKAR AKSHAY DHANANJAY	Dijkstra Alg	5	5	4	3	17	85	86.25
10	1454009	SHRAVASTI SAMYAK SADANAND	Dijkstra Alg	5	5	4	2	16	80	
11	1454002	SAMLETI VIPIN RAMMANOHAR	Dijkstra Alg	5	5	5	3	18	90	
12	1454005	MANE BALASAHEB RAJSHEKHAR	Dijkstra Alg	5	5	4	4	18	90	
13	1454012	PATIL SAMPADA GANPATI	Distance Vector	3	3	3	4	13	65	61.25
14	1454016	PUJARI VAISHNAVI BHIMRAO	Distance Vector	3	3	2	1	9	45	
15	1454017	MORADI VARSHA MALLAPPA	Distance Vector	4	3	3	2	12	60	
16	1454018	CHAVAN SNEHAL ANIL	Distance Vector	3.5	3.5	4	4	15	75	
17	1454022	GAURAV SACHIN GOVIND	Link State	4	3	5	5	17	85	68.75
18	1304003	KARAJAGI YOGIRAJ SHASHIKANT	Link State	4	3	1	1	9	45	
19	1454010	MUNDE RAHUL KISAN	Link State	3	4	4	2	13	65	
20	1454019	RATHOD SANTOSH SHESHARAO	Link State	4	4	5	3	16	80	
								AVERAGE	68.75	

Figure 1. Evaluation of JIGSAW activity for CN course.

RAJARAMBAPU INSTITUTE OF TECHNOLOGY, Rajaramnagar

TERM WORK EVALUATION SHEET

CLASS: T. Y (B. Tech) SEMESTER: I
DEPARTMENT: Information Technology YEAR: 2015-16
SUBJECT: INTERNETWORKING PROTOCOLS(IT 3051) Collaborative Activity: JIGSAW FACULTY: Mr. D. Rajesh

Sr. No:	Roll. No:	STUDENT NAME	TITLE	Need for Protocol Content	Working (5)	Demo (5)	Q & A (5)	TOTAL (20)	TOTAL (15)	%	Team Mean Score
1	1304001	BHOSALE MRUNAL ATUL	DHCP Protocol	2	3	3	4	12	9	60	68.75
2	1304004	LONDHE SONALI DHONDIRAM	DHCP Protocol	3	2	3	4	12	9	60	
3	1304005	NALE PRAJAKTA VAMAN	DHCP Protocol	4	4	3	4	15	11	75	
4	1304006	KHARAVANE PRAJAKTA PRABHAKAR	DHCP Protocol	4	4	4	4	16	12	80	
5	1304012	ASHTEKAR AISHWARYA MILIND	DNS Protocol	5	5	3	5	18	14	90	86.25
6	1304013	JADHAV NIKITA VIJAY	DNS Protocol	4	4	4	5	17	13	85	
7	1304032	PAVAR TEJASVINI VISHVAS	DNS Protocol	4	4	4	5	17	13	85	
8	1454024	ZAMBRE SVETA SHANKAR	DNS Protocol	4	4	4	5	17	13	85	
9	1454004	SHIVEKAR AKSHAY DHANANJAY	IPv6 Protocol	4	4	5	4	17	13	85	88.75
10	1454009	SHRAVASTI SAMYAK SADANAND	IPv6 Protocol	4	5	5	4	18	14	90	
11	1454002	SAMLETI VIPIN RAMMANOHAR	IPv6 Protocol	4	5	5	4	18	14	90	
12	1454005	MANE BALASAHEB RAJSHEKHAR	IPv6 Protocol	4	5	5	4	18	14	90	
13	1454012	PATIL SAMPADA GANPATI	TCP Protocol	1	2	1	4	8	6	40	48.75
14	1454016	PUJARI VAISHNAVI BHIMRAO	TCP Protocol	2	5	3	4	14	11	70	
15	1454017	MORADI VARSHA MALLAPPA	TCP Protocol	1	3	1	4	9	7	45	
16	1454018	CHAVAN SNEHAL ANIL	TCP Protocol	1	2	1	4	8	6	40	
17	1454022	GAURAV SACHIN GOVIND	ICMPv6 Protocol	5	4	5	5	19	14	95	86.25
18	1304003	KARAJAGI YOGIRAJ SHASHIKANT	ICMPv6 Protocol	3	2	3	5	13	10	65	
19	1454010	MUNDE RAHUL KISAN	ICMPv6 Protocol	5	4	5	5	19	14	95	
20	1454019	RATHOD SANTOSH SHESHARAO	ICMPv6 Protocol	5	4	4	5	18	14	90	
							AVERAGE			75.75	

Figure 2. Evaluation of JIGSAW activity for IP course.

From the figures 1 and figure 2 it is observed that the average comprehension skills of the students improved by 7 percent which is calculated from the differences of JIGSAW activity assessment for CN and IP courses (68.75, 75.75) respectively. Figure 3 shows the student team's participation for the JIGSAW activity during the regular class for the CN course as well as IP course. The same students with same teams have given the demonstration of JIGSAW activity for different subjects in different semesters.

Figure 3: Student team's participation in JIGSAW activity

The interesting feedback that we received form the stu-dents is that they are facing difficulties to demonstrate the given concepts using the JIGSAW activity. The feedback statements of the students are as follows:

"JIGSAW activity is good but it cannot be applied on each topic", "JIGSAW activity is good, but topics like IPV6 couldn't be appropriate way to learn using JIGSAW". Extra activities like JIGSAW is notbetter way to learn protocols".This feedback from the students helped us to incorporate different activities like: Poster design, Concept map, Mind map, presentation and demonstration using a tool like Wireshark packet analyzer and Network simulator to promote active learning amongst the students. Figures4, 5&6 provides the snapshots of the mind map, concept map, poster design assignments submitted by the students. The concept map provided the students the entire concepts covered for a specific unit at a glance which can also be used as easy reference before examinations. The mind map helped the students understand well the lengthy and difficult concepts that involved step by step process.

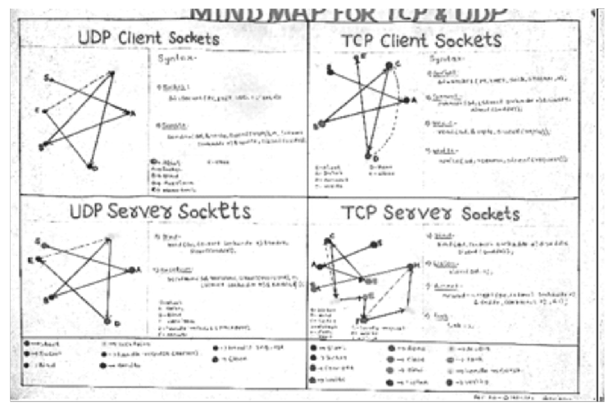


Figure 4: Mind map for the topic TCP & UDP protocols

Table 5 illustrations the results for In-Semester Evalua-tion (ISE), Mid-Semester Evaluation (MSE) with a weigh-tage of 20 and 30 marks respectively. The analysis shows that the results of ISE showed fewer improvement but the progress of MSE is upright. The investigations on the re-sults of ISE showed that the assessment methods for the students graduated in the year 2015 were not appropriately designed and followed traditional methods. The ISE for 2017 graduating students are well defined and RUBRICS were used where the student's demonstration skills were assessed appropriately. Overall with well-designed assessment methods for 2017 graduating students, they outperformed than the 2015 graduated students which can be observed in the total column of table 5.

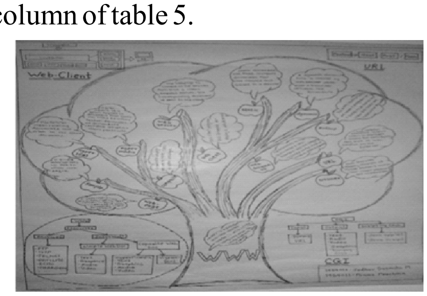


Figure 5: Concept map for the topic World Wide Web

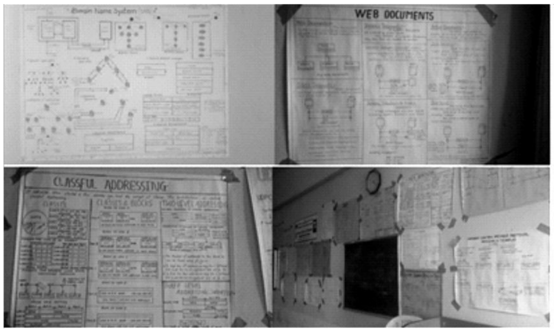


Figure 6: Poster design assignments submitted by the students

Table 5: Comparison of average results for CN & IP courses

COURSE	ISE (20)	MSE (30)	TOTAL (50)
CN-2015 Batch	17.6	13.62	32.23
IP-2015 Batch	14.82	15.76	**30.58**
CN-2017 Batch	14.95	17.58	32.54
IP-2017 Batch	14.3	19.64	**33.94**

5. Pedagogy for Practical Courses using Magic of Making Mistakes (PC-MoMM)

Tocontinuously update the curriculum of the depart-ment, the current requirements of the industry were identi-fied through Faculty Industrial Visits, Industry Institute Interactions and Alumni feedback and in view of that, the curriculum is updated and the assessment and evaluation procedures were designed by incorporating the "Outcome-Based Education" (OBE) methods. Programming is the most important skill that any IT graduates must exhibit to be able to work from day one when assigned a project to be developed. This confirms the student's ability to apply basic concepts and principles of IT to solve real world problems. During the interactions with the industries it was found that the students are lagging with programming skills. Also during the campus interviews, the selection process is of Boolean type. That is; given a student to develop a program, the student is qualified only when the program executes without any errors providing the ex-pected output. But the assessment of programming skills of the students for the course during the academics is not based on executed or not executed. Rather it considers partial execution, partial output, and execution with few errors etc. Even after students undergoing several practical sessions for each of several programming courses; the observations on student's programming skills were dis-pleasing. To address this scenario we at IT department teamed up to design a new pedagogy for programming courses.When theBoolean evaluation of programs is intro-duced in the department for the first time for IP course, it was observed that the learning practices of the students changed involving several malpractices like storing the programs in some directory of all computers before day of exam, getting a pen drive to the exam hall and chits con-taining the programs written on it. In paper [4], the authors have taken several efforts to improve the programming skills of the students.But the efforts could not provide instant feedback to the students where they are going wrong while practicing the programs during the practical hours. The authors also mentioned that they have started a "Placement Club" that provides students an environment to make mistakes and learn from them to avoid repeating the mistakes during their interviews, professional life and work place practicing the mantra "Making mistake is not a mistake but repeating is a mistake". This paper adopts and extends the concept of learn by making mistakes and design the students' programming evaluation using this making mistake therapy titled "Magic of Making Mistakes" that will also improve the learning practices of students. To implement this pedagogy, initially the types of mistakes or errors that occur while executing the programs are categorized, listed and defined as shown below.

1. Compiler/Syntax errors
2. Runtime/Logical errors
3. Incorrect input
4. Incorrect commands
5. Type mistakes
6. Lack of preparation

The activities during the laboratory slots are very well planned to promote active and collaborative learning among the students. Usually the semester is for 12-14 weeks of duration. Hence the students are supposed to practice and perform 10-12 experiments during the seme-ster for respective courses. The two hours practical slotal-located for the practical course per week is planned accor-dingly to provide both formative assessmentand consecu-tive practical slots for summative assessment to the stu-dents as follows:

1. The faulty will instruct the students on one expe-riment only for the first five minutes. These in-structions are made available to students at the start of semester itself.

2. Students are given forty five minutes of time to execute/perform the program/experiment.

3. Immediately after completion of forty five minutes, the faculty will clap to indicate the students to stop execution.

4. All the students in the lab will stand up and the students who have executed the program successfully will assist the students who did not. Students are allowed to take their seats only after all the students show the output to the faculty.

5. The students will record the type of errors they made into their observations report while programming.

6. The steps from 1 to 5 are repeated for the second hour of the lab for the next experiment.

7. In the next practical slot the students will give test on the two experiments they have practiced in the previous practical slots where the students are evaluated based on whether the programs are giving required output or no (Boolean evaluation). The students also record the errors they made during the test into their observations.

During the practical hours which is of two hour dura-tion, the faculty provided necessary instructions for two experiments, students successfully practiced two experi-ments and recorded their mistakes into the report. All this learning activities in the laboratory was driven to offer formative assessment that provided the students a feedback on the things that went wrong, things that keep going wrong and things that might go wrong in future.

During the immediate next week slotof the lab a pro-gramming test is conducted on the experiments that were completed during previous practical slot through peer as-sistance, collaborative learning and formative assessment. The duration of test for each experiment is one hour and during this test the assessment is of summative where the students are graded. The evaluation is of Boolean and students score maximum marks if the program is executed successfully else zero. The students are again informed to record the errors that occurred during the test into their observations report. This activities were not time consum-ing because in two practical turns the students could com-plete two experiments and the faculty could perform both formative and summative assessments. Care should be taken that the experiment planned can be completed in one hour. If any experiment is taking much time, each week slot can be used to conduct only one experiment. The error reports are collected for each experiment from the students using GOOGLE forms. The student reports are formatted, analyzed and displayed to the students to monitor their performance.

Figure 7 shows the error reports of the students. The first row gives the types of errors. The second row shows the total number of errors of that type committed by students. The first column is the experiment number and the next columns show the number of errors made by students of that type. The last column shows the total number of errors committed by the students for that experiment. The graphs for the same were plotted and shown in figure 8. The figure 8also shows graph for errors experiment wise displayed in green color at the top, graph for errors type wise in brown color at the right top corner and the bottom lines shows the number of errors of each type for each experiment. The graphs are plotted based on the 74 stu-dent's responses for 10 experimentsresulting in 732 res-ponses in total. Each student is provided with the total number of errors he/she made for each experiment. The total number of errors collected from the class is 2116.

This report provided both students and faculty the performance of each student and their learning process. The more faculty knows about the learning process the more effective faculty can be in designing and delivering appro-priate instructions. We have taken this information to modify the instructions differing from experiment to experiment. Each student is individually mentored based on their error reports. When this method was shared among the other faculty associates they were overwhelmed as it is able to get the count of errors of each student and in total and helped to reduce the errors of each student form experiment to experiment.

TOTAL/ TYPE	Compiler/Syntax errors	Runtime/Logical errors	Incorrect input	Incorrect Commands	Type mistakes	Lack of preparation	TOTAL/ EXP
	569	416	223	238	438	232	2116
EXP 1	109	72	36	28	74	39	358
EXP 2	99	72	39	28	70	36	344
EXP 3	63	50	37	61	62	49	322
EXP 4	58	41	20	20	55	21	215
EXP 5	56	45	24	15	37	13	190
EXP 6	8	21	8	22	11	11	81
EXP 7	10	19	13	22	8	11	83
EXP 8	61	38	22	18	50	23	212
EXP 9	51	29	11	16	30	20	157
EXP 10	54	29	13	8	41	9	154
EXP 11	0	0	0	0	0	0	0
EXP 12	0	0	0	0	0	0	0
EXP 13	0	0	0	0	0	0	0
EXP 14	0	0	0	0	0	0	0
EXP 15	0	0	0	0	0	0	0

Figure 7: Error report of each typeand for each experiment

An activity is also planned to identify the different type of learners in the laboratory and address the Active, Se-quential and Global learners. Given a problem statement in a lab with 20 students and when instructed to implement a program the following observations are made.

1. Most of the started typing programs on the comput-er.

2. Few students first had written the steps to solve the problem and then started programming.

3. Some of the students who were unable to implement the programs were asked to pair.

4. Other students browsed the internet and executed the programs successfully but could not explain the program.

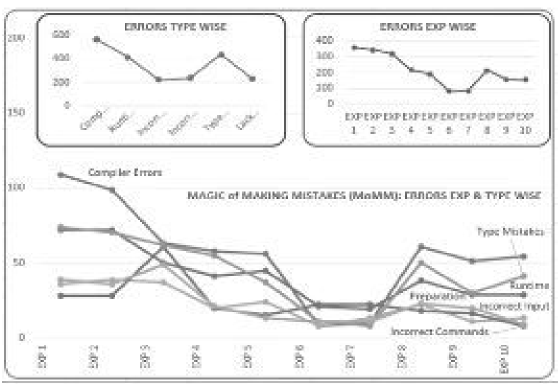


Figure 8: Graphs showing the analysis of errors of students

One of the component in Continuous Assessment of la-boratory course is conducting viva. To effectively conduct this assessment component, MCQ tests are designed that contains questions related to each experiment. This type of assessment for viva is done for the first time in the IT department at RIT. This test is conducted online using ICT. This drastically saved the assessment time of faculty. The only requirement was to plan a set of MCQ tests specific for the experiments. All the traditional limitations like unable to pay attention to each student, evaluate properly due to insufficient arewell addressed.

Figure 11shows the feedback of students for the course CNplotted in blue color and for IP course in brown color-for which the pedagogy mentioned in this paper is applied. This histogram shows that the cognitive skill have im-proved from course to course.

RANGE	ISE (20)	MSE (30)	ESE (50)	CAS(30)	P TOTAL (100)
0-5	1	1	0	1	1
6-10	9	2	0	0	0
11-15	28	11	0	0	0
16-20	36	28	0	1	0
21-25	0	23	0	6	0
26-30	0	9	0	20	0
31-35	0	0	0	39	0
36-40	0	0	0	7	0
41-45	0	0	0	0	0
46-50	0	0	0	0	0
51-55	0	0	0	0	6
56-60	0	0	0	0	7
61-65	0	0	0	0	2
66-70	0	0	0	0	1
71-75	0	0	0	0	6
76-80	0	0	0	0	7
81-85	0	0	0	0	0
86-90	0	0	0	0	6
91-95	0	0	0	0	31
96-100	0	0	0	0	7

Figure 9: Result analysis of IP course 2015.

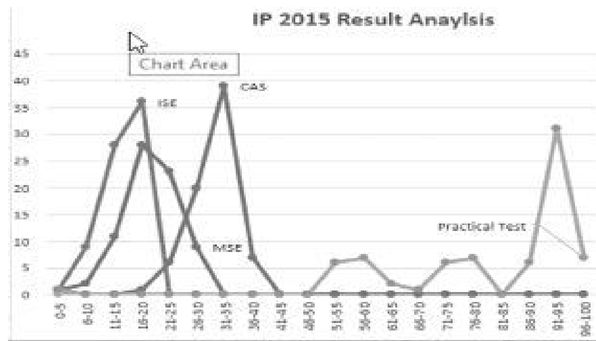


Figure 10: Graphs showing result analysis of IP course 2015.

Figure 9 and 10 shows the result analysis for the course IP during the year 2015 even semester (JAN-JUNE)for which the above discussed pedagogies were applied. The columns in the figure 9 shows student marks distribution for ISE, MSE, ESE, CAS of IP lab and IP programming test with 20, 30, 50, 30 and 60 as maximum marks respec-tively. The marks of ESE are not announced during the making of this paper.The bell shaped curves in figure 10 shows that the marks of the students are distributed as per the student's subject skill levels which shows that the evaluation was carried out appropriately.

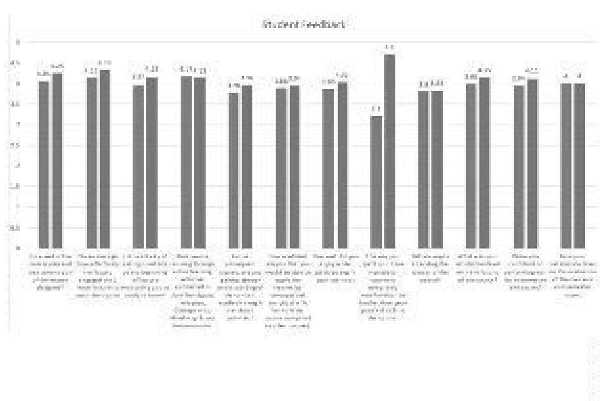


Figure 11: Feedback results of CN & IP Courses.

Table 6: Feedback Questions for CN & IP courses

Sr. No.	Feedback Question	Score	
		CN	IP
1.	How well is the course plan and assessment plan of the course designed?	4.05	4.25
2.	On an average how effectively the faculty engaged the 1 hour lecture to teach the course.	4.12	4.33
3.	Is the activity of asking questions at the beginning of lecture motivating you to study at home?	3.97	4.16
4.	Rate you're learning through active learning activities conducted in class like: jigsaw, role play Concept map, Mind map&tool demonstration.	4.17	4.13
5.	In the subsequent classes, are you gaining deeper understanding of the concept studied through the above activities?	3.78	3.96
6.	How confident are you that you would be able to apply the theoretical concepts and analytical skills learnt in the course compared to other courses.	3.88	3.94
7.	How well did you enjoy while participating in such activities	3.86	4.02
8.	The way you spent your time in practical course is completely redefined by the faculty. Rate your practical skills in the course.	3.2	4.5
9.	Did you enjoy attending the classes of the course?	3.8	3.83
10	What was your satisfaction level with the faculty of the course?	3.98	4.15
11	Were you confident of performing well in the semester end exams?	4.11	3.94
12	Rate your satisfaction level on the evaluation of the course's end semester exam.	4	4

The same twelve questions mentioned in table 6 were used to collect the feedback from the students for the two different course Computer Networks (CN) which is in the curriculum of second year2ndsemester and Internetworking Protocols (IP) course which is in the curriculum of third year 1stsemester. Overall it was observed that there was an exorbitant improvement in the practical skills of the students.

6. Conclusion & future work

The paper has provided to the reader an innovative pe-dagogy usedfor IT program courses in engineering educa-tion at RIT. The results are highly motivating and can be adopted for theory and programming courses offered in Computer Science and Information Technology programs. Educating theory course using TC-BT provided students with in-depth understanding of the course content at ease and inculcated the practice of continuous learning. Educating programming subjects using MoMM made students familiar about their mistakes. The learning of the students gradually improved with reduction in the number of mistakes they made. In future we plan to adapt TC-BT and MoMM pedagogies to all the courses and test the efficacy of these pedagogies.

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