Journal of Engineering Education Transformations,
Volume No. 37, January 2024 Special Issue, eISSN 2394-1707

Outcome Based Curriculum Development for Studi Courses: Data Mining an example course

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***Abstract*—Over the past few decades, with a growing emphasis on learner-centric methodologies, the Outcome-Based Education (OBE) framework has become prominent, with the aim of bridging the gap between academic learning experiences and industry requirements. Outcome Based Education (OBE) has been proving its prominence to ensure intended outcomes and quality. Efforts in designing and development of outcome-based curriculum help to create an effective learning environment. Outcome Based Curriculum Development (OBCD) ensures not only the domain knowledge but also centennial mastery over the knowledge, skills and attitudes needed for Industry 4.0 and above. To fill the gap between academic learning and industry requirements, Studio Pedagogy is gaining prominence, particularly for a few hard core courses that require more activity-based learning rather than traditional teaching-learning, i.e. Studio-Based Learning (SBL). This paper discusses OBCD for such an engineering course, Data Mining that needs theoretical concepts to learn by doing, being taught to 5th semester students as a case study. The end survey and assessment performance demonstrated the effectiveness of designing and implementing curriculum for this course as a Studio course with Studio Based Learning.**

***Keywords*— Outcome based education, Outcome based curriculum Development, Studio Pedagogy, Studio Based Learning, Learning -by -doing.**

***JEET Category*— Curriculum design, its implementation and learnings**

I. INTRODUCTION

The words of William Arthur Ward, "Teaching is more than imparting knowledge; it is inspiring change. Learning is more than absorbing facts; it is acquiring understanding" emphasizes the significance of Outcome Based Education (OBE). The educational methodology known as Outcome-Based Education (OBE) gives more importance to the students in the learning outcomes. It is a student-centric teaching and learning approach in which the curriculum, course content, delivery and assessment are designed in such a way as to achieve defined objectives and outcomes. It focuses on involving the students better in the learning process and measuring their performance i.e. outcomes at different levels of course delivery throughout. The OBE emphasizes on what students are expected to know, understand, analyze and apply, and ultimately what skills and knowledge they need to have when they leave the program(Spady 1994). Though William G. Spady, an educational psychologist and sociologist coined the term outcome-based education in 1988, his continued efforts focus on Transformational OBE in his recent (2021) book Outcome Based Education's Empowering Essence. According to Spady, transformational OBE is founded on four principles that, if consistently, methodically, creatively, and concurrently applied, would guarantee that all pupils had the knowledge, skills, and attributes required for successfully fulfilling their varied life roles (Spady 2021). Though for the last two decades the teaching fraternity has been working on OBE, a lot of focus is still needed to get more insights and clear understanding about the Transformational OBE that liberates education from its entrenched, limiting Industrial Age thinking and practices.

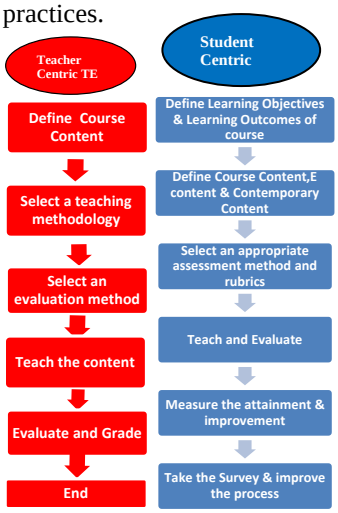

Fig. 1. Traditional Education and Outcome Based Education Processes.

As shown in Figure 1, the Traditional Education(TE) process is teacher-centred; content, lectures, syllabus coverage, and formal assessment methods. It focuses on transmitting information from the teacher to the student. Traditional learning provides the learner with knowledge or skills, or both, but often fails in developing creative thinking and applicative skills with very little focus on curriculum development and is not outcome based. Unlike the TE system, key aspects of OBE include clear learning objectives, learning outcomes, Student-Centered teaching-learning process,

This paper was submitted for review on September 08, 2023. It was accepted on November, 11, 2023.

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Measurable goals, Curriculum alignment, Assessment and Evaluation, Continuous improvement, Accountability, Quality assurance and Global Perspective (Sun et al 2020). The OBE shifts the focus from teaching to learning, prioritizing the needs and abilities of individual students aiming to achieve the specified outcomes (Biggs 1996). OBE also emphasizes specific, measurable, achievable, relevant, and time-bound (SMART) objectives. It helps to easily assess student progress and instruction effectiveness. Traditional assessment methods are replaced or supplemented with learner centered approaches(Huba et al 2000) such as Diagnostic, Formative, Interim, and Summative, such as problem based (Boud D. et al 1997), case study-based and project based evaluations. OBE encourages ongoing assessment and feedback to continuously improve the educational process, thereby ensuring quality. OBE has been adopted in various countries and contexts as a way to standardize and improve the quality of education. This can be particularly important in an increasingly interconnected and competitive global economy. In higher education particularly in professional programs, the OBE is gaining its popularity as employers are looking for graduates with applicative and creative thinking skills in the workplace. An effective OBE curriculum design needs careful planning and a clear understanding of the intended learning outcomes. In 2012 Kalianna and Chandran's study emphasized that the three key aspects that the OBE system should focus on are outcomes, curriculum design and responsibility of academics and learners (Kalianna et al 2012). Few core courses in any engineering stream have more importance and are used everywhere in the daily routine in the work places. Students need expertise in such courses. They need learning by doing practical assignments, more case studies, discussions, collaboration and cooperative learning, and projects in a dynamic and integrated environment. Such courses can be termed as studio courses. Studio teaching is an approach to teaching that can be used to replace the standard lecture approach and is based on sound pedagogical principles. It is very flexible, and leads to superior learning in most instances. According to Kjesrud R.D., Studio-Based Learning is abundantly understood as essential in a few disciplines, such as Computer Science and Dance, for incrementally scaffolding procedural knowledge and for forwarding meta-cognitive learning (Kjesrud R.D,2021). This paper focuses on how crafting the curriculum and development of an engineering undergraduate studio course impacts its outcome. This Paper discusses the steps of developing a conceptual framework and implementation of outcome based curriculum as an example.

The primary objective of this paper is to present a thorough and demonstrative example of how OBCD and student-centric learning and assessment methodologies play a prominent role and help to meet the goal of the Outcome-Based Education Framework. This paper briefs on the development of Course Outcomes (CO) and Program Specific Outcomes (PSO). Additionally, the paper will focus more on the impact of how active learning methodologies help to cultivate critical thinking and problem-solving skills and there, by improving the performance of the students in that particular course. The paper intends to contribute to a thorough understanding of Outcome-Based Education by examining its versatile impact on contemporary pedagogical practices through detailed examination.

Section II discusses the significance and process of Outcome Based Curriculum Design and Development. Section III explains the concept of Studio-Based Learning and its practices. Section IV presents the design of the studio course curriculum for the chosen Data Mining Course with specific selective active learning methods suitable for the respective topics. Section V illustrates the results of the implementation of the proposed SBL curriculum for this Data Mining course that needs learning by doing methodologies for effective learning in the form of direct and indirect methods of course attainment. Section 6 concludes the paper.

II. Outcome Based Curriculum Development

Outcome Based Curriculum Development (OBCD) is the fundamental step of Outcome Based Education (OBE) as OBE is an approach in which designing a curriculum is driven by the learning outcomes that the student should perform. OBCD emphasizes on application of knowledge and acquiring skills, rather than on memorizing concepts (Praveen, A.,2019). Its goal is to equip the students with the ability to face the global competition in the real world rather than secure a good score in the course to meet the expectations of employers (Urvashi et al 2023).

OBCD has a significant role in OBE. It is a step by step process of designing a Curriculum or improvising the existing Curriculum with an objective of meeting defined learning outcomes. Curriculum refers to the academic content that is to be imparted during learning. Curriculum development is a process that defines program/course learning outcomes, activities that needs to be done to achieve outcomes and assessment of those outcomes. While developing Curriculum development OBCD's major Components are Curriculum Planning, Curriculum Design, Curriculum Implementation and Evaluation.

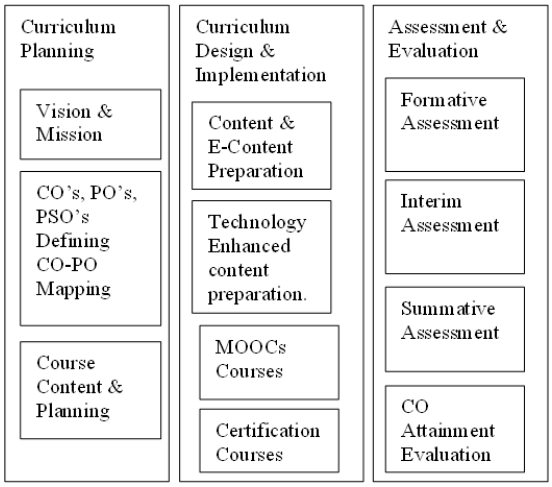

Fig 2: Outcome Based Curriculum Development Process

These components can be better understandable with relevant detailed examples of a course and help to comprehend the features of Outcome-Based Teaching-Learning. In this

paper, an engineering undergraduate course Data Mining is chosen to demonstrate how the OBCD is useful for the success of OBE. The OBCD process starts by defining vision & mission, the course learning outcomes, mapping the course outcomes with program outcomes, identifying the suitable assessment strategies, and designing the active learning methodologies there by allowing the learner to taste the learning experiences. In 2012, (Kim et al,2012) proposed the OBCD framework for existing nursing courses in Korea. Designing and implementing course and topic-specific active learning methods as well as assessment methods plays an important role in achieving better outcome attainment (Rithvik et al, 2020).

The Curriculum planning is the process of identifying and organizing the course structure of a program and instructional material of courses that aligns with the defined learning outcomes. Learning outcomes are the knowledge, abilities and competencies that a student should acquire and be able to demonstrate at the end of course or program. So curriculum planning phase includes identification of Course Outcomes (CO), mapping of COs with Program Outcomes (PO) & Program Specific Outcomes (PSO), course content planning and courses in a program keeping in the view of Vision & Mission. Course Outcomes (COs) define precise learning accomplishments that the learners are expected to attain on completion of that particular course or module. COs are to be clear, precise, measurable, and reflect the intended learning outcomes for the course. COs are to be defined after clearly understanding the course objectives, with appropriate clear verbs and rubrics following Bloom's taxonomy levels. The twelve graduate traits known as Program Outcomes (POs), as specified by the National Board of Accreditation, outline what students should know and be able to achieve by the time they graduate.

Program Specific Outcomes (PSOs) are to be drafted within the OBE framework with the goal of upholding the educational programs' excellence. Table 1 shows the sample Cos and CO-PO & PSO mapping for our chosen Data Mining Course.

Course outcome attainment is calculated from two components; 80% of direct attainment and 20% of indirect attainment. Direct attainment is evaluated 30 % by students' continuous performance during the course delivery in the form of class assignments; case study-based home assignments, quizzes, sessional examinations, seminars, laboratory assignments, mini projects etc-and 70% from summative assessment in the end semester examinations. This direct attainment provides strong evidence of student learning. The direct attainment breakdown for the data mining course is depicted in Figure3. Indirect attainment is evaluated from students' course exit survey to reflect on the student's learning.

Curriculum design and implementation deals with identifying resources including web resources, course content and e-content preparation, as well as technology enhanced content preparation for making active learning methods as part of course delivery. It also includes identifying and registering students for respective Massive Open Online Courses offered by various national agencies and certification courses offered by various national and international organizations and industries for making students as industry ready with a global perspective.

These MOOCs and certifications help students to build their noteworthy resume. In designing course delivery and assessment, proper planning and care is to be taken care-off of involving the students actively to meet the predefined attainments (M.R.Anala et al 2015).

Assessment & Evaluation, the third step of the OBCD process, is vital to the education process and goes hand in hand with curriculum design & implementation. All three Assessment types; Diagnostic, Formative and Summative play a major role emphasizing the outcome based course delivery. Diagnostic assessment is a pre-assessment that helps teachers to evaluate students' strengths, weaknesses, knowledge and skills before their course instruction and helps for course delivery planning. Summative assessment is mostly used in our traditional teaching learning process. It evaluates student learning at the end of instruction to ensure that they have met required standards. Assessments of student learning, helping to identify learning needs and adjust teaching appropriately to meet diverse students' needs. Through differentiation and adaptation of different teaching methods, it increases and achieves a greater equity among student attainment levels. Students' "learning to learn" skills can be built with these

TABLE I
CO'S, PO'S & PSO'S MAPPING
COURSE OUTCOMES

CO	Learning Outcomes	Indirect Assessment @ 30%
CO1	Understand the basic concepts of warehousing and mining.	3
CO2	Derive various interesting patterns and associations in datasets.	3
CO3	Design and develop classifier models to predict future trends.	5
CO4	Apply unsupervised learning techniques for a given	5

CO-PO-PSO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2											2	
CO2		2	3		2								3	1
CO3		2	3	1	2								3	1
CO4		2	3	1	2								2	3	1

assessment practices and they can do peer and self -assessment as well.

- The key elements of Formative assessment that have emerged from research (Sibusisiwe M., 2008) are:
- Establishing an interactive classroom and the use of diversified assessment tools.
- Defining learning goals and tracking students' progress in reaching those goals on an individual and peer basis.
- Using diverse instruction methods to meet the needs of diverse students.
- Using varied assessment approaches to assess student understanding levels.
- Using feedback from the assessment to adaptively select the different instruction methods further.
- Active involvement of students in the learning process.

Assessment Type	Assessment Component		Marks	Assessment Dates	Duration (Mins)	CO1	CO2	CO3	CO4
Continuous Assessment Total = 30 %	Assignment -I		Max Marks:10	Assignment –I Dates	45				
	Sessional –I		Max Marks:12	Sessional –I Dates	60				
	Assignment -II		Max Marks:10	Assignment –II Dates	45				
	Sessional –II Lab Performance and Project based		Max Marks:12	Sessional –II Dates	60				
	Formative Assessment	Home Assignment	Max Marks: 5	Home Assignment					
		Attendance	Max Marks: 3	Continuous Evaluation					
End-Semester Summative Evaluation Total = 70 %	Semester End Exam		Max Marks:70	End Sem Dates	3 hrs	✓	✓	✓	✓

Fig 3: Detail Direct Assessment breakdown for the course Data Mining with course code 20IT5404A

For Studio Courses that emphasize simultaneous theory and practical learning, the weightage for formative assessment is to be increased as it aids in continuous improvement of learning outcomes. In VR20 regulations of our institution, Data mining course is identified as Studio course and it's credits were increased to total of credits of data mining theory and lab courses handled independently in previous regulations. This modification incorporated in curriculum rectifies the disadvantage of lack of synchronism between coverage of theoretical concepts and lab exercises. The board of studies approved the modifications suggested in the design of Data Mining studio course curriculum design and credits alterations for VR20 regulations. Studio pedagogy and studio-based learning that are helpful for the curriculum design of these kind of courses are elaborated in the next section.

III. STUDIO-BASED LEARNING

Studio Pedagogy promotes an interactive engagement of students that is a key to meaningful learning and intellectual development. Studio-Based Learning (SBL) features holistic learning for whole learners (Philip Crowther, 2013) and addresses three types of learning; learning *about*, learning *how*, and learning to *become*. Table 2 (A and B) maps these learning types featured in SBL to Bloom's revised taxonomy. Learning *about* includes factual and conceptual knowledge, learning *how* includes procedural knowledge, and learning to *become* includes metacognitive knowledge.

SBL invites and involves learning in the community; it means that the community members share resources and knowledge via discussions to promote learning for everyone. SBL scaffolds learning-by-doing in iterative micro-consultations. Learning *about* can be achieved through iterative dialogue by teaching and resources. Dialogue only cannot adequately suffice and scaffold learning *how*. It requires space creation for experience and practice and hence teachers must know when to stop teaching and ask students to start doing it. Teachers learn skills like how to assess rapidly, practice decision-making, and influence small successes for meeting larger goals. Students learn problem-solving skills and, ultimately, they rightly attribute success not to teachers but to themselves. Teachers witness a growth in self-regulated learning through two or three micro-exchanges. Students gain the confidence that they have the ability to do those tasks and they feel those tasks are not so daunting (Efklides, 2011). Learning to *become* is the main mission of higher education institutions (HEIs) and iterative dialogue, action, and serial micro consultations guarantee metacognitive reflection better than our traditional teaching sessions.

TABLE II
SBL TYPES OF LEARNING MAPPED TO BLOOM'S REVISED TAXONOMY (KJESRUD R.D,2021)

Type of Learning	Knowledge Dimension	Cognitive Process	Example
Learning about	Facts	Recall	Statements that go inside the punctuation marks
	Concepts	Understand	Sources carry more credibility if they are balanced and disclose bias
Learning how	Procedural	Apply	Strategy: Thinking of an example will help me apply new facts/concepts.
		Analyze	Strategy: Thinking of an analogy will help me analyze facts/concepts.
		valuate	Strategy: Playing the "believing/doubting game13" will help me evaluate facts/concepts
		Create	Strategy: Using a matrix can help me synthesize ideas
Learning Become	Metacognitive	All	Strategy: Reflecting on my process helps me become a confident scholar.

Studio course curriculum design, delivery and assessment methods play a key role in improving the learning outcomes of learners. Various active learning methods designed and

followed as part of course delivery and assessment are given below.

- Preparation of ICT tools
- Preparation of Formative Assessments emphasizing query- based learning and applicative learning.
- Designing practical lab experiment sessions with an emphasis on practice.
- Designing Summative and peer assessments.
- Designing Project based assessments with an emphasis on team work, creative thinking and design.
- Designing Seminar/GD topics for improving thorough understanding and presentation skills.
- Preparation of placement related content to prepare students for global placements

IV. DESIGN OF CURRICULUM DELIVERY AND ASSESSMENT FOR DATA MINING STUDIO COURSE

In the fifth semester of undergraduate Information Technology, students of an autonomous reputed institution affiliated to JNTUK, Kakinada, we have a Data Mining course. The Data Mining course deals with the algorithms and computational paradigms to find patterns and regularities in databases, to perform prediction and forecasting useful for Knowledge Discovery process, for extracting useful knowledge from raw data. Knowledge discovery requires expertise in data selection, cleaning, coding, using different statistical and machine learning techniques, and visualization of the generated structures. All these concepts are covered in this course with illustrations of the whole process with suitable examples. Course delivery should include concept explanation with more examples, case studies, critical analysis, hands-on sessions for visualization, learning by practice sessions and project-based assignments. The course delivery needs two hours of theory and two hours of practical sessions per week. We identified that the studio-based learning better suits this course and carefully identified the following active learning methods to be included as part of the Course curriculum delivery and implementation.

In the words of Mark Van Doren, ”The art of teaching is the art of assisting discovery”. Hence, the teachers have to explore and think innovatively to design course delivery and assessment methods. It is more effective if teachers choose based on the specific topic being taught and its outcome. To meet the challenge of stimulating learners’ curiosity and to draw centennial’s attention, designing topic-specific ICT tools helps (Haritha et al 2022). In engineering education, flipped learning, a kind of formative assessment, should help to enhance the students’ ability to understand and think critically (Abdelhak et al.,2017), as they need to adopt the changing technologies day to day, even after their placement. The challenge of stimulating curiosity in a learner is a challenging task, in particular millennium students. It requires more efforts in the design of ICT tools that attracts them in getting prior knowledge and in creating curiosity among their technology-driven minds and then proper instructional, lesson and curriculum design.

Think-Pair-Share is of short-duration formative assessment activity that helps to actively engage the students, giving real case study examples like allowing the students to think about whether dividing the customers of a company according to their profitability, predicting the outcomes of tossing a (fair) pair of dice, predicting the future stock price of a company using historical records, Monitoring the heart rate of a patient for abnormalities etc need simple data base queries or need data mining algorithms.

Case-study-based Learning engages students to understand analyze and discuss the specific scenarios that resemble the real-world examples. It is a learner-centric method that allows intense interaction among participants as they build their knowledge as a learning community and work together as a group to study the case. The instructor can act like a facilitator while the students collaboratively think, analyze and discuss problems that have no specific and single answer and solve the questions in their own way. The following is one of the case studies using conceptual schema, a designing topic of data mining.

Case Study Example: A Big-University data warehouse consists of student, course, semester, program and teacher dimensions and count and average grade as measures. The average grade measure stores the student's actual course mark when the conceptual level is at its lowest (for instance, for a certain student, course, semester, and teacher combination). Avg grade records the typical grade for the specified combination at higher conceptual levels. Based on the aforementioned scenario, respond to the following questions: (a) Create a schematic of the data warehouse's snowflake schema. (b) What specific OLAP operations (such as rolling up from semester to year) should be carried out starting with the base cuboid [student, course, semester, and teacher] in order to provide the average grade of CS courses for each Big-University student? (c) How many cuboids will this cube contain (including the base and corner cuboids) if each dimension has five levels (including all), such as "student major status university all"?

These kinds of different case study examples, designed for different student teams help them to think, analyze and apply the concepts learnt in their classes.

Problem-based and/or Project-based learning enables us to present complicated real-world situations as a means of encouraging student acquisition of concepts and principles instead of directly presenting facts and concepts to students. PBL promotes skills such as critical thinking, problem-solving, working in groups as a team member/lead and communication skills. It provides a platform for finding and evaluating research materials as a team and life-long learning. Different sets of problem solving assignments are to be carefully prepared and assigned for slow learners and advanced learners with different difficulty levels based on their individual skills. Projects based on current trending and societal burning issues like prediction of Caronavirus (COVID-19) from patient X-rays and CT-scans by using data mining techniques involve students more and encouraging them to prepare and present research papers can give enormous transformation in the students’ learning attitude.

Exploration of such projects helps them to make students as lifelong learners. As implied by Benjamin Franklin's adage, "Tell me and I forget. I learn and I retain. At the conclusion of each module or unit, assessments modeled after the Sudoku Puzzle-like Game shown in Figure 4 can be used to recap the concepts learned and engage students more actively.

V. Discussion on Attainment of COs

The result of the Course Outcomes attainment for the Data Mining course through Direct Assessment Tools is presented in this section. The assessment is done based on the internal examinations i.e., two assignment tests, two sessional tests, home assignments and the semester-end examinations. The Sessional 2 test is based on problem solving practical sessions and project based assignments. Figure 5 shows screenshots of a few problem solving assignments, home assignments and project tasks given and submitted by students through the institutions' Learning Management Solution.

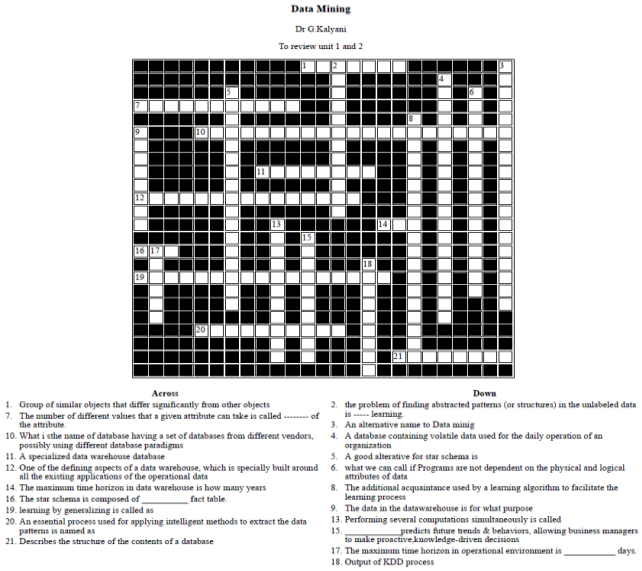

Fig 4: Sudoku Quiz after Completion of Unit 1

All the 60 students' marks are considered for calculating the attainment level of each question in the internal question papers as well as the external papers. Figure 6 shows sample micro analysis of all students' performance in all assignments, home assignments, sessional tests and external examination. From the micro analysis we can observe that there is improvement in the sessional 2 test compared to sessional test1. Sessional test 1 is a theoretical question answering test whereas sessional test 2 is a practical problem solving and project-based test. This improvement demonstrates the efficacy of studio-based learning implemented in this course. Computation of CO attainment of questions given in each individual assessment test is done by considering all the students of that class. The questions in the assessment test will be mapped to the COs initially. Based on the percentage of students attained, the class average the CO attainment value of that question was decided.

After calculating the attainment level of each question, then the average of all questions related to a particular CO is done to calculate the final attainment of CO with respect to the internal examinations. Similarly, the evaluation will be done by considering the external examination marks also. Figures 7 and 8 show CO attainment obtained in direct assessment and indirect assessment respectively. Based on the attainment levels of the internal and external examinations the direct assessment and indirect of COs is computed, which is shown in Table 4 and shown in Figure 9. The final direct assessment values are computed by considering for 30% weightage to internal examinations and for 70% weightage to external examinations.

Figure 10 shows the course end survey taken from students on the teaching methodologies and assessment methods followed in the course delivery.

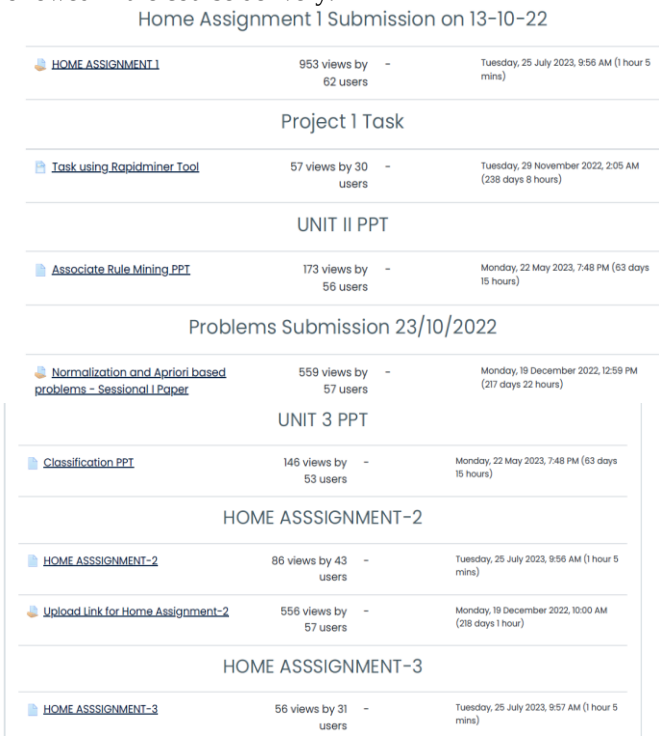

Fig 5. LMS screen shot depicting diverse assessment activities

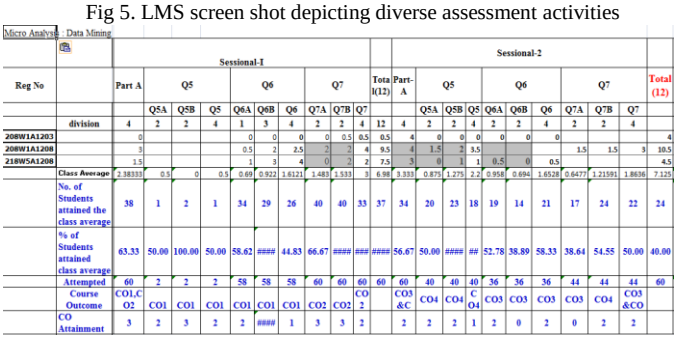

Fig 6.Micro Analysis of Data Mining Course 20IT5404A

The left figure is the survey result of implementing studio-based learning in the data mining course and the right figure is the course end survey of previous batch students for whom SBL was not implemented. It clearly shows 80% of the students gave excellent satisfaction with the learning by doing methods followed in the course which is much better than with-out using these practices.

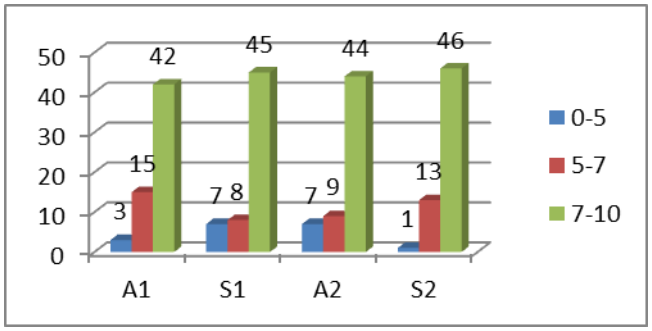

Fig 7.Attainment of course outcome through Direct Assessment

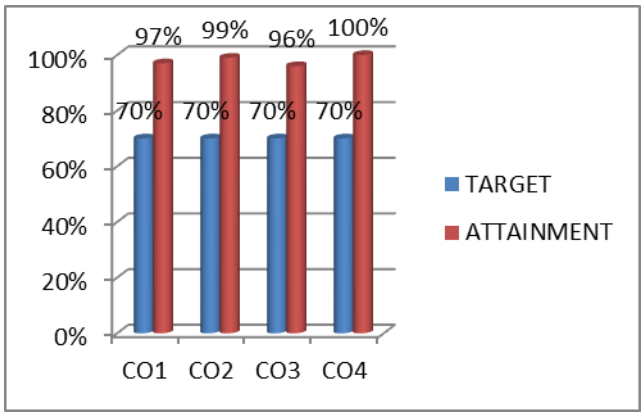

Fig 8.Attainment of course outcome through Indirect Assessment

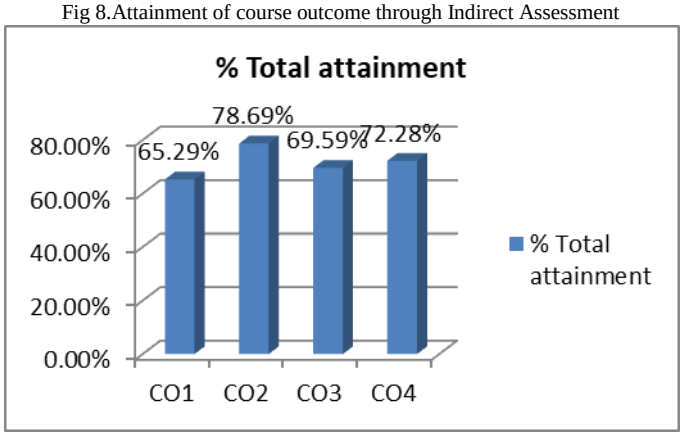

Fig 9. CO Attainment through Indirect (30%) + Direct Assessment (70%)

In this paper the results of the students of the section handled by one of the author (course coordinator) in our autonomous Institute is presented. However, similar improvement is observed in the other three sections having 180 students in total, handled by other course instructors.

TABLE III
. FINAL CO ATTAINMENT OF 20IT5404A

CO	INDIRECT ASSESSMENT	Indirect @ 30%	Direct	Direct @ 70%	Total
CO1	97	29.1	51.7	36.19	65.29
CO2	99	29.7	69.99	48.99	78.69
CO3	96	28.8	58.28	40.79	69.59
CO4	100	30	60.4	42.28	72.28

Based on the results obtained in this data mining studio course for the next three semesters being implemented for students of various programs, we can identify similar studio courses like artificial intelligence, deep learning and network security etc and suggest respective modifications in the curriculum development of those courses to the board of studies for approval.

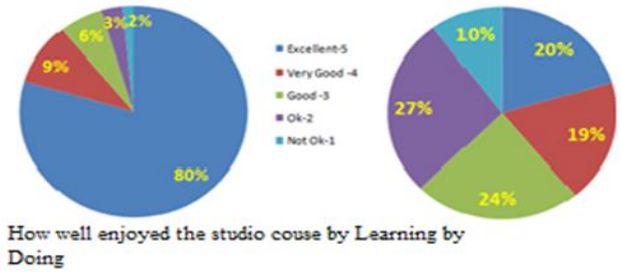

Fig 10. Course end survey from students: Learning by Doing studio course(left), same course taught in the previous year without SBL(right)
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VI. CONCLUSIONS

In this paper, the significance of the implementation of relatively new Studio Pedagogy and Studio-based learning for hard core subjects like Data Mining in Computer Science stream is discussed. The effective role of active learning methods and integrating formative assessments in the Outcome Based Curriculum Design and Development in such studio courses is elaborated with examples used in the course delivery. From this case study, it is demonstrated that the use of such active learning methods, learning by-doing teaching methods improved learning outcomes. It also demonstrated the significance and the process of Outcome Based Curriculum Design & Development of studio courses in Computer Science stream in the OBE framework. This kind of improvement in curriculum development can be implemented for identifying studio courses and their design in other technical programs also.

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