Optimum Use of LMS for Dynamic Mathematics Classrooms in Blended Mode

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Abstract— **Recently the education industry has moved at an increasing pace towards quality assurance programs. There is a high demand for efficient use of Information and Communication Technology (ICT) in education, especially to improve the quality of mathematics education. After COVID-19 lockdowns, ICT has become essential in the era of blended learning. Variations in pedagogy and assessments in mathematics are always challenging. Due to difficulties in learning mathematics, the need for innovative mathematical pedagogy is rising daily in online and blended learning environments. Through this paper, the authors attempt to provide more opportunities to mathematics teachers and students to learn through LMS. Through KJSCE-LMS (Moodle based LMS specially customized for students of K J Somaiya College of Engineering (KJSCE), Mumbai), the authors demonstrate the optimum use of innovative Teaching-Learning-Evaluation (TLE) techniques that can be easily practiced in online or blended mode of mathematics education. These technology-enhanced TLE methods were applied in the first year undergraduate engineering mathematics classroom in the urban part of India. To check the promethean ways to enhance pedagogical learning experiences by students, qualitative and quantitative surveys were conducted. Results of the survey reveal that teachers' systematic usage of KJSCE-LMS can make mathematics learning easy, effective and meaningful. 98% of the students agreed that the contents uploaded on LMS helped them to understand the concepts effectively. LMS can also help strengthen the learning process, motivate students, improve their learning outcomes, and positively impact their wholesome development.**

Keywords—**Assessment; Blended learning; Innovative teaching techniques; LMS; Mathematics education; Pedagogy; Online assessments**

JEET Category—**Practice**

I. INTRODUCTION

"WE are living in an ever-changing world" (Sethy, 2008, p.29). COVID-19 has revolutionized the education system across the globe. Before COVID-19, due to the difficulties in digitalizing mathematical contents, educators lacked ICT knowledge, minimal training and opportunities for learning about ICT, and limited technical support; Mathematics teachers hardly used ICT in mathematics classrooms. Information and communication technology (ICT) is a tool that supports the learning process and holds the promise of new solutions to all the challenges that education is facing (Oduma & Ile, 2014). According to Das (2019), there was a need for more training for mathematics educators regarding computer usage and ICT applications for teaching purposes.

The article published in NDTV Education (Singh, 2018) revealed that at least 89% of parents feel that Mathematics is the toughest subject their kids study. Furthermore, 77% of parents surveyed believed that the subject was not being taught well in school, leading to the necessity of tuition classes.

COVID-19 has a historical impact on education. Suddenly, the offline classrooms turned to complete online mode. Due to sudden turbulence, all mathematics educators had no option but to adopt ICT and try to make interactive online classrooms. ICT is not easy to apply to Mathematics & Application of Mathematics (Das, 2019). The Learning Management Systems (LMS) were the handiest ICT for teachers to create a better learning environment during a pandemic. (Raza et al. 2021) investigated students' acceptance of the LMS during the COVID-19 pandemic and showed the need for improving the LMS experience.

A learning management system (LMS) is a software application or web-based technology used to plan, implement, track, assess and report a specific learning process. LMS is typically used for knowledge management that helps gather, organize, share and analyze learning resources. It provides an instructor with a way to create and deliver content, monitor students' participation and assess students' performance. It allows students to use documentation, online content, discussion forums, etc. One study reveals that the students who utilized LMS in their teaching-learning methods obtained significantly more fantastic mathematical knowledge achievement than those who solely received traditional instruction (Ojeda-Castro et al., 2017).

Various LMS are available such as Moodle, Blackboard, Edmodo, Schoology, Canvas, Google Classroom, D2L Bright space or the university's internal LMS. Due to the traditional approach to teaching mathematics, hassle with typing of mathematical content, the weak mathematical background of students & difficulties in understanding, LMS are not very popular or frequently used in mathematical classrooms (Das, 2019).

Even after COVID-19 lockdowns, students' tendency to use technology became the turning point of classroom innovations. The blended learning mode turned out to be a better way of learning mathematics than the complete online or offline mode. According to (Yustina et al. 2020), blended learning is a learning approach that combines face-to-face learning with online learning. (Tayebinik & Puteh 2013) summarized that blended learning is more favorable than pure e-learning and offers many advantages for learners, like producing a sense of community or belonging. Blended learning also improves students' higher-order thinking skills (Eliyasni et al., 2019).

(Setyaningrum, 2018) highlighted that blended learning increases students' understanding of mathematical concepts, while (Lin et al., 2016) stated that it improves student performance in the mathematics learning process & (Rifa, 2018) mentioned that a positive perception of mathematics could be developed through blended learning. Moreover, based on various researches, blended learning benefits students in understanding mathematics. Bauk, 2015 & Yigit et al. 2014 believes that blended learning simplifies the assessment process.

(Fotiyeva & Shockley, 2015) indicated a relationship between the instructional method and the pass/fail rate when comparing the traditional and the technology-enhanced classes. As suggested by (Raza et al., 2021) & inspired by the recent research about the need for blended learning and technology integration in mathematical courses, authors strategically implemented LMS to enhance the day-to-day learning experiences of students.

The paper demonstrates the optimal use of Moodle-based LMS in undergraduate Engineering Mathematics courses in the urban part of India. Authors have used Moodle based LMS specially customized as per the need of students of K J Somaiya College of Engineering (KJSCE), Mumbai. Henceforth, it will be referred as KJSCE-LMS. However the results can be utilized for any LMS and any other course. Through the paper, the authors showcase innovative technology-supported Teaching-Learning-Evaluation (TLE) techniques that can be quickly adopted in online or blended learning environments. The suggested techniques, if used during offline education backed with a perfect blend of innovative online pedagogy & assessment practices using LMS, can strengthen the learning process and improve students' learning outcomes. The paper may also inspire the mathematics teaching fraternity to be creative with various features of LMS and adopt it in daily TLE. The student's feedback about implementing TLE in hybrid classes justifies the claims. We conducted qualitative and quantitative surveys to collect the data. Out of 100 FYBTech semester II students, 86 responded to the study.

II. Diversified Pedagogical Experiences Via LMS

Learning is a continuous process. (Khalaf, 2018) states that traditional or face-to-face learning is strongly influenced by the role of teachers, so problems begin to emerge in the absence of direct mentoring by the teacher. Maximum students faced this problem during the COVID-19 lockdown period. Hence, LMS becomes desirable as it provides continuous learning even after college hours and flexibility in activity conduction. Referring to the research of (Tran et al., 2020), a teacher must be equipped with good ICT skills to develop e-Learning or digital literacy.

LMS can help tremendously in designing a well-structured pedagogical plan and implementing it seamlessly. Effective pedagogy involves creating activities related to whole-class (big or small), tutorials and practical sessions, concentrates on guided learning, and nurtures self-paced learning. Authors used KJSCE-LMS to create a unique learning environment for students through blended learning.

The target students were the students' fraternity who had experienced complete offline mode before the COVID-19 pandemic and also experienced complete online mode during the crucial years of their high school learning. The integration of technology in learning was desirable due to tech-savvy students. At the same time, the poor mathematical background, lack of basic conceptual knowledge required as prerequisites and limited lecture hours for offline interactions became the biggest challenge for mathematics teachers to achieve the desired learning outcomes within the stipulated time limit.

The authors adopted the planned systemic approach, which motivated students to use KJSCE-LMS regularly for their mathematical studies. Students experienced plenty of KJSCE-LMS supported teaching-learning methods in the class, supported by study material uploaded on LMS. The authors describe some of the methods below.

A. Flipped Classroom

Due to the COVID-19 pandemic, the education field was highly affected. Students could not properly grasp the concepts studied in the online mode, or they lacked the required prerequisite knowledge once they joined back regular offline classes. The authors were teaching an undergraduate course where they faced the same challenge, and due to time constraints, they could not spend more time clearing students' prerequisite knowledge.

The authors used the 'Flipped classroom' technique through LMS to address this issue. The technique was used to cover the prerequisite, begin the new concepts, revise the topics, and summarize the concepts.

Study materials such as videos, notes, and formulae related to the prerequisite concepts were uploaded on LMS, through which students were exposed to concepts before arriving at class. (Fig. 1) LMS helped teachers to notify students on time about the uploaded activities and send timely automated reminders. During Offline sessions also students were encouraged to visit LMS and go through this material. The flipped classroom was backed with active learning offline strategies like think-pair-share, jigsaw etc. during lecture hours.

Flipped Classrooms in blended mode helped teachers prioritize learning and promote a deeper understanding of a concept. It also helped students gain confidence in learning

mathematics in greater depth.

B. Expert online sessions or Curated internet content and videos for beyond classroom activities

Positive changes are always appreciated. Frequent guest lectures are recommended to break the boredom of traditional teaching-learning in mathematics by the same teacher throughout the semester. Due to logistic, economic and time constraints, we cannot use this solution frequently in offline mode. In blended learning, through technology, this technique was implemented at regular intervals by uploading expert sessions, international talks etc. on LMS.

We have shared beyond syllabus reference materials and videos illustrating applications, real-life uses or visualizations for some of the syllabus-related topics on our LMS. We have carefully chosen and curated these materials as per students' academic level and understanding. Since we have abundant internet resources worldwide, we could benefit our students from the knowledge shared by renowned global experts on specific topics. (Fig. 2)

Sharing this knowledge through LMS removed all the hurdles of keeping the guest lecture in offline mode. Through these activities and the inclusion of informal and blended learning, we have provided a way of personalizing and further engaging learners.

We endorsed the knowledge imparted through the videos and other materials by either discussion in the classroom or the follow-up quiz and discussion forum created on the LMS course page. In the survey, 97.6% of students agreed that content uploaded on LMS helped them to understand concepts more effectively. (Fig. 3)

C. Graphical representations and visualizations

Understanding mathematics becomes difficult due to a lack of visualization and knowledge about real-life applications of mathematical concepts. To address this issue, LMS was a handy tool for us.

We developed the E-content related to visualizations and applications of mathematics in Engineering. Such contents are beneficial for students' motivation. (Desai, 2020). We had made efforts to find the videos online. We also used some web-based software to demonstrate the visualization of concepts such as 2D/3D curve tracing, multiple integration, application and illustration for the idea of eigenvalues and eigenvectors, which are otherwise very difficult to explain on a plain blackboard.

We shared a few videos on LMS for students at the beginning of the topic in the class, and some content was reserved for the end to facilitate in-depth learning and better insight into the subject. (Fig. 2)

83.4% of the students admitted that this type of content uploaded on LMS helped them to increase their attention towards mathematics & mathematics learning. (Fig. 4) Graphical representations and visualizations for topics made mathematical concepts easier to digest for various students. This helped us create self-motivated learners who understand the mathematics behind real-life activities and enjoy the beauty of mathematics.

Fig 1: Prerequisite material for Flipped classroom
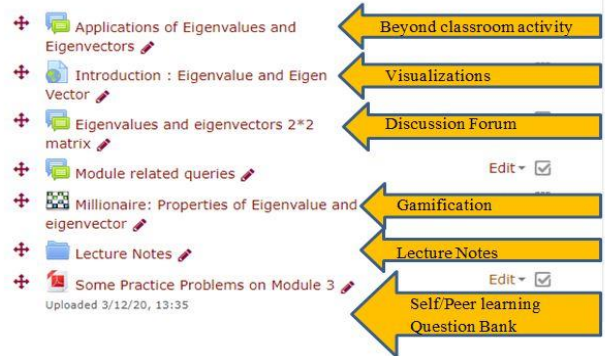
Fig 2: Illustration of various pedagogical activities
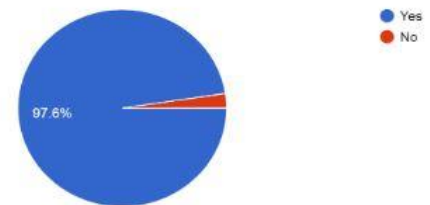
Fig 3: Understanding concept effectively

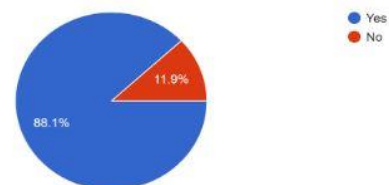Fig 4: Increase in attention towards Mathematics learning

Fig 5: Increase in motivation due to Gamification

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D. Gamification

Games are fantastic for learning at any age. We can effectively teach many mathematical concepts with the help of games. It aids in improving the student's interest in learning. Authors used features of games available on Moodle-based LMS. Fun games like snake and ladder, Sudoku and millionaire were designed to test students' understanding of several concepts. (Fig 2) These games created an enjoyable learning environment where students could learn and understand the subject more effectively. In the survey, 88.1% of students voted that gamification helped increase their motivation toward learning Mathematics. (Fig. 5) This feature is discussed in detail in the forthcoming research paper by the authors.

E. Lecture notes & Question banks

Through LMS, we provided regular lecture notes, class presentations etc. at the end of every sub-topic covered in class. This practice also made lectures more flexible in terms of time and content. The students highly appreciated this feature of LMS due to quick access & 24*7 hrs. availability of one place centralized study material. Students can any time refer to the same content covered in class. They can revise topics, and while revising, they can reconnect with the classroom learning. Repetition of same content strengthens the retention abilities of students.

Question bank along with the topic was an important feature. Exhaustive ranges of questions from moderate level to an expert level were listed in the question bank. The question banks comprise questions from the previous year's exam question papers. This feature helped students for the most summative formal assessments.

94% of students voted this feature was the most helpful feature for learning Applied Mathematics. (Fig. 11) This feature also motivated students to be regular with LMS course page to see subsequent updates.

F. Self-learning and self-paced learning

LMS provides the centralized and latest information about the course. This centralized hub of learning materials means students can find anything they need related to the course within just a few clicks or taps away. It encourages self-learning and self-paced learning. In the literature, it is often mentioned that learners will have different achievements and struggles in any traditional course and the role of the teacher is now shifted from detecting and in-person instruction to a facilitator who designs lessons with activities, motivate students to curate knowledge from the available resources and helps learners use their methods for finding answers.

Through the above-mentioned teaching techniques backed up with the active learning offline strategies, the Authors regularly uploaded the course content on LMS in a properly structured manner. Students referred to these materials at their convenience and assimilated them as per their pace of learning. The question banks provided to students for further practice were another motivation for self-learning. We encouraged students to solve hard difficulty level problems, which promoted independent thinking ability amongst them for the subject.

G. Peer learning

LMS helped in many ways to promote peer learning amongst students. After sharing videos, learning material, question banks, pre-requisite contents etc. on the LMS, we encouraged students to analyze, discuss and solve problems collaboratively. For some concepts, we initiated a discussion forum on LMS. (Fig. 2) We posed some challenging questions in the discussion forum. This feature helped us create open-ended questions. Students could give their opinions & views about the topics. They could also raise their queries through discussion forums. Due to 24*7 accessibility, and association with other social media, students could get quick and timely responses to their queries many times from their peers. This type of activity on LMS motivated students to engage in self-learning and peer-learning. Discussion forums were the tool for teachers to understand students learning informally. A discussion forum can be very effective online/blended teaching replacement for the "Minute Paper" technique widely used in offline teaching.

III. INNOVATIVE ASSESSMENT TECHNIQUES THROUGH LMS

One of the most critical aspects of Outcome Based Education (OBE) is Continuous Assessment (CA). CA can be efficiently planned with the help of LMS. Assessments are the learning tool used to determine students' progress in achieving their learning goals. Formative assessment plays an essential role in the continuous learning process and backward design; it acts as a catalyst for motivation. Students demonstrate an understanding of the course content through their performance in various assessment tools. Multiple Choice Question (MCQ) is the most common test format in education. Other than MCQ with a single correct option, there are a variety of activities available on LMS to design effective assessment tools according to the requirement of the course. Fig. 6 highlights several assessment tools practiced by the authors. Authors have widely used formal assessment tools like quizzes, MCQ with a single correct option, MCQ with multiple correct options, embedded quiz, activity-based assessment, research-based assessment and assignments with rubrics etc. Authors have used LMS features like games, discussion forums etc. as informal assessment tools.

A. Self-Evaluation Quiz

Due to COVID-19, the targeted student batch experienced lockdown and complete mode of online education during the critical growing years. We conducted a prerequisite quiz as the first informal assessment tool. This assessment aimed to give students a chance to self-evaluate their pre-acquired knowledge in previous mathematics courses. The quiz results clearly indicated to students where they stand in terms of previous mathematical knowledge and which topic should be revised before starting the applied mathematics course. This quiz motivated students to revise concepts already uploaded on LMS which would be helpful in their further studies. The in-class discussion follows the quiz to reinforce their learning.

B. Graded Quizzes

We conducted at least one graded quiz on each module. LMS has features to offer different types of quizzes based on the objective of the graded activity. Some quizzes had single correct options, while others had multiple correct options. We used one more kind of quiz, an embedded quiz for evaluation. This quiz type allows the teacher to create different sub-questions based on the primary question data set. This type of quiz is helpful to check the problem-solving capabilities of students, where students can be graded based on the answer to each step. (Fig. 7)

We created a comprehensive question bank which later was utilized to generate random quizzes. This question bank allows teachers to maintain the questions' variants while conducting the assessment. These quizzes were auto-graded, and students could review their attempts and understand the mistakes they made quickly. As a result, teachers and students benefited from fast and accurate evaluation and timely feedback on the activity. Timely feedback of assessments helped the teacher to design future teaching strategies and helped students to identify weaknesses and timely improve them.

C. Assignments

In the Mathematics course, evaluating students for their problem-solving techniques and ability to represent the solution lucidly and concisely is essential. We conducted several assignments to appraise the quality of students. Some of these assignments were graded without rubrics, and some were graded with the help of rubrics. We can easily do the assessment of these assignments on the LMS, and we can leave comments and feedback on the students' work. There is no fear of losing the pages of these assignments, and the students can always go back and refer to their work and modify their solutions with the help of teachers' feedback.

D. Rubrics

A rubric is a tool that can be used to score a student's work with the help of pre-defined criteria and performance ratings. A well-defined rubric helps students understand the teacher's expectations concerning the assigned work. The rubric also allows teachers objectively assess 'students' submissions with minimal errors. We can reduce the effect of personal bias with the help of a well-defined rubric. A rubric can be efficiently designed and attached to a graded assignment in the LMS. (Fig. 8)

E. Research and application-based activities

Research is essential in undergraduate studies. (Desai, 2022) showed the possibility of research-based online assessment which can give a foundation of research in the course of Mathematics. We designed similar graded activities in blended mode to boost students' research aptitude and motivate them to find applications for mathematical concepts. One of these activities was an assessment based on poster presentations. In this activity, students were encouraged to research the Application of a given mathematical concept and present their findings in attractive and informative posters. LMS played an essential role in conducting this activity as we shared all the application areas with the students, making them aware of mathematics' importance in engineering and science.
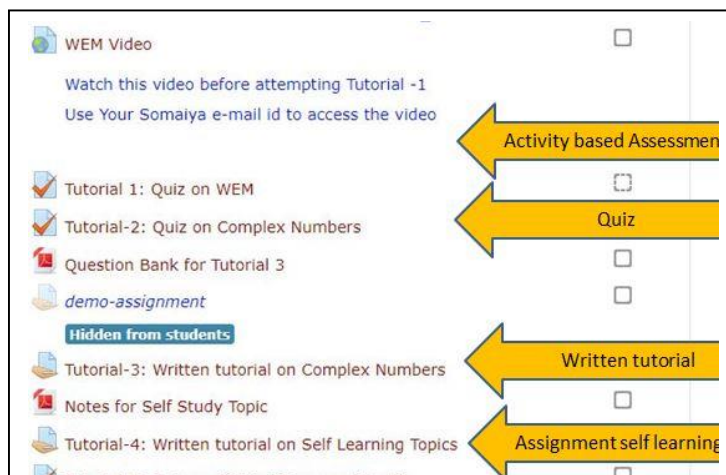

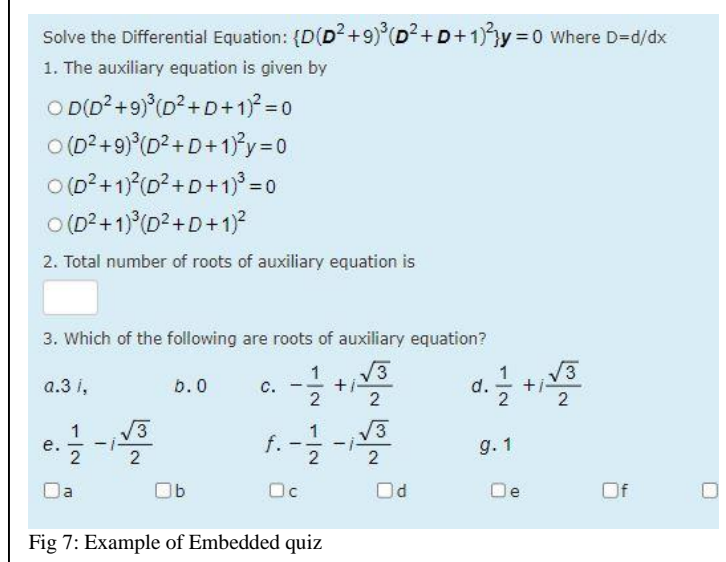Fig 6: Highlight of assessment tools under LMS

Fig 7: Example of Embedded quiz

One other similar activity was application-based tutorials. In this activity, a session was conducted to explain some branch-specific applications of mathematical concepts to the students. We uploaded the supporting study material to LMS and then conducted a graded activity (quiz or assignment) with the help of LMS.

F. Versatile Grade book

The LMS automatically generates a gradebook based on all graded activities conducted in the course. We can divide this grade book into different sections and add the activities to the appropriate sections of the grade book. Teachers can define the weightage of various activities in the final grade calculation. All these features of LMS can make the life of a teacher relatively easy in assessment-related work. We can generate different charts with the help of LMS to understand the distribution of grades obtained by students in each activity. (Fig. 9) We can also make an overall comparison of grades in different activities. (Fig. 10)

Overall a good LMS can satisfy the need for efficient, effective formative assessment; also the need to perform these assessments in an increasingly online environment, and the increased demand for program-level tracking of learning outcomes.

Rubric for IA-1 Ready for use

Relevance	The information provided is relevant to topic assigned 3 points	Most information provided is relevant to topic assigned 2 points	Most information provided is not relevant to topic assigned 1 points	The information provided is not relevant to topic assigned 0 points
Utilization of Poster	Most part of the poster is utilized to cover maximum information. 3 points	There is some scope of covering more information on the poster. 2 points	There is a much scope of covering more information on the poster. 1 points	Very less information is covered on the poster. 0 points
Creativity	Poster is creative 3 points	Poster can be more creative 2 points	Poster is not so creative 1 points	Poster is not at all creative 0 points
Plagiarism	Information provided is in own words 3 points	Some information provided is not in own words 2 points	Most information provided is not in own words 1 points	Information is directly copy-pasted from other source 0 points

Fig 8: Rubric example for poster making

Fig 9: Bar chart for individual assessment
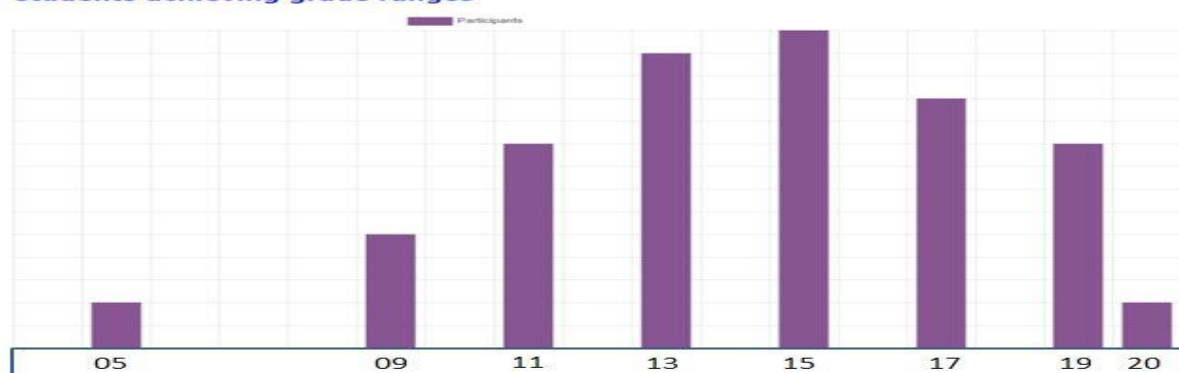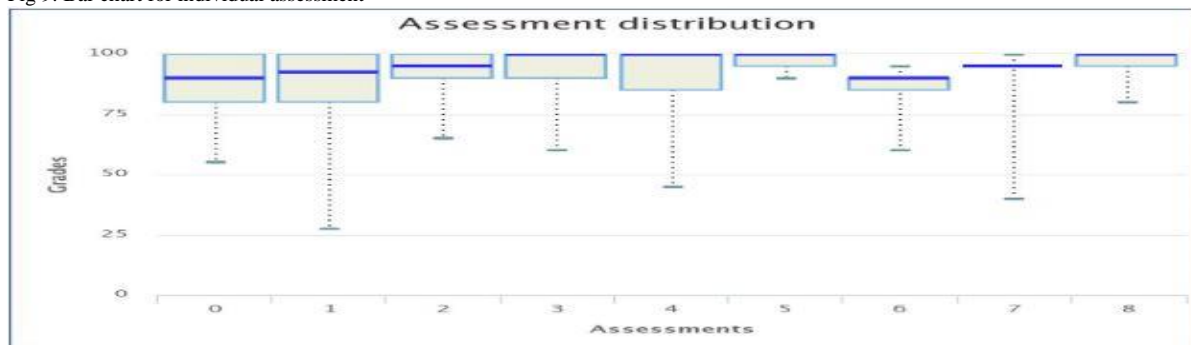

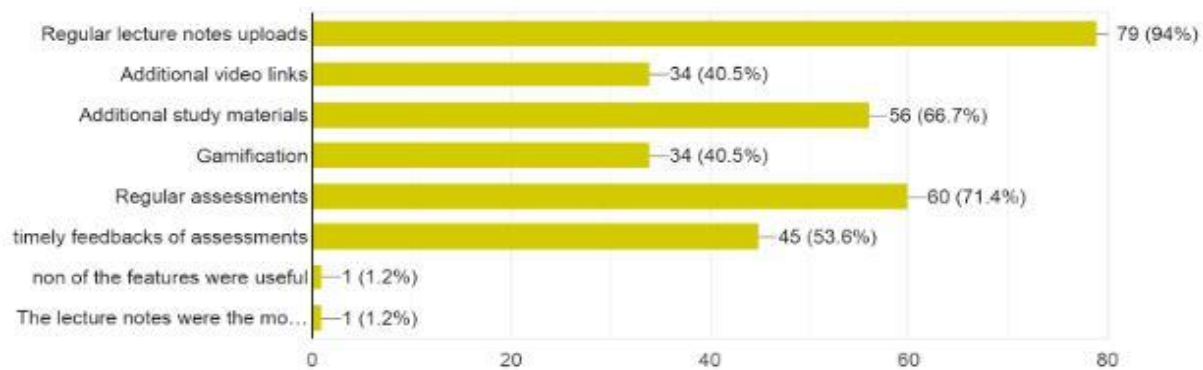Fig 10: Box plot for collective grade distribution

Fig 11: Gauging usefulness of LMS features

IV. STUDENTS' SURVEY AND RESULTS

Bancheva (2010) explains that the application of e-Learning in universities requires teachers to spend much time preparing material, and students are also required to have self-discipline. Therefore, LMS remains the primary choice for students facing difficulty with time management and the face-to-face method.

The authors surveyed students' experience and satisfaction levels while using the LMS for different activities. The survey form was sent to 100 students, out of which 86 responded to the survey. Following are the responses of students.

In response to the question about the most useful feature of the LMS, 94% of students agreed that the regular upload of lecture notes was very useful. 67% of students found the extra study materials helpful. 71% of students enjoyed the regular assessments, and 54% of students were satisfied with the timely feedback of assessments. (Fig 11)

98% of the students agreed that the contents uploaded on LMS helped them to understand the concepts effectively. (Fig 3) 83% of the students believed that the content uploaded on LMS increased their attention toward mathematics learning. (See Fig 4) 90% of the students felt that using LMS to refer to various contents has increased their confidence in learning mathematics. (Fig 12) 88% of the students were satisfied with mathematics learning due to the help of LMS in the teaching-learning and assessment. (Fig 13) 99% of the students verified that LMS helped them give timely feedback on their tutorials and tests thanks to various due date reminders via mail. (Fig 14) Moreover, 75% of the students acknowledged that beyond syllabus content uploaded on LMS helped them relate mathematics with other engineering fields and real life. (Fig 15)

V. CONCLUSION

With 98% of students' acceptance, through the paper, the Authors demonstrated the optimum use of LMS can make Mathematics learning easy, more effective and meaningful. LMS can be utilized to create dynamic classrooms. While most research demonstrates "what" to be implemented in mathematical pedagogy, the authors tried to answer "What, When and How" to implement innovative pedagogy to achieve desired learning outcomes.

The paper attempts to answer the most burning social questions of making mathematics easy for students using innovative technology-based pedagogy and assessment. Teachers' systematic and intelligent way of implementing Moodle-based LMS helped create an interactive active learning environment & dynamic mathematics classrooms. LMS came to the aid of authors in various aspects, including time, place, resource management and efficient implementation of strategies planned for the students. It also helped teachers cater to diversity with students with different learning styles. The proposed techniques can be extended to any LMS, any subject in online or blended learning mode. The offline education supported with a perfect blend of innovative online pedagogy & assessment techniques suggested here will create the perfect blended learning environment for students. This environment also helps students to improve their motivation to learn mathematics.
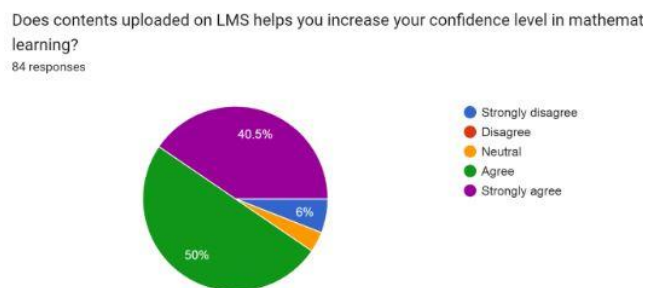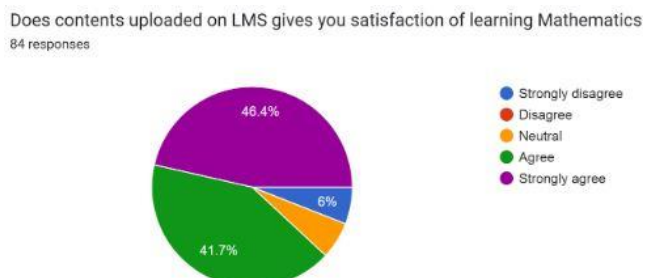

Fig 12: Increase in confidence level
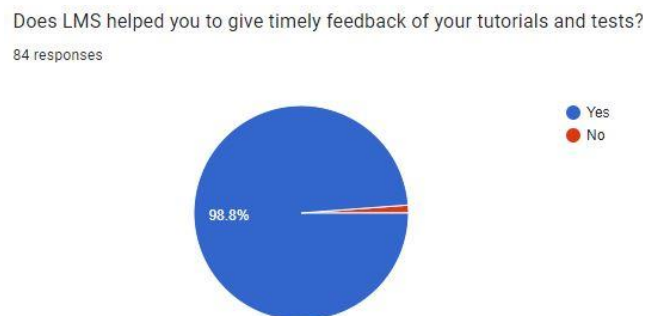

Fig 13: Satisfaction of learning

Fig 14: Timely feedback for assessment due to reminders

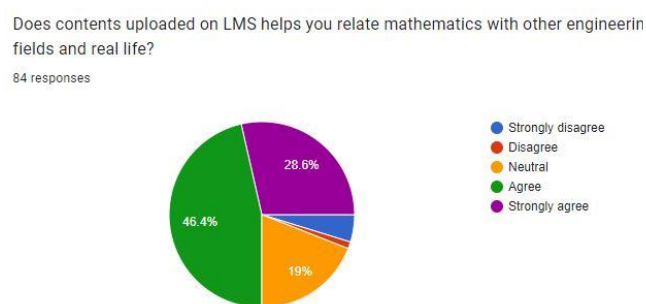Fig 15: Relate with applications in engineering and real life

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