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Diversifying Assessment Approaches: A Success Story of Assessing Microcontroller and Embedded Systems

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***Abstract*— As a result of the incorporation of technology, engineering graduates must possess the ability to tackle complex problems, utilize information and communication technology (ICT) tools, and develop a lifelong learning, all of which are expected outcomes of the programs. In order to focus on analyzing, evaluating, and creating, Bloom's higher-order thinking skills have required changes in both teaching methods and assessment methods. The Microcontroller and Embedded System (MES) course covers a broad range of applications and necessitates the practical implementation of hardware design, software development, and the integration of software with hardware. This involves utilizing a variety of tools such as editors, compilers, and debuggers. In this case study, Project-based learning, product-based learning, and open book examinations are utilized as separate methods to examine difficulties and achieve higher degrees of learning. The paper presents a diversified assessment approach, including evaluation through hands-on workshop and practical sessions, continuous evaluation through logical tests, project-based learning focusing on societal problems, and open book exams allowing prompt solutions by referencing various materials. The effectiveness of various assessment approaches is determined by the enhancement of outcomes, improvement in feedback, and startup funding for the product.**

***Keywords*— Project based learning, Microcontroller, Embedded system, Diversified assessment, Effective teaching.**

ICTIEE* Track*: Assessment of Effective teaching
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(Refer to the Paper Submission and Review Guidelines for more details.)

I. INTRODUCTION

ASSESMENT is crucial in fostering the development of students' learning capacities in higher education (Carless et el., 2017; Boud & Falchikov, 2006). Although these conventional methods are successful in assessing certain cognitive skills, they often fail to capture the broad range of skills and analytical thinking capacities of learners (Gulikers et al., 2004). In the field of modern education, diversified assessment is crucial to creating a more dynamic and efficient learning atmosphere (Muller, 2005).

Diversified assessment is an evaluation process that includes a set of techniques and helps students acquire knowledge, skills, and competencies (Brown et el., 1999). Diversified assessment incorporates various evaluation methods, including formative and summative assessments, project-based evaluations, peer assessments, and self-reflections (Bevitt, 2005).

The primary goal of the Microcontrollers and Embedded Systems (MES) course is to help students become more adept at both logical and creative thinking. Students studying electrical engineering can enroll in MES during the sixth semester. Learning about different microcontrollers, such as the ARM-based microcontroller and the 8051 microcontrollers, is part of the MES course. Any application utilizing a microcontroller must be developed with a solid grasp of hardware interfacing, programming, and microcontroller architecture. The first semester of study covers the C programming language, and the sixth semester offers MES. This disparity makes it difficult for students to work with programming. Additionally, the two programming languages that students had to learn were assembly-level programming and low-level programming, or C. In addition to the previously mentioned issues, switching between two programming languages causes students to become disinterested. Furthermore, subpar academic performance is the consequence of the traditional MES assessment.

The adoption of an academic assessment system in higher education is covered by Liang (2023). It illustrates the advantages of utilizing a range of assessments to boost student motivation, get around the drawbacks of depending just on one kind of evaluation, and enhance instruction and learning. Guraliuk et el. (2023) talks about implementation-quality assessments in education. O'Neill & Padden (2021) looks at the drawbacks and advantages of these approaches, including increased student empowerment and engagement. Alhassan (2020) talks about the conventional techniques for evaluating students' academic performance based on their assessment grades. Zhu et. el. (2023) talks about techniques for game-based assessment. Garside et el. (2009) examine how using student-choice assessment techniques can improve academic performance. The literature that has been mentioned, however, ignores the crucial problem with learning outcome-based assessment techniques.

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This paper discusses the learning outcomes of the MES course by implementing diversified assessment combined with effective teaching and learning processes. In order to facilitate effective learning, students were given a hands-on workshop on the 8051 microcontroller and its applications without any prior programming or 8051 architecture knowledge. Additionally, classes were created with a greater emphasis on practical application and centered around a single programming language rather than two. Written exams have been totally disregarded in favor of a variety of components such as (a) project-based learning, (b) logical quizzes, and (c) open book exams as part of diversified assessment. The course is designed in such manner that the ratio of class room teaching and self - paced learning is 65:35. Students have been surveyed before and after the course to measure the effectiveness of the diversified assessment. Moreover, the results of this batch of students have been compared to those of previous batches in which traditional assessment was implemented. The result analysis and survey have been discussed in the results and discussions.

II. Effective Teaching Strategies

Logical and critical thinking skills are necessary for courses like MES, and an efficient teaching-learning process is also necessary to foster these traits in the students. Without any prior programming or 8051 architecture knowledge, students have been given a hands-on workshop on the microcontroller and its applications as part of an effective teaching approach. Additionally, rather than covering two programming languages, the course has focused more on one and kept the classes more hands-on and practical.

A. *Workshop on 8051 Microcontroller and its interfacing*

The goal of the workshop was to give students a basic understanding of application development and 8051 microcontroller interfacing. It is made to assist students in the design, programming, and implementation of embedded systems. The workshop covered key concepts like the interface of LEDs, LCDs, motors, and ADC-DAC, giving students the knowledge and abilities they need to tackle creative problem-solving in the field of embedded systems.

Students were able to configure and interface 8051 microcontrollers with motors, LCD/keypad interfaces, and ADC/DAC through the workshop. Students who participated in the workshop gained the following knowledge and abilities: (a) creating simple programs; (b) debugging embedded systems using LCD screens and keypads; (c) using timers to precisely delay events and count them; and (d) building dependable serial connectivity for data sharing.

B. *Effective teaching*

It is essential to keep sessions of the MES in such a way that students remain interested, invested, and focused. These have been achieved by (a) the inclusion of practical implementation of learned topics, (b) engaging students in a virtual classroom, and (c) detailed timeline planning of the course.

1) *Practical realization of learned topics*

Simulation software allows for the practical visualization of many MES topics. Hence, the design of the sessions has been done in such a way that any complex topics, such as designing timer circuits, serial communication, c-programming, etc., can be implemented practically with Keil µVision (student version).

2) *Virtual classroom*

Due to missing classes or a lack of study materials, it has been noted that students frequently do not follow any specific topics or assignments. A virtual classroom on Canvas Learning Management System has been developed as a solution to these problems and to ensure the proper conduct of the course. Establishing a virtual classroom where students can freely discuss, share their most recent discoveries or learnings, monitor their assessment grades, and access all study materials is the primary goal. This classroom serves as a means for students to receive all the important announcements, course materials, assignments, project status, videos, instructions, and faculty availability. The virtual classroom's layout is designed to provide students with all the materials they need for MES in one convenient location. Fig. 1, which provides snippets of the online classroom.

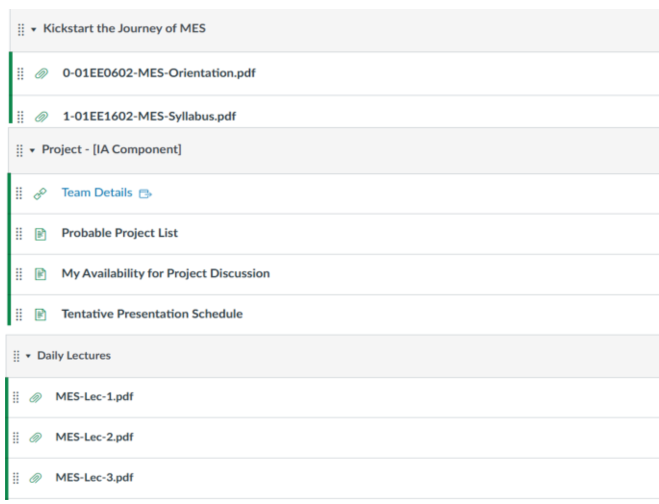


Fig.1 Modules of the Virtual classroom

3) *Course timeline*

Since classes meet for three to four months during the semester, it is not unusual to see students missing a lot of lectures. Students who miss the lectures will become disengaged from the material. In the end, students become disinterested or miss more classes. Students are given access to a thorough plan outlining the topic delivery to prevent such problems. This aided the students in following the topic. Additionally, students have the option to review the subjects covered in the sessions they were unable to attend. This encourages students to study the course in advance of the following class. The course timeline provides idea about submission dates of the projects, reviews and exams. This helps in planning their work throughout the semester. Fig. 2. provides the monthly planning of MES course. Monthly planning of the course MES includes two segments namely (i) Teaching and learning and (ii) Evaluation. Teaching and learning planning help students know about what they will learn in each week in the course. Evaluation planning inform students about the important dates for submission of the presentation review and exams.

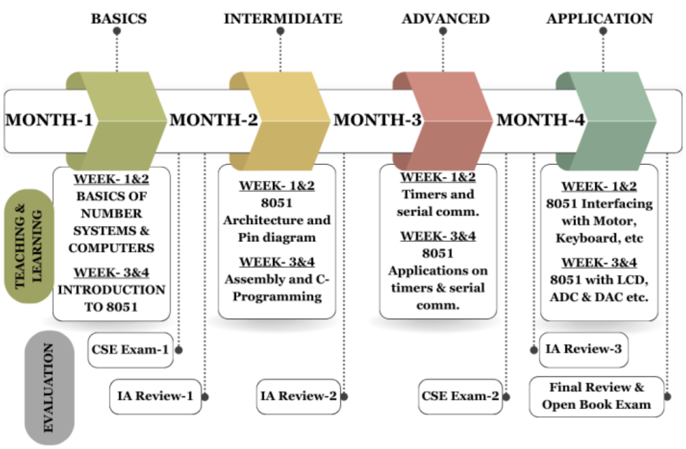


Fig.2 Course timeline of MES

III. Diversified Assessment Methodologies

Diversified assessment strategies have been effectively implemented to evaluate student learning outcomes for MES. Diversified assessment has been employed, considering components like (a) project-based learning and (b) logical quizzes (c) practical performances; (d) viva voce examinations; and (e) open book exams. Table I gives a breakdown of the marks for diversified assessment components.

TABLE I
Diversified Assessment Components of MES

Sr. No.	Components	Marks
1	***Continuous Systematic Evaluation:*** Students will go through Logical Quizzes.	20
2	***Mid semester exam (IA):*** ***(A) Project –*** [20 Marks] - Students need to prepare a project related to the domain MES. ***(B) Assignments –*** [10 Marks] - Students need to write assignments based on the design of programs related to the subject topics.	30
3	***End semester examination*** ***Open book examination*** – [100 Marks] - Students will be given one real life problem and they need to design the solution within the given time. Students will have to develop the logic block diagram, list of the components needed to design the product, program and interfacing circuit.	50
4	***Term work*** ***Laboratory Report –*** (25 Marks) - Students will submit laboratory reports regularly and consolidated marks from all experiments will be considered for term work evaluation. The involvement of students will also be considered for overall evaluation.	25
5	***Viva*** ***Oral Examination*** – (25 Marks) - Students will appear in the viva voce examination at the end of the term.	25

A. Project based learning

With the objective of delivering practical knowledge and generating employability from the subject, students have been divided into groups and given projects. Students have selected the projects in such a way that they can solve any real-life problems, and they take their project to the product level. Sixteen teams were created through a systematic selection process. The assessment process for the project employs a four-step review process throughout the semester term. The project groups will give four presentations based on their learning of various segments. The four-step review process includes presentations on the following criteria: (a) idea formation; (b) software design requirements; (c) hardware implementation progress; and (d) project exhibition. Each review presentation holds five marks. List of the projects taken by the students is presented in the Table II.

TABLE II
Projects Selected by Teams

Teams	Projects
1	Smart Garage Door
2	Smart Hybrid Energy Management System
3	Smart Agriculture System
4	Home Automation system
5	Stick for blind people using Arduino
6	Smart Car
7	Password Based Door Locking System using 8051
8	Water level indicator with Arduino
9	Mobile control Robotics car
10	Smart Dustbin
11	Smart Parking System
12	Weather Reporting System
13	Streetlight Monitoring System
14	Password Based Door Lock Using Arduino Uno
15	Smart Trolly
16	Smart Energy Monitoring system for residential buildings

1) Idea formation

In this review session, students have presented their findings after identifying their problem statement. Students delivered presentations that reflect the insights they have gained from their research on their problem. Hence, students need to give a presentation that includes the following points: (i) Project Introduction; (ii) Problem Statement; (iii) Project Features; (d) Historical Analysis; (iv) Current Scenario/Synchronic Analysis; and (v) Methodology. Students have been evaluated based on (a) presentation delivery, (b) clarity of the problem, (c) attendance and (d) performance in the questions and answers that follow the presentation.

2) Software design requirements

The second step of the four-step review process is a review presentation on software design requirements. This review is to assess students' proficiency in designing and presenting software solutions for microcontroller-based projects, showcasing their thorough comprehension of software engineering principles, coding practices, and project management skills. In this review presentation, students will be giving presentations on: (a) flowchart of the code; (b) explanation of code; and (c) simulation. The evaluation of the students for this review has been done according to the rubrics given in Table III.

TABLE III
RUBRICS PLANNING FOR EVALUATION OF REVIEW-II

Criteria	**Ratings**		
Presentation delivery	5 to 3.5 Excellent Addresses all required topics properly	3.5 to 2 Average Addresses required topics moderately	2 to 0 Needs improvement Misses required topics
Code understanding	5 to 3.5 Excellent Explains the program with logic	3.5 to 2 Average Moderate explanation of program	2 to 0 Needs improvement Lack of understanding and errors in code
Working status	5 to 3.5 0-2 errors	3.5 to 2 2-5 errors	2 to 0 5-10 errors
Logic development	5 to 3.5 Excellent	3.5 to 2 Average	2 to 0 Needs improvement

3) Hardware implementation progress

The third phase of the project bases student evaluation on their work on the hardware. This review evaluates students based on their understanding of how to design, construct, and integrate hardware components for microcontroller-based projects. Students need to prepare and give presentations on the following topics: (a) Features or objectives; (b) List of components selected; (c) Ratings or specifications of selected components; (d) Comparison of selected components with other available components; and (e) Circuit connection. The evaluation of the students for this review will be done according to the rubrics given in Table IV. Fig. 3 (a) and (b) shows pictures of the software design and hardware implementation reviews respectively.

TABLE IV
RUBRICS PLANNING FOR EVALUATION OF REVIEW-III

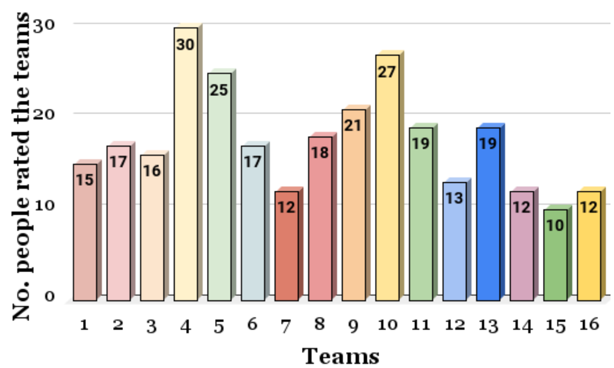
Criteria	**Ratings**		
Presentation delivery	5 to 3.5 Excellent Addresses all required topics properly	3.5 to 2 Average Addresses required topics moderately	2 to 0 Needs improvement Misses required topics
Selection of hardware components	5 to 3.5 Justifies all required components with comparative analysis	3.5 to 2 Misses 1-2 required components	2 to 0 Misses major required components and lack of comparative analysis
Working status	5 to 3.5 100-80% complete	3.5 to 2 80-60% complete	2 to 0 60-0% complete
Circuit understanding	5 to 3.5 Excellent Explains the circuit without mistakes	3.5 to 2 Average Moderate errors in the explanation	2 to 0 Needs improvement Lack of understanding of the circuit

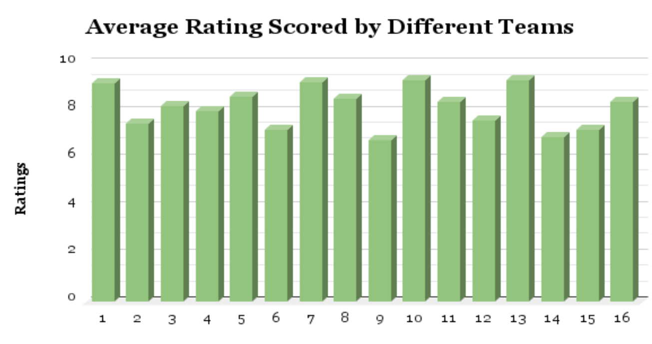

(a)

(b)
Fig. 3. (a) Software design review (b) Hardware implementation review

4) Project exhibitions

A project exhibition was organized to showcase the final product created by the students. After working on the project throughout the semester, students were instructed to display their finished output publicly at the project exhibition. The project teams were evaluated by faculties and students of the different semesters of the electrical department. Fig. 4 shows the evaluation result for the different teams in the project exhibition.



(a)


(b)
Fig. 4 (a) Rating contributions to each team (b) Average ratings given to different teams

A. Open book exams

The open book examination evaluates students' ability to apply concepts of microcontrollers to solve real-world issues. This exam assesses problem-solving abilities, utilization of theoretical principles, and the capacity for critical thinking in the creation and execution of solutions based on microcontrollers. Additionally, the exam evaluates students' proficiency in documenting their problem-solving methodology, which encompasses composing articulate and succinct code, generating schematics, and elucidating their design decisions. This technique guarantees that students not only comprehend the theoretical aspects of microcontrollers but also possess the practical abilities required to address real-world engineering difficulties. In this exam, students have been asked to design a real-life traffic system with some additional tasks. Students have been given one sample question and one final question for the open book exam. Students have to solve the final question in the exam. The rubrics of the open book exam and the question paper of the exam is presented in the Table V & VI respectively.

TABLE V
RUBRICS PLANNING FOR EVALUATION OF OPEN BOOK EXAM

Questions	Marks	Criteria-1	Criteria-2	Criteria-3
Block diagram	20	0 - 10 Marks for Missing 3 - 5 blocks	10 - 15 Marks for Missing 2 - 3 blocks	10 - 15 Marks for Missing 0 - 2 blocks
Interfacing diagram	30	0 - 15 Marks for Missing 3 - 5 blocks	15 - 25 Marks for Missing 2 - 3 blocks	25 - 30 Marks for Missing 0 - 2 blocks
Logic explanation	20	0 - 10 Marks for Making >5 logical errors	10 - 15 Marks for Making 3-5 logical errors	15 - 20 Marks for Making 0 -3 logical errors
Program	30	0 - 15 Marks for Making >5 logical errors	15 - 25 Marks for Making 3-5 logical errors	25 - 30 Marks for Making 0 -3 logical errors

TABLE VI
OPEN BOOK EXAM QUESTION PAPER

Question No.	Question
Q.1	Write a program with neat block diagram, interfacing diagram and programming logic to implement following: There are following lights on a cross road. • Green light- indicates vehicles can move • Walk light- indicates walkers can walk • No walk light – indicates walkers can't walk • Yellow light- indicates vehicles will halt • Red light- indicates vehicle can't pass ***Task-1:*** By default, for 4 seconds, green light and no walk is ON. For next 1 second, make yellow light and no walk light ON. For next 1 second, make red light and walk light ON and then continue from green light. ***Task-2:*** If you receive, serial communication message "emergency" from ambulance at 19200 baudrate, then green light will be extended till a signal on serial communication "No emergency" is received, otherwise green light will be off after 5 seconds. Moreover, put this message on LCD. ***Task-3:*** If temp goes beyond 40C, green will be ON and no other lights will remain ON till the time temp is more than 40C.

IV. RESULTS AND DISCUSSIONS

To analyze improvements in the performance of the students in the MES course, a survey of students of electrical engineering was taken before starting the course. The survey revealed critical aspects in terms of technical skills and, above all, self-evaluation. Fig. 5 shows a visualization of the data, which indicates how students have self-evaluated them across three core aspects: programming ability, hardware performance, and practical microcontroller-based projects. For the survey, the average rating of the students in all three aspects is around 3. This rating suggests a satisfactory foundation but significant room to grow.

The lowest rating achieved in the development of microcontroller-based projects was around 2.96. Moreover, students have been surveyed to learn about their prior knowledge required for the three core aspects discussed earlier. From the survey, as shown in Fig. 6, 92% of students had prior knowledge of C-programming and 96% had prior knowledge of analog and digital electronics (ADE). However, it can be concluded that the students had less confidence in their ability to apply this knowledge to make microcontroller-based projects.

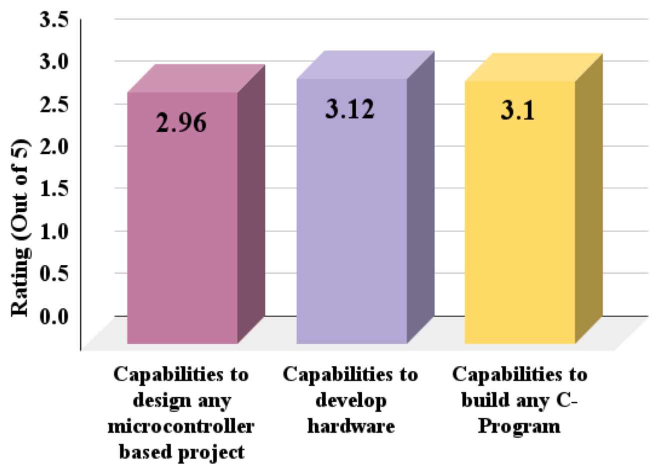


Fig. 5 Students survey ratings on their capabilities of (a) Programming (b) hardware implementation and (c) Microcontrollers based project design prior to the course of MES

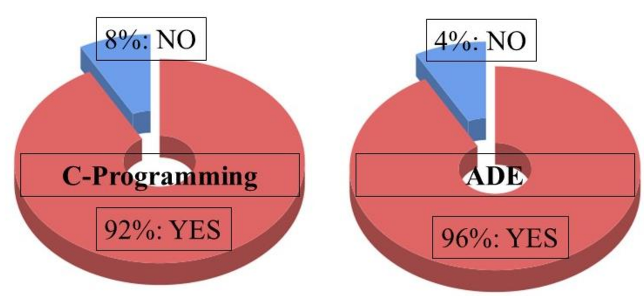


Fig. 6 Prior knowledge of students about C-programming and ADE

Considering the above-stated problems, a variety of assessment methods, such as logical quizzes, project-based learning, hands-on workshops, and open book exams, were implemented. To understand the effectiveness of the diversified assessment, a post-survey of the same students has been conducted. The graphical data shown in Fig. 7 demonstrates that employing a variety of assessment methods has a notably greater impact on improving students' comprehension of MES courses compared to traditional methods.

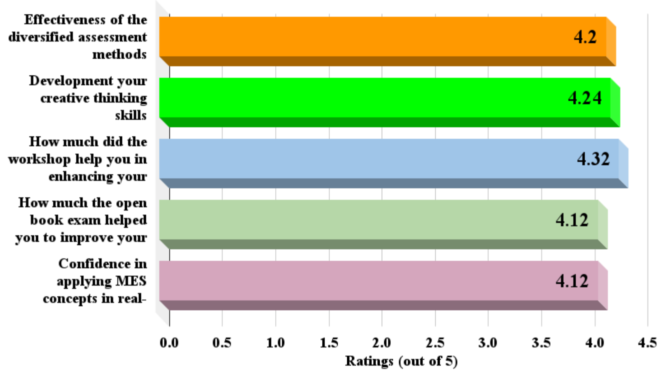


Fig. 7 Students survey details post the conduction of MES course employing diversified assessment methods

Furthermore, it has been notified that these varied evaluations significantly enhance students' creative thinking abilities. The combination of workshops and programming assignments significantly improved students' proficiency in coding for embedded systems, as evidenced by their favorable feedback. The open-book exam served as a catalyst for enhanced learning, motivating students to explore the subject matter more extensively and strengthening their comprehension. Fig. 8 shows a comparison of the effectiveness of the various assessment methods.

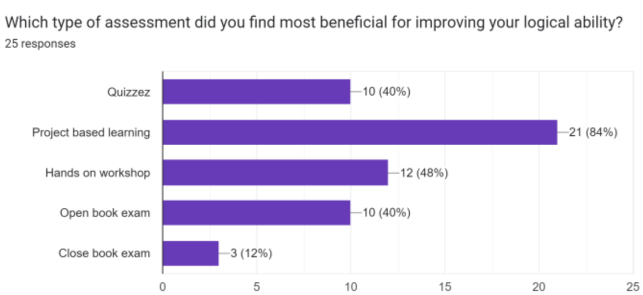


Fig. 8 Comparative analysis of effectiveness of the various methods employed for the assessment

It has been notified that project outperformed other forms of assessments in enhancing logical abilities, underscoring the importance of hands-on, practical learning experiences in the curriculum. Moreover, a comparative analysis is performed that compares the results of the students who passed the course MES, employing conventional methods, with the results of the students who studied MES in the previous year with the present batch of students who learned the course employing diversified assessment methods. Previous year, 78% of MES students passed using traditional exams and lectures. After various assessment were introduced, the success rate reached 100%. This significant improvement clearly illustrates that different evaluation methods reinforce student learning and memorization for the course. The findings emphasize that creative assessment approaches are essential for achieving educational excellence, as conventional measures may not provide a comprehensive learning experience. This year, 3 groups used their project ideas in the 6th semester and took them further and applied for a startup grant, 2 of which were sanctioned the desired grant and will be taking the same project for their final year project.

CONCLUSION

In this paper, a novel diversified assessment pedagogy is proposed, combining effective teaching techniques and various assessment methods. The objective of proposing this assessment is to develop higher-order thinking skills as per Bloom's taxonomy, convert projects into products, and produce a produce a good university result for the course MES. In order to achieve these objectives, various assessment methods were employed, which are: (a) hands-on workshops; (b) logical quizzes; (c) project-based learning; and (d) open book exams. The effectiveness of the proposed assessment pedagogy was measured by conducting student surveys before and after the MES. From the survey, it has been observed that the confidence of the students to do programming has increased by about 44%, the creative thinking of the students has increased by about 42%, and their confidence to develop microcontroller-based projects has been boosted. Moreover, the students' passing rate for the course has also increased from 78% last year to 100% this year. The results of the survey highlight the importance of an educational approach that aligns theoretical teaching with hands-on practical exposure to bridge the gaps and prepare students better for solving real-life professional challenges.

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