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ORIGINAL

A psychological approach - teaching microprocessors and microcontorllers: an innovative pedagogical approach for engineering undergraduate students

Un enfoque psicológico - la enseñanza de los microprocesadores y microcontornos: un enfoque pedagógico innovador para los estudiantes universitarios de ingeniería

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ABSTRACT

Introduction: microprocessors and Microcontrollers course is intended to introduce the architecture, programming of microprocessors and interfacing various hardware circuits to microprocessors. They are very important and integral part of the computers. These are the systems working under the microscopic levels to perform macroscopic functions. Understanding these minute and complicated processes required, which requires logical thinking and creative visualization. The students taking up this course as a part of their UG Curriculum find it difficult to understand these concepts.
Methods: often the Classroom teaching turns out to be one-way involving only the faculty, this paper discusses various pedagogical methods such as Just a Minute (JAM), Role Play, Project Based Learning, Self Directed Learning (SDL) and Small Group Discussion (SG) to make the concepts clear to the students and also convert the session to an interactive two-way communication session.
Results: the efficiency of the applied methodologies for teaching Microprocessors and Microcontrollers is found to be 83,33 %.
Conclusion: the application of these techniques must be broadened to improve the quality of the Education Provided Worldwide.

Keywords: Microprocessors and Microcontrollers; Just a Minute (JAM); Role Play; Project Based Learning; Self Directed Learning (SDL); Small Group Discussion (SG).

RESUMEN

Introducción: el curso de Microprocesadores y Microcontroladores pretende introducir la arquitectura, la programación de microprocesadores y la interconexión de varios circuitos de hardware con microprocesadores. Son una parte muy importante e integral de los ordenadores. Son los sistemas que trabajan bajo los niveles microscópicos para realizar funciones macroscópicas. La comprensión de estos minúsculos y complicados procesos requiere pensamiento lógico y visualización creativa. Los estudiantes que toman este curso como parte de su plan de estudios UG tienen dificultades para entender estos conceptos.
Métodos: a menudo, la enseñanza en el aula resulta ser unidireccional, con la participación exclusiva del profesorado. En este artículo se analizan varios métodos pedagógicos, como Just a Minute (JAM), Role Play, Project Based Learning, Self Directed Learning (SDL) y Small Group Discussion (SG), para aclarar los conceptos a los estudiantes y convertir la sesión en una sesión de comunicación interactiva bidireccional.
Resultados: la eficacia de las metodologías aplicadas para la enseñanza de Microprocesadores y Microcontroladores es del 83,33 %.

Conclusiones: la aplicación de estas técnicas debe ampliarse para mejorar la calidad de la Educación que se imparte en todo el mundo.

Palabras clave: Microprocesadores y Microcontroladores; Just a Minute (JAM); Role Play; Project Based Learning; Self Directed Learning (SDL); Small Group Discussion (SG).

INTRODUCTION

For several decades in the world, Microprocessors have been around us. Many Arithmetic and Logical problems are being solved nowadays using microprocessors. A microprocessor is the heart of a computer. It consists of the Memory, Control Unit (CU) and the Arithmetic and Logic Unit (ALU).[3] A microprocessor is supported with chips to perform operations. As a result, many researches were put up for choosing large chips for the efficient performance of microprocessor.

Traditionally, Microprocessor and Microcontroller courses have been taught by concentrating mainly on the architecture, Addressing modes, Interfacing and Assembly Language Programming of these devices, with very little exposure to their practical applications, Mayer et al.[21] Microprocessor and Microcontroller teaching is a one semester compulsory course for Undergraduate Engineering students. Both Electrical and Electronic Engineering students and Computer Engineering students take this course in their third professional year. The course has traditionally been taught using the normal chalk and talk methods where much of the emphasis has been given to the theory with little practical sessions.

The big challenges in the educational institutes are to stream the human resource with certain skill-sets to full-fill the needs of industry base courses for understanding Microprocessors and Microcontrollers.[1,2] In order to train the students to get skill in this field and ready for industry, teach the subject of high complexity in such a way the students has to incorporate with real application. In recent times, different active learning strategies have been implemented for teaching Microprocessor and Microcontroller course.[9,11,14] One of the key features of these methods is the 'training and education 'or 'hands-on-experience' in laboratory for the theoretical understanding of microprocessors.[17,19] Various active learning strategies, such as problem- or project-based learning, have been applied in order to stimulate students' motivation and accomplish more learning outcomes[20] thereby requiring additional laboratory facilities, larger budgets, and more time and commitment from both students and teachers. Problem-based learning (PBL) was implemented for second year undergraduate students for microcontroller system laboratory course by Hedley et al.[19]

METHOD

In this paper a practical and innovative method to make the sessions more interactive and live has been discussed. Since Microprocessors and Microcontrollers is a complex subject, the adaptations of newer pedagogical teaching methods will help the students to get a great hold of the subject in the prescribed time and also will make them Industry ready. The course outcomes of Microprocessors and Microcontrollers are

- Understand the architecture of microprocessors and microcontroller.
- Understand the programming model of microprocessors and microcontrollers.
- Interface different external peripheral devices with microprocessors and micro controllers.
- Analyze a problem and formulate appropriate computing solution for processor or controller based application.
- Develop an assembly language program for specified application.

The methodologies adopted for Class room Teaching and Laboratory Teaching were

- Just a minute(jam)
- Role play
- Project based learning
- Self directed learning (sdl)
- Small group discussion (sg)

The JAM (Just A Minute) methodology is an educational technique that can help enhance classroom learning by encouraging students to express their thoughts concisely and clearly. Here's a brief overview of how you can use the JAM methodology for better understanding in class:

Setup and Objective

- Purpose: the primary goal is to help students articulate their thoughts and understanding on a topic within a short timeframe, usually one minute. This encourages clarity and brevity in communication.
- Context: it can be used in various subjects to assess comprehension, encourage participation, and

promote quick thinking.

Implementation Steps

- Select a Topic: choose a topic related to the lesson or subject matter. It can be a concept, a question, or a problem the students need to discuss or explain.
- Instructions: explain to students that they will have one minute to speak about the topic. They should focus on expressing their main ideas clearly and concisely without going off-topic or repeating themselves.
- Preparation Time: give students a brief moment to prepare their thoughts before they start speaking. This could be a few seconds or up to a minute, depending on the complexity of the topic.
- Speaking Time: have students take turns speaking for one minute each. You can use a timer to ensure they stay within the allotted time.
- Feedback: after each student has spoken, provide constructive feedback. Highlight what was clear and well-expressed, and offer suggestions for improvement.

Benefits

- Improves Clarity: students learn to convey their ideas more clearly and succinctly.
- Enhances Listening Skills: as students listen to their peers, they gain different perspectives and reinforce their own understanding.
- Encourages Participation: the short timeframe reduces anxiety and encourages more students to participate.
- Develops Quick Thinking: students practice organizing their thoughts quickly and efficiently.

Variations

- Group JAM: have students work in small groups to discuss a topic for one minute and then present their collective ideas to the class.
- Written JAM: instead of speaking, students write a concise summary of the topic in one minute.
- Peer Review: after each student speaks, have their peers provide brief feedback or ask follow-up questions.

Using the JAM methodology can make classroom activities more dynamic and engaging, helping students build valuable communication skills and deepen their understanding of the subject matter.

Role play in a classroom setting is a dynamic and interactive teaching method where students act out specific roles or scenarios to explore concepts, practice skills, or solve problems. It can be particularly effective for enhancing engagement, developing empathy, and reinforcing learning. Here's a comprehensive guide on how to use role play in the classroom:

Define the Objective

- Purpose: identify the learning goals you want to achieve through role play. These could include understanding a historical event, practicing a language, solving a problem, or exploring different perspectives.
- Context: ensure the role play is relevant to the current lesson or topic.

Project-Based Learning (PBL) is an instructional method where students engage in a project over an extended period, focusing on solving a real-world problem or answering a complex question. This approach encourages deeper learning, critical thinking, and application of knowledge. Here's a detailed guide on implementing PBL in the classroom.

Define the Project

- Objective: identify the learning goals and objectives. Determine what students should know or be able to do by the end of the project.
- Question or Problem: develop a central question or problem that the project will address. This should be open-ended, challenging, and relevant to real-world issues.

Self-Directed Learning (SDL) is an educational approach where learners take the initiative in diagnosing their learning needs, setting goals, finding resources, and evaluating their progress. This method emphasizes the learner's autonomy and responsibility for their own learning process. Here's a comprehensive guide on implementing SDL in the classroom.

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Understand SDL

- Definition: SDL is a process where individuals take control of their own learning journey. It involves setting personal learning goals, identifying resources, and evaluating progress independently or with minimal guidance.
- Core Elements: includes self-assessment, goal setting, planning, resource identification, and self-evaluation.

Small Group Discussion (SG) is a collaborative learning technique where students work in small groups to discuss a topic, solve a problem, or explore a concept. This method encourages active participation, enhances critical thinking, and improves communication skills. Here's a detailed guide on implementing small group discussions effectively in the classroom.

Define the Purpose

- Objectives: clearly identify the learning objectives for the discussion. What do you want students to achieve or understand by the end of the discussion?
- Relevance: ensure the topic is relevant to the lesson and aligns with the educational goals.

Each methodology has its own well defined objectives. The Just a Minute approach was very useful for quick revision of the small concepts. It was found that apart from the revision aspect this also kindled their interest towards learning new concepts. The students out of their interest also made a video of one of the JAM session which was uploaded in the YouTube. The link for the YouTube ishttps://www.youtube.com/watch?v=wVKyw0Hd1N4. The Role Play was very useful for the students to get the concepts clear in their mind. It will be useful for longer retention of the concepts in the memory. A sample Role Play photograph of students performing "Shift Rotations of Instruction Set of 8086 Architecture" is provided in fig.1. Project Based Learning paves a way for practical learning of the concepts in the Lecture Halls. The students found it useful for the application based learning of theoretical concepts. A video of Project Based Learning, where the student discussed the Representation of Addressing Modes of 8086 using ALP programming is available in the YouTube link https://www.youtube.com/watch?v=0e52QKSE1YU. The Self Directed Learning (SDL) sessions strive to improve the capabilities of the student to comprehend the concepts by themselves. The session was helpful for the students to come up with many doubts and to clarify them then and there. The Small group Teaching was applied in the Microprocessor and Microcontroller Laboratory to improvise the learning experience. Under this method the students were divided into small groups consisting of 3 to 4 people in each. This facilitated the better understanding and created an environment for individual attention to each student by the Faculty. These applied techniques will be useful for the students to get a greater hold of the subject and also this will convert the lecture sessions into interactive sessions.

Figure 1. Role Play Activity in Class Room

Analyses and outcomes

Every new methodology adopted to enhance the process can be proved efficient only after analysis and

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evaluation of the applied methodology. Analysis is required to find out the efficiency of the applied methodology and also to know the views of the concerned people for whom it is being planned and implemented. Hence we have analyzed the implemented pedagogical teaching methodologies with the help of a survey form. Though the implementation of the methodologies was done prior to the COVID-19 pandemic under routine working environment, the analysis and evaluation was carried out during the COVID-19 pandemic. Hence the survey was made completely online.

METHOD

An online survey form (using Google forms) titled "MICROPROCESSORS AND MICROCONTROLLERS: PEDAGOGICAL LEARNING ASSESMENT SURVEY". Sample Screenshot of the online survey form is provided in the figure 2. The methods adopted were practiced for VI semester Engineering Students of Department of Computer Science and Engineering. The form was circulated to the randomly selected 75 students, who were part of the class which comprised of 114 students. The form did not have space for the information of the name and other personal details student, this anonymous submission was employed in order to make the participants more comfortable in answering the questions. The form consisted of 10 questions of which 9 questions were related to the evaluation of the methodologies applied and the 10th question was to find the most efficient method employed according to the participants. Likert scale was used for the response of the questions 1 to 9, which had the options Strongly Agree, Agree, Neutral, Disagree and Strongly Disagree. The questions that appeared in the survey are presented in the table 1.

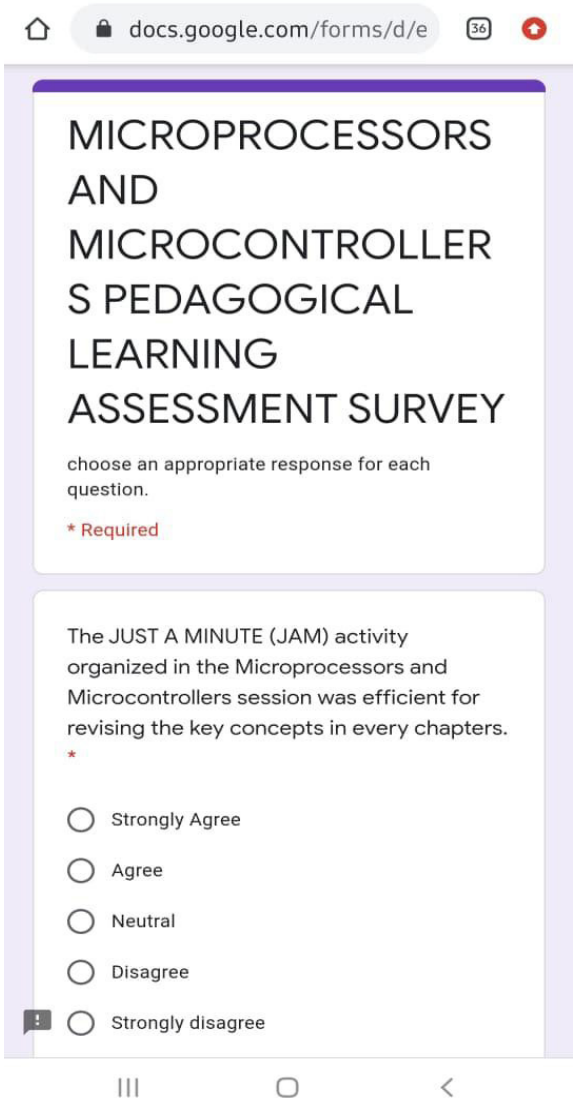

Figure 2. Screenshot of the Online Survey Form

The students were given the link for the online survey form and sufficient time was given for the students

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to go through the questions and submit their response. The form was circulated to the randomly selected 75 students, who were part of the class which comprised of 114 students.

Table 1. Questionnaire for Online Survey

Question Numbers	Questions
1	The ROLE PLAY activity organized in the Microprocessors and Microcontrollers session was efficient for clear understanding of the concepts.
2	The ROLE PLAY activity organized in the Microprocessors and Microcontrollers session was efficient for clear understanding of the concepts.
3	The Project Based Learning activity organized in the Microprocessors and Microcontrollers session was efficient for the Practical understanding of the concepts in the lecture hall.
4	The Small Group (SG) teaching implemented in the Microprocessor and Microcontrollers laboratory was efficient in understanding the concepts than Large Group teaching.
5	The Self Directed Learning (SDL) sessions conducted was very useful for understanding the concepts by our own to a greater depth.
6	The Outcomes of the Course very well attained through implementation of such Pedagogical Teaching Methods.
7	The implementation of the Pedagogical Teaching Methodologies in the Classroom Lecture Sessions was good.
8	The implementation of the Pedagogical Teaching Methodologies in the Practical Sessions in Laboratories was good.
9	The implementation of these Pedagogical Teaching Methodologies helped you to achieve a greater hold of the subject.
10	According to you, the best Pedagogical Teaching Method employed for your course was?

The efficiency "η" can be derived by using the formula

$$\eta = \frac{outcome\ acquired}{most\ favorble\ outcome} \times 100$$

The most favorable outcome that can be acquired from this case may be 9*75*α, as α is the most expected outcome.

The Ideal Efficiency (ηi) of the applied methodology may be considered when the response for all the questions turns out to be "Strongly Agree" that is "+2" from the table. The Ideal Efficiency can be calculated as.

$$\eta i = \frac{9*75*\alpha}{9*75*\alpha} \times 100 = 100\%$$

RESULTS AND DISCUSSION

After the collection of data from all 75 participants of the survey, the responses were analyzed. The response given by the participants for questions 1 to 9 is presented in the table 2.

Table 2. Questionaire Responses from the Participants

Response q. Nos.	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1	53	22	0	0	0
2	52	23	0	0	0
3	49	24	2	0	0
4	51	22	2	0	0
5	52	20	3	0	0
6	52	22	1	0	0
7	52	23	0	0	0
8	51	21	3	0	0
9	53	19	2	1	0

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It can be observed from the table that most of the response to the questions put forth to the students is “strongly Agree” followed by “Agree”, a very few “Neutral” and only one “Disagree”. As we can see, the Questions given to them are in favor for efficient learning through the applied pedagogical teaching methodologies. The positive response from most of the students may be considered as the efficiency of the applied pedagogical teaching methodologies. The response is also represented in the form of a graph in figure 3.

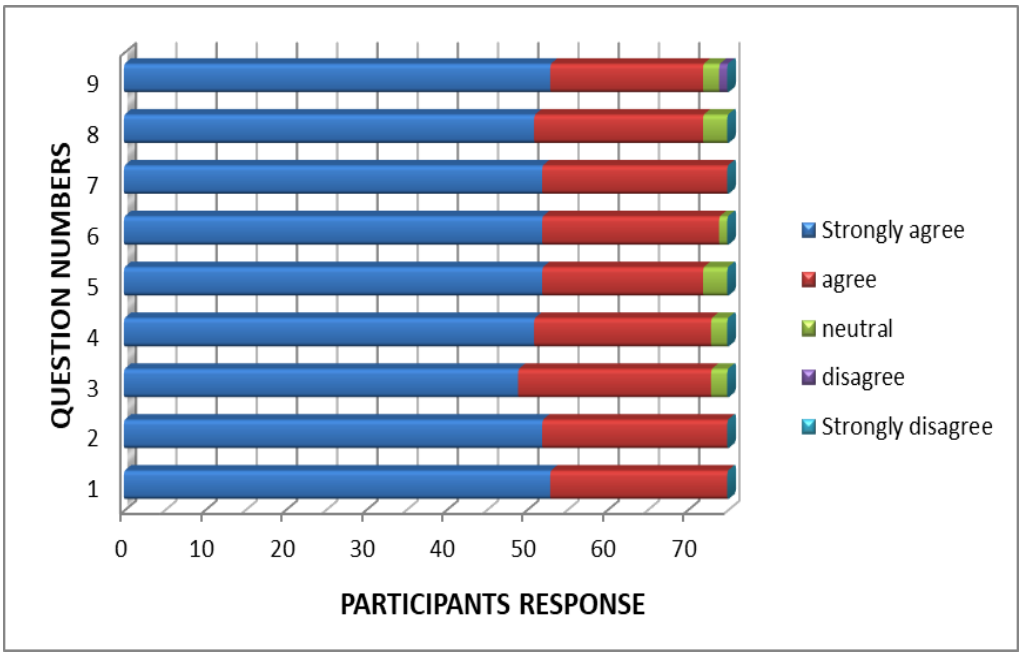

Figure 3. Response for Questions 1 to 9

Efficiency Calculation

For the purpose of calculation of efficiency of the process the responses are designated as follows.

Table 3. Value Designation for Responses

Response	Value assigned	Represented by
Strongly agree	+2	A
Agree	+1	B
Neutral	0	Γ
Disagree	-1	Δ
Strongly disagree	-2	E

The Acquired Efficiency through application of the pedagogical teaching methodologies can be calculated as:

$$\eta a=\frac{outcome\ acquired}{most\ favorble\ outcome}\times 100$$

$$\eta a=\frac{465*\alpha+196*\beta+13*\gamma+1*\delta+0*\varepsilon}{9*75*\alpha}\times 100$$

$$\eta a=\frac{465*(+2)+196*(+1)+13*(0)+1*(-1)+0*(-2)}{9*75*\alpha}\times 100$$

$$\eta a=\frac{465*(+2)+196*(+1)+13*(0)+1*(-1)+0*(-2)}{9*75*\alpha}\times 100$$

$$\eta a=\frac{465*(+2)+196*(+1)+13*(0)+1*(-1)+0*(-2)}{9*75*(+2)}\times 100$$

$$\eta a=0.8333\times 100$$

$$\eta a=83.33\%$$

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Thus the efficiency of application of the pedagogical teaching methodology in the teaching of Microprocessors and Microcontrollers has been derived to be 83,3 %.

The response to the 10th question "According to you, the best Pedagogical Teaching Method employed for your course was?" is also tabulated in the table 4. It is clearly visible that the preference of the Pedagogical Teaching Methodologies is of the order,

JUST A MINUTE>ROLE PLAY>PROJECT BASED LEARNING>SG>SDL.

The preferences of the students are also represented in the graph in figure 4.

Table 4. Preferences of the Participants

Q. Nos.	Pedagogical teaching methodology	No. Of response
1	Just a minute(jam)	35
2	Role play	24
3	Project based learning	7
4	Small group teaching (sg)	5
5	Self directed learning (sdl)	4

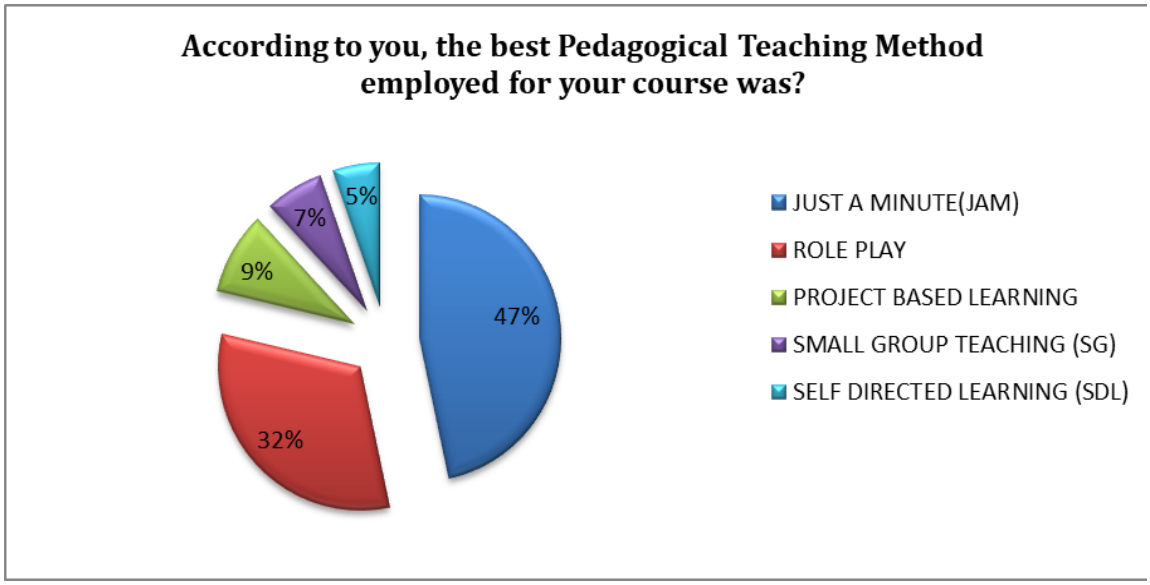

Figure 4. Preferences of the participants

DISCUSSION

To discuss the pedagogy of our method(s) in relation to existing pedagogical practices, it's important to compare and contrast how our approach aligns with or diverges from traditional and contemporary educational theories and methods. This analysis can provide insights into the effectiveness, strengths, and areas for improvement of our method. Here's a structured approach to this discussion:

Table 5. Traditional and contemporary educational theories and methods

Detail	Pedagogy Approach	Results Achieved
Manikandakumar et al.[24]	Active Learning for OOAD Course	9 % increased CO attainment
Deepa et al. (2021)	Blended Learning for Microprocessor Course	15 % increase in Assignment Grade
Prithviraj et al.[22]	Storytelling with data for C++ Programming Course	In Quiz 50 % to 80 % achieved in students scoring 17/20
Our pedagogy method	JAM, Role Play and Project based Learning for Microprocessors and Microcontrollers Course	Improved from 60 % to 83,33 % understanding Clearly and produced 100 % results

CONCLUSIONS

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The UG Education plays an important role in modeling the future of every engineering aspirant. Development of more efficient ways of teaching the UG students is required in order to meet the ease the process of learning. The concepts in the UG curriculum need to be imparted into them so as to enable them to understand the basics clearly. This is an important step towards the "vertical Integration" of learning which continues beyond UG Education, PG Education and so on. This study emphasis the application of methods such as Just A Minute(JAM), Role Play, Project Based Learning, Small Group Teaching (SG) and Self Directed Learning (SDL). The future of pedagogy will likely see increased integration of digital tools and technology. This includes the use of educational apps, online platforms, and virtual simulations to enhance learning experiences. Technology can facilitate more personalized learning pathways, allowing students to learn at their own pace and according to their interests. In summary, while traditional and innovative pedagogical methods each have their strengths, the future of education will likely involve a blend of both, supported by technology and a focus on developing skills for lifelong learning. Educators will need to remain flexible, continuously adapt to new developments, and strive to create inclusive and effective learning environments.

The application of the Pedagogical Teaching methodologies must be emphasized to create a more knowledgeable Engineering Society and also to prepare the students to face the technologically advancing Industry.

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Investigation: Muthusundari Subramanian.
Methodology: Muthusundari Subramanian.
Drafting - original draft: Muthusundari Subramanian.
Writing - proofreading and editing: Muthusundari Subramanian.