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AI-Enhanced Personalized Learning Practices in Higher Engineering Institutes

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***Abstract* – The main task of engaging the students with an interesting classroom environment is challenging in nature. The better way of teaching the students with effective learning pedagogy seems to be more effective. In this technological era, every student requires some technological involvement in their day-to-day process. So, with a broadcasted mindset, an active learning pedagogy has been initialized in this manuscript which gives more and more active methods of learning especially for engineering students. This research mainly focuses on a widely available learning process that is more effective in context with an easy understanding of the concepts. The AI – Enhanced Personalized learning methodology has been utilized in this manuscript. A deep understanding of the concept lies in the visual representation of the concept. In context to this, the simulation-based active learning pedagogy has been implemented for the Electrical Engineering graduates of the third year. The pedagogy related cource outcome (CO) has been framed. The effectiveness of the implemented method has been evaluated with various feedback responses and their scores in the end-semester with and without AI methodology help to view the performance metrics of the implemented AI – based learning learning pedagogy. Surely, this method yields good results in the performance of every student.**

***Keywords* – Active learning methodology, Teaching pedagogy, AI-based learning methodology, Program Outcome, Renewable energy sources.**

I. INTRODUCTION

Ttechnological advancement in the past few decades has made a lot of improvements and developments in the electronics industry. Also, due to Covid 2020, all the school and college students are familiar with the gadget's operations. Teachers can help students learn content through a variety of instructional methods, and they can show their understanding and abilities in a variety of ways. With the focus on these, much research is going on in the field of software-based study applications (Tahmina, 2022). A lot of tools related to education have been developed for the completion of the course outcomes. When students are required to attend lectures online, it can be quite challenging for them to maintain their attention and focus on the lecture material. Students' ability to pay attention tends to suffer as a result. It calls for the use of active learning strategies like the muddiest point technique, one-minute papers, think pair share, and peer assessment. The achievement of program outcomes is crucial in outcome-based education. Program outcomes are measures of numerous skills achieved in graduating students, including analytical skills, teamwork, communication skills, and professional ethics (Desai, 2022), (Moharir et al., 2022). Much of the research is carried out with a lot of experimentation Cooperative learning, problem-based learning, and project-based learning were all employed by some authors to teach an undergraduate course, and he discovered that these methods helped expose the students to different approaches to the same problems. In order to give the students the chance to pause, concentrate their thoughts, and address any remaining questions before leaving class, they experiment with a writing exercise—a one-minute report (Dargar & Srivastava, n.d.). She then emphasized the significance of this activity. The equal importance of classroom activities as well as web-based activities should be trained by the teaching faculty alongside the curriculum (Ayua & Eriba, 2023). To uncover proof of the efficacy of active learning, researchers critically investigated the fundamental components of active, collaborative, cooperative, and problem-based learning approaches. The study clarifies how active learning approaches (Kabilan, 2022) are evaluated to see if they are effective. The teaching methods are classified as direct method, lecture method, demonstration method, socratic method, project method, and tutorial method.

The complete structure of teaching methods is illustrated in Table 1 as follows.

Table I

Teaching methodologies

Methods of Teaching
1. Direct method

2. Lecture method
3. Demonstration method
4. Socratic method
5. Project method
6. Tutorial method

The abovementioned methods in Table I apply to general classroom teaching. But, for engineering education, the method of teaching should be still more effective. There is a wide variety of teaching methodologies applied to each course as shown in Figure 1. Each of the courses does not need to go with the same methodology (Moharir et al., 2022).

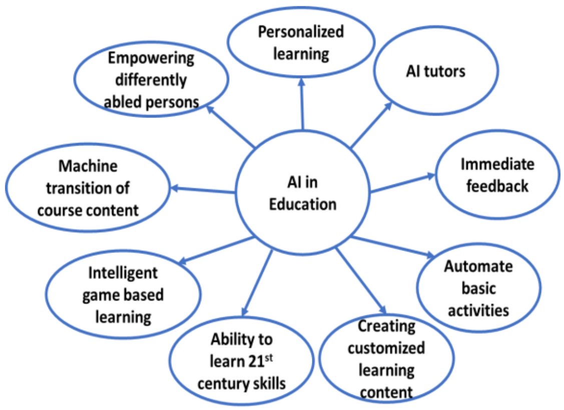

Fig. 1. Innovative Learning Technique

So, this paper is fully concentrated on the AI – enhanced personalized teaching methodology for Electrical and Electronics Engineering (EEE) students with various softwares. Section 2 talks about the course considered for the AI - based teaching methodology (Z. Chengwei, L. Yihua, 2021), (Chilukuri, 2020) and its program outcome. Section 3 tells us the adopted teaching technique for the course mentioned. Finally, section 4 gives us a wide picture of the outcome of the course with the corresponding feedback and results obtained. Then, the conclusion part and future works.

II. COURSE DESIGN AND IMPLEMENTATION

The considered course for the proposed AI - Enhanced personalized learning methodology is Renewable energy resources (Rajesh, 2021), (Kabilan, 2021). It mainly deals with the available renewable energy sources. Practically, it is impossible to install and analyze the characteristics of all renewable energy resources in a real-time environment. To study all the characteristic features in detail, the simulation method of learning gives a handshake to it. The program outcome (PO) for the renewable energy resources subject includes engineering knowledge, problem analysis, design, and development of solutions. Conduct investigations of complex problems, modern tool usage, environment and sustainability, ethics, individual and teamwork, communication, project management finance, and life-long learning.

The above-mentioned are the available program outcomes of Electrical and electronics engineering (Banu et al., 2023). Ultimately every faculty should keep the focus on the mentioned program outcome. The next part of the curriculum is program-specific outcome (PSO). It tells the analysis and solution of complex problems in Electrical and Electronics Engineering using modern tools, design and development of electrical and electronics products/systems that meet specified needs and finally is to understand and demonstrate the importance of sustainable energy development (Khan et al., 2022). The next main thing to focus on is course outcome (CO)(Kabilan, 2021), the proposed course outcome is listed as follows. These kind of CO's can be better utilized in higher engineering institutes (Van den Beemt et al., 2022).

Table II
Proposed course outcome for Renewable Energy course

S. No.	Course Outcome (CO)
1	Understanding of Renewable Energy Concepts and AI Integration
2	Data Analysis and Modeling Proficiency
3	Personalized Learning Plan Development
4	AI-enhanced individual-specific System Design and Optimization for renewables
5	Ethical and Sustainable Renewable Energy Practices

From the above Table II the proposed AI-Enhaced personalized learning methodology course outcome for the renewable energy course has been featured. The detailed structure of the CO is as follows.

1) *Understanding of Renewable Energy Concepts and AI Integration*
   - Develop a solid understanding of renewable energy technologies, policies, and challenges.
   - Explore how artificial intelligence (AI) can be effectively integrated into renewable energy systems and decision-making processes.
2) *Data Analysis and Modeling Proficiency*
   - Acquire data analysis and modeling skills necessary for working with renewable energy data.
   - Use AI techniques to process and analyze renewable energy data sets, making informed decisions related to energy generation, efficiency, and optimization.

3) *Personalized Learning Plan Development*

- Develop the ability to create personalized learning plans for renewable energy projects.
- Tailor renewable energy solutions based on individual project requirements, environmental factors, and energy demand.

4) *AI-Enhanced System Design and Optimization*
   - Learn to design renewable energy systems that incorporate AI algorithms for optimization.
   - Apply AI-driven algorithms to enhance the efficiency and performance of renewable energy installations, such as solar farms, wind turbines, or energy storage systems.

5) *Ethical and Sustainable Renewable Energy Practices*
   - Explore the ethical considerations and sustainability principles relevant to renewable energy and AI integration.
   - Develop the ability to make responsible and environmentally conscious decisions in the context of renewable energy projects enhanced by AI.

These course outcomes aim to equip students with the knowledge, skills, and ethical awareness needed to leverage AI-enhanced personalized learning methodologies effectively within the field of renewable energy.

III. ADOPTED METHODOLOGY

The teaching methodology utilized for active learning pedagogy is AI-enhanced personalized learning methodologies. The operating flow of the AI-enhanced personalized learning methodology is shown in Figure 2.

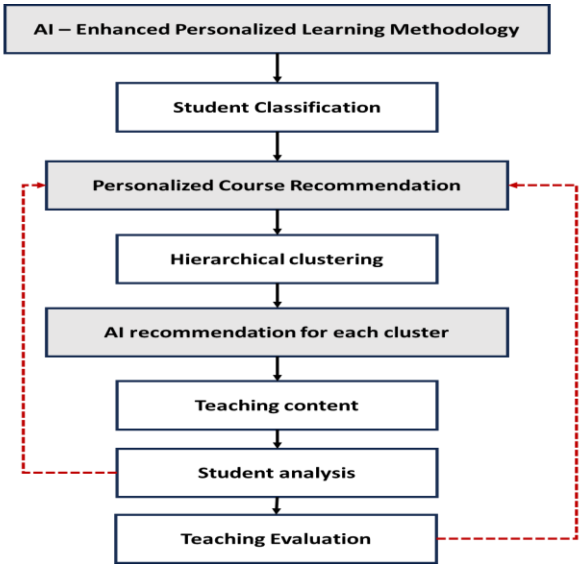

Fig. 2. Flow chart of the AI – Enhanced personalized learning methodology

The above flow chart showcases the step-by-step implementation of the artificial intelligence-enhanced teaching and learning process. At the beginning stage, the student classification is carried out. All sorts of students along with their databases are being collected who are enrolled for the course. Then, from the earlier grade history of each student, they are evaluated for certain course recommendations with various software tools such as EnergyHub, Energy3D, Reopt, SolarSPELL, EduCannon, SimScale, and EnergyWhiz. Each software is specific in its purpose. After the personalized allocation of the AI tool for each student depending upon the data collected for each student, the teaching content for each software has been prepared. Then the student analysis is carried out with various criteria and the database is again updated depending upon the current data. Finally, the teaching evaluation is taken through feedback. Each tool is described for its functionality as follows.

1) *EnergyHub by NREL*

The National Renewable Energy Laboratory (NREL) offers EnergyHub, an educational platform that uses AI to provide access to renewable energy datasets, simulations, and educational resources. It's a valuable tool for both educators and students to explore renewable energy technologies.

2) *Energy3D*

This is a simulation-based learning platform that allows students to design and simulate renewable energy systems, including solar panels, wind turbines, and geothermal systems. It offers a hands-on approach to learning about renewable energy.

3) *REopt by NREL*

REopt is an optimization platform that uses AI to identify the optimal combination of renewable energy sources and storage solutions for a given location. It can be used as a teaching tool to explore renewable energy system design.

4) *SolarSPELL*

SolarSPELL (Solar Powered Educational Learning Library) is an offline digital library that uses solar power and AI to deliver educational content in areas with limited access to the internet. It can be a valuable resource for teaching about renewable energy in remote regions.

5) *EduCannon*

EduCannon is an AI-enhanced video platform that allows educators to create interactive video lessons. Educators can use this tool to embed quizzes, discussions, and additional content into videos related to renewable energy topics.

6) SimScale

SimScale is a cloud-based simulation platform that can be used for simulating fluid flow, heat transfer, and structural mechanics in renewable energy systems such as wind turbines and solar panels. It provides valuable hands-on experience.

7) EnergyWhiz

Developed by the Florida Solar Energy Center, EnergyWhiz is an online competition platform that encourages students to explore renewable energy through hands-on projects. While not AI-based, it fosters active learning and creativity.

Along with the AI tools mentioned above the evaluation plan is categorized as follows in Table III.

Table III
Evaluation pattern

S.No.	Evaluation Pattern	Weightage	CO
1	Assignments	5 %	1,2,3,4
2	Case study of personalized AI-software	5 %	2,3,5
3	Seminar	5 %	3,4 & 5
4	Unique idea	5 %	2,3,4 & 5
3	Evaluation by the AI team	30 %	2,3,4 & 5
4	End semester	50 %	All

The above-mentioned methodology is applied to the set of 45 students for the renewable energy course. The performance analysis for each student based on their database and cluster outcome is detailed in the next section.

IV. Results and Discussion

This section details the relative analysis of the performance output of the AI - Enhanced personalized teaching-learning methodology implemented with the students of strength 45. At first, the CGPA of each of the students, and activities involved by each of the students may be co-curricular and extra-curricular were collected as a database. Based on the student information, the AI module is trained for the learning process. After the training process, the students are clustered according to their personalized views and as per the AI suggestion. Each student is provided with a tool and its corresponding personalization. Depending on the data base of each student, each student is categorized as follows.

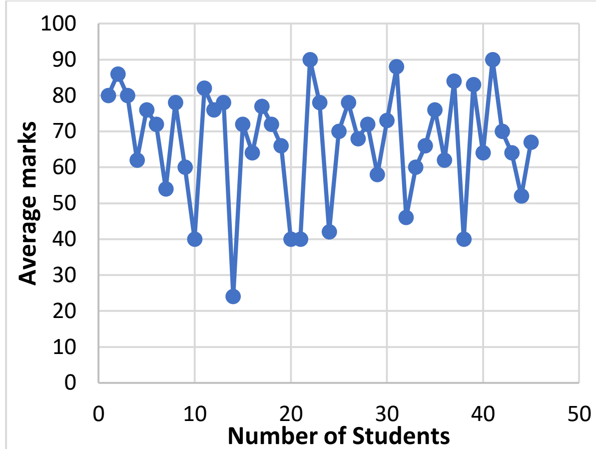

Fig. 3. Graph of average marks stored from sem 1 to sem 4

The above figure illustrates the average marks scored by as set of 45 students for continuous 4 semesters. The 45 students are being grouped into a cluster category and then separate AI-enhanced personalized software will be provided. This leads to the individual student monitoring based on his skills and interest.

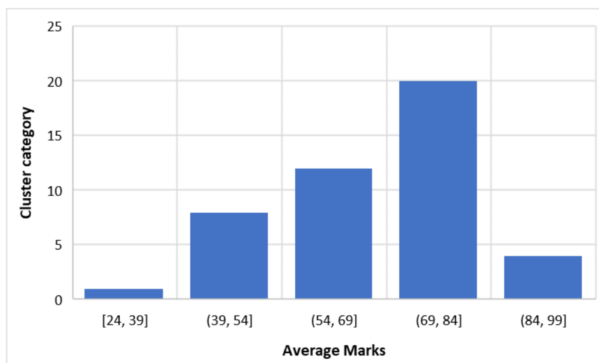

Fig. 4. Historgram of the marks categorization of each student for training the algorithm

The above figure clearly demonstrates that the students are being categorized according to the marks stored and they are aggregated separately. Out of 45 students, 3 members scored between 84 to 99, 20 members scored between 69 to 84 marks on an average, then 12 members scored between 54 to 69, after that 8 students scored between 39 to 54 and finally 2 members scored between 24 to 39. From this cluster they are segregated for various AI utilizations.

Table IV
AI-based Software allotment category

S. No.	Average Marks	AI software personalization	Reason
1	0 - 25	EnergyWhiz	Due to slow learner category this software engages with basic projects with competitions
2	25 - 50	SimScale	Due to beginner category it gives more hands on training
3	50 - 75	SolarSPELL	Due to Good learner category it gives it provides high range of learning options
4	75 - 100	Energy3D	Due to excellent learner category, it gives vast range of modelling

The AI – Enhanced personalized tools for each category of students are being allotted as shown in the above table. The performance of the each students are monitored on a regular basis. The performance of each student in comparison with applying AI based learning methodology and without AI learning methodology. The application of AI based teaching and learning methodology yields the better performance.

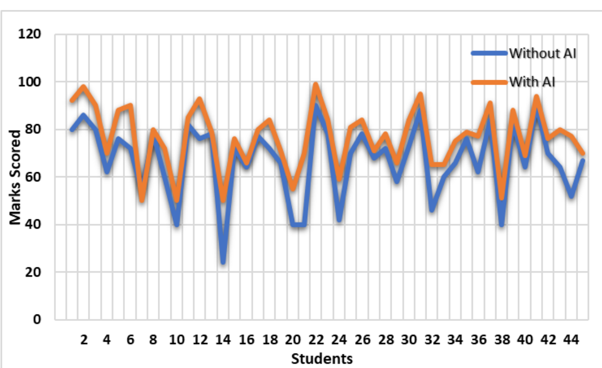

Fig. 5. Graphical comparison of students based on with and without AI methodology.

From the graphical illustration above, the final evaluation of all students are shown in Figure 5 for the subject of renewable energy sources. The considered students are previous year students and current year students for the same course. In which, the performance of each student has been improved for a good extent. Neary 5% of students only scored the near by average, others have shown a good performance improvement.

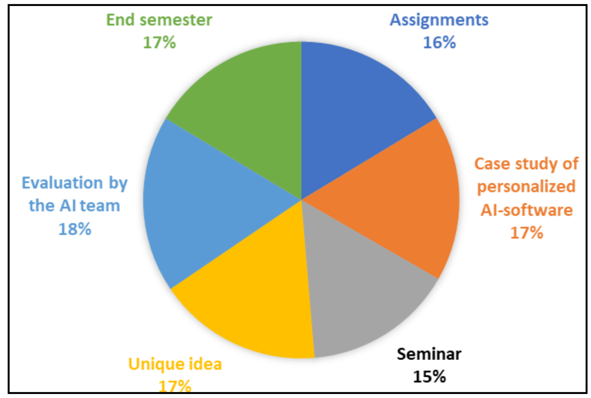

Fig. 6. Response of the students for survey questionnaire.

The above figure clearly shows about the response given by the students for each of the CO's. All the CO has been attained and all of them met the requirements of the students.

Thus, the performance metrics along with the feedback analysis have been carried out. The results show that the implemented AI – Enhanced personalized tools for renewable energy courses were satisfactory. The same was analyzed with the set of questionnaires prepared to find the feedback from the student's point of view. The final results from the students provide better encouragement to move forward in execution for the next course. For the higher engineering institutes, these kind of AI-based teaching and learning methodology suits well.

V. Conclusion

An effective and innovative teaching methodology provides a better instinct in the student's mentality upon learning. An innovative AI – Enhanced personalized teaching and learning methodology has been implemented for the renewable energy course. This course is highly dependent on real-time experimentation. As renewable energy implementation is of higher cost, all the course outcomes are not studied in detail. To resolve these issues, an effective simulation-based teaching methodology has been implemented for the electrical and electronics students with a strength of 45 students. The utilized simulation methods with the AI tool for the said methodology are EnergyWhiz, SimScale, SolarSPELL and Energy3D. The final results are analyzed for the students along with the feedback analysis. The results provide higher performance in terms of understanding the concept, gaining knowledge, independent circuit design, co-student feedback, and final exam preparations. The same methodology is further extended for the comparison with the end semester examination and other courses in future work. Also, the higher engineering institutes can implement this methodology for the upliftment of the younger minds.

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