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Use of MATLAB AI and MATLAB GPT for Teaching Material Preparation and Classroom Engagement Tools in Analog and Digital Communication Courses

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Abstract

In the Industry 4.0 era, the challenges to be overcome by engineering education are twofold: covering increasingly complex theoretical concepts and developing practical, hands-on skills. Analog and Digital communication courses are characterized by abstract mathematical foundations and intricate signal processing requirements,, hence often presenting significant learning barriers for undergraduate students. This paper aims to present a novel pedagogical framework using MATLAB AI tools and Large Language Models (in particular MATLAB GPT) in order to bridge the gap between theoretical abstraction and practical application. Implementation of this framework was performed on two-core courses of the Electronics and Telecommunication engineering programme. A methodology that used MALAB AI for developing interactive simulations of modulation schemes (AM, FM, QPSK, M-ary PSK) and MATLAB GPT for drafting customized lecture notes, problem sets, and real-time contextually aware student support, was developed. Results from the pilot implementation with 37 students show a 15-20% increase in attendance and participation along with a 30-40% reduction in faculty preparation time. Survey data indicated that 92.2% of the students feel there is significant improvement in conceptual understanding because of real-time AI feedback. The following study validates a "human-in-the-loop" AI teaching methodology and presents a scalable model to modernize engineering curricula.

***Keywords*—Active learning, Digital communication, Engineering Education, Generative AI, Hybrid Intelligence**

***JETLP Category*—Practice**

1. Introduction

The rapid development of Artificial Intelligence and Industry 4.0 introduces a seismic shift that is sweeping across the landscape of higher education. Engineering disciplines are especially in need of graduates who can demonstrate more than theoretical knowledge but also digital fluency and adaptability (IndiaAI, 2024; Rane, 2023). Traditional pedagogical approaches, often based on static textbooks and passive "chalk-and-talk" lectures, are increasingly inappropriate for teaching modern communication systems with their dynamic, stochastic nature (Chan & Lee, 2023).

Analog and digital communications courses are the backbone of Electronics and Telecommunication engineering. However, students often find it difficult to visualize these abstract concepts, such as signal modulation, noise interference, and channel capacity, which are highly based on complex mathematical derivations. While simulation tools like MATLAB have been long-standing tools in engineering laboratories, use has conventionally been siloed from the lecture component, reduced to rote exercises rather than active exploration tools.

The recent emergence of Generative AI (GenAI) in general, and Large Language Models (LLMs) in particular, such as GPT, provides a revolutionary opportunity for democratizing access to personalized tutoring and content creation Feuerriegel et al. (2023). In association with strong computational engines, GenAI is able to perform like a "virtual teaching assistant" by generating code, explaining derivations, and creating adaptive assessments Tlili et al. (2023).

This paper presents best practice in implementing MATLAB AI and MATLAB GPT in undergraduate communication courses. With the help of these tools, we attempt to create an interactive simulation of complex topics such as AM/FM modulation and QPSK using, in tandem, MATLAB GPT to draft compact lecture notes and problem sets matched for the learning level of the students. This serves to illustrate that AI-powered platforms not only speed up teaching but also encourage active learning and enhance the understanding of abstract concepts.

2. Literature Survey

2.1 Simulation in Engineering Education

There are an enough literature papers on the usefulness of simulation tools in engineering pedagogy. The complex communication systems such as 5G, WLAN, and MIMO etc. are modeled using sophisticated tool boxes and applications of MATLAB and Simulink. (MathWorks, 2024). Computational simulations, as emphasized by research, create a path from mathematical theory to physical reality by making abstract principles accessible visually (Hwang & Tu, 2021). To develop a high end simulations, instructors needs to learn complex programming is required that is why it is barrier to widespread classroom integration (Qadir, 2023).

2.2 Generative AI and Active Learning

Generative AI differs from traditional machine learning in such a way that it generates new, meaningful content-text and code to images-based on the training data (Feuerriegel et al., 2023). In the recent literature authors have presented that systems like GenAI, ChatGPT are used as virtual tutor which accelerates students learning by providing immediate and personalized

feedback (Chan & Lee, 2023). More recent frameworks have suggested using AI to support "Exploratory" and "Refinement" stages of learning, which basically shifts the instructor's role from a broadcaster of knowledge to a facilitator of inquiry (Xu & Ouyang, 2022).

2.3 The "Hybrid" Gap

While the literature supports individual uses of MATLAB for technical simulation and LLMs for generating text, there is a lack of research on integrated applications in specific engineering domains. Most current studies focus on broad ethical concerns or general programming support rather than domain-specific pedagogical strategies (EDUCAUSE, 2024). In this respect, there is an urgent need for "Hybrid Intelligence" frameworks that integrate the computational accuracy of tools like MATLAB with the conceptual explanation capabilities of GenAI to provide a holistic learning environment (Rane, 2023). This paper contributes to filling this gap by presenting the cohesive workflow that integrates MATLAB AI and GPT to support preparation and classroom engagement in teaching materials.

3. Methodology

It followed a systematic workflow of "Plan-Train-Execute-Assess" to integrate AI seamlessly into the existing curriculum without disrupting the core pedagogical goals.

Planning: The clear learning objectives centered on the basics of analog and digital communication were thus set on the first day (e.g. AM/FM modulation, quantization, coding, error analysis).

- MATLAB Toolboxes: Emphasis on automated signal processing and generation of waveforms.
- MATLAB GPT Interface: This interface provides AI generated explanations with code, theory, explanation and reasoning which help students learning concepts, importance of parameters easily.

The implementation of this practice was approached in a systematic workflow that integrated AI tools with traditional teaching methods:

3.1 Teaching Material Preparation:

- The lecture summary, explanation of key concepts, and assignment questions pertaining to Analog and Digital communication topics were generated through MATLAB GPT.
- For the classroom use we have used GPT with specific prompts such as “Explain QPSK modulation with constellation and higher version of QPSK” and “Explain concept of amplitude modulation signal with code and variation of parameters”.
- Then, by applying the MATLAB tools for artificial intelligence, various iterative visualizations were generated, like waveform plotting, constellation diagrams, and modulation demonstrations.

3.2 Classroom Engagement:

- In the lectures, students engaged with MATLAB simulations, where they modified parameters like carrier frequency, modulation index, and symbol rate.
- MATLAB GPT was utilized, which instantly provided hints, clarification, and illustrative examples once questions were submitted by students during class.
- Short quizzes and reflective assignments were automatically generated and graded by AI-assisted tools, which enabled rapid feedback.

3.3 Integration across Courses:

- The practice was implemented for two core courses of Analog and Digital Communication.
- The students participated in laboratory sessions, where they have simulated the communication signal, effect of channel noise on the signal, understanding of modulation schemes using the scripts which are generated by MATLAB AI.

3.4 Support Tools:

- All the outputs generated by AI were first checked by the teacher to ensure correctness and pedagogical relevance.
- Resources were shared with a student which contains some problems, exercises, solutions, simulation templates etc.

3.5 Theoretical Explanations:

The theoretical laws such as Shannon's capacity theorem, Nyquists theorem which requires understanding of multiple parameters, were explained using GPT-generated answers where step-by-step explanation is provided to the students with mathematical formulas and derivations.

3.6 Problem solving:

The use of GPT was done to generate solutions to the numerical in the problem solving sessions. The answer provides the hints, detailed feedback and multiple approaches to solve the problem which widens the horizon of problem solving ability of the students.

4. Results and Discussion

The impact of this intervention was evaluated through a combination of quantitative survey data (N=37) students of second year electronics and telecommunication engineering program and qualitative faculty observations.

4.1 Quantitative Impact of Student Engagement

Survey results indicate a profound shift in student interaction with the course material. As shown in Table-1, the vast majority of students integrated these tools into their daily workflow.

Table 1: Students Response to feedback questions (all values in percentage)

How often did you use MATLAB AI and MATLAB GPT for course- related task in Analog and Digital Communication?	Never	Rarely	Sometimes	Often	Always
	1.5	1.5	6.4	88.3	2.3
How easy was it to access and use MATLAB AI and MATLAB GPT for learning purposes (e.g. problem sets, simulations, study material)?	Very difficult	Difficult	Neutral	Easy	Very easy
	0	0.2	1.3	1.3	97.2
How effective was MATLAB AI in providing interactive simulations (e.g. QPSK, AM/FM modulation) to understand complex communication concepts?	Not effective	Slightly effective	Moderately effective	Very effective	Extremely effective
	0.8	1.1	4.6	18.2	75.3
Did MATLAB AI and MATLAB GPT tools enhance your engagement during class lectures and laboratory sessions?	Not at all	To a small extent	To a moderate extent	To a great extent	Completely
	0.3	0.4	3.7	5.5	90.1
Did the real-time feedback from MATLAB GPT (e.g. quiz results, hints) help you improve your conceptual understanding of the subject?	Not at all	Slightly	Moderately	Significantly	Very much
	0.1	1.1	2.1	4.5	92.2

A striking 90.6% of students reported using the tools "Often" or "Always" suggesting high adoption rates. Furthermore, 97.2% of students rated the accessibility of the tools as "Very Easy", validating the decision to use a user-friendly interface like MATLAB GPT over raw code environment.

4.2 Effectiveness in Concept Visualization

The primary pedagogical goal was to demystify abstract concepts. The data supports the success of this objective. 93.5% of students found MATLAB AI "Very Effective" (18.2%) or "Extremely Effective" (75.3%) in providing interactive simulation for complex topics like QPSK and AM/FM modulation. 96.7% reported that the real0time feedback (hints, quiz results) "significantly" or "very much" improved their conceptual understanding. As shown in Figure 1 below, 22 % responses are for instant feedback and hints beneficial feature.

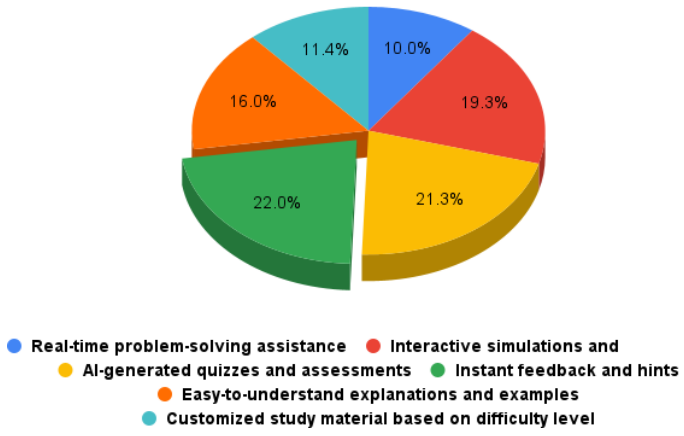

Figure 1: Students responses for beneficial features (N=37)

4.3 Impact on Faculty Workload and Efficiency

From a course handling perspective, the implementation was highly successful. Generating different activities/problems for the students, providing quick feedback, generating simulation task etc. has reduced the burden on the instructor and therefore more time can be spent in explaining the concepts and providing one-to-one attention to the students. This reclaiming of time allowed faculty to:

- Personalized one-on-one guidance during lab sessions.
- Curating more advanced open-ended design problems.
- Facilitating high-level theoretical discussions rather than basic debugging.

4.4 Challenges and Limitations

The challenges that were identified are shown in Figure 2 below. It shows that about one-third of the students struggled with over-reliance on the AI. This leads to concern that if AI is not handled properly it can damage the critical thinking of the students. As per the students response some them were not able to understand the explanation provided by the AI and the complex wording generated by AI lack of certain context.

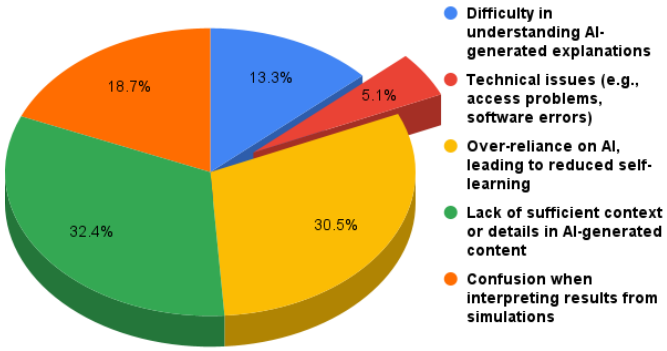

Figure 2: Students responses for challenges faced (N=37)

4.5 Pedagogical Implications

The findings from this paper indicate that AI tool promotes active learning. The activities like interactive simulations, problem solving, variations in parameters etc. promote the higher order thinking skills among students. At the same time reduces burden on the teachers for preparing the different question sets. Increased students engagement and motivation for learning suggests that students like to work on the task given based on AI and explore the new things related to task.

4.6 Lessons Learned

1. Human Intervention: The answers/materials generated by the AI needs instructor intervention for validation and aligning the material with course objectives and providing necessary guidance to students.

2. Integration with traditional teaching: The AI tools should be integrated with traditional teaching method with balances the use of AI without affecting the critical thinking power of both students and teachers.
3. Customization: The activities given using AI tools should be idea based and not complete assignment/task/exercise. The AI prompts should be customize to generate new ideas, variations etc. without affecting cognitive levels of the students.
4. Requirement of appropriate licenses: For using full power of AI tools appropriate licenses are required and MATLAB is also licensed software.
5. Improvements based on feedback: Continuous feedback from the students should be taken to improve the delivery of the task and use of AI tools at different stages.

5. Conclusion

The study in this paper demonstrates the integration of MATLAB AI and MATLAB GPT along with traditional teaching method in undergraduate analog and digital communication courses. This integration of MATLAB AI provides students with detailed understanding of the concepts, enhances students engagements, comprehension where students are exposed to the power of AI in learning the complex concepts of communication. The concepts like visualizing modulation schemes, their constellation, effect of noise on the signal are easily understood by the students and study reveals that more than 90% of students integrated the tools into their learning routing. Faculty workload for material preparation is decreased by over 30%. In future, we aim to address the challenge of over-reliance by designing assessment frameworks that require students to critique and debug AI-generated solutions, rather than simply accepting them. Additionally, we plan to expand this methodology to include hardware-in-the-loop (HIL) simulations, bridging the final gap between AI simulation and physical implementation.

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