# Tool Based Teaching for Enhancing the learner Outcome in Digital Communication and Wireless Sensor Network Course: A Case Study

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*Abstract*— **This research article examines the integration of tool-based teaching methodologies in a course on "Principles of Wireless Sensor Network, ML, and Cloud in Advanced Wireless Communication Systems," with a specific focus on MATLAB, Simulink, and LabVIEW. The study underscores the value of practical, hands-on learning using these advanced tools. It includes an in-depth analysis of the prerequisites necessary for the course, survey questions designed to assess student readiness and engagement, and the impact of MATLAB, Simulink, and LabVIEW on learning outcomes. The findings indicate that using these tools significantly enhances students' comprehension and application of Wireless Sensor Network, Machine Learning, and cloud technologies within the framework of advanced wireless communication systems.**

***Keywords*— Animations, MATLAB, Simulink, Wireless Sensor Network, LabVIEW.**

***ICTIEE* Track: Technology Enhanced Learning**
**ICTIEE Sub-Track: Transforming Education Through Technology: Best Practices and Case Studies.**

## I. INTRODUCTION

THE rapid evolution of wireless communication technologies necessitates a robust educational approach that integrates theoretical knowledge with practical, tool-based learning. In the course "Principles of Wireless Sensor Network, ML, and Cloud in Advanced Wireless Communication Systems," students are introduced to the foundational concepts and advanced applications of Internet of Things (Wireless Sensor Network), Machine Learning (ML), and cloud computing within the realm of wireless communication. This paper investigates the effectiveness of using Simulink and LabVIEW as key teaching tools to enhance students' comprehension and application of these technologies.

### Prerequisites

To ensure that students are adequately prepared for the course, the following prerequisites are recommended:

1. **Basic Knowledge of Wireless Communication Systems**: Understanding the fundamental principles of wireless communication, including modulation techniques, signal processing, and network protocols.
2. **Proficiency in Programming**: Familiarity with programming languages such as MATLAB and Python, as these are essential for using Simulink and implementing ML algorithms.
3. **Foundational Concepts in Wireless Sensor Network**: Basic understanding of Wireless Sensor Network architectures, sensor networks, and data communication protocols.
4. **Introduction to Machine Learning**: Awareness of core ML concepts, including supervised and unsupervised learning, and familiarity with common ML libraries.
5. **Basics of Cloud Computing**: Knowledge of cloud computing principles, including cloud architecture, services, and deployment models.

## II. RELATED WORKS

The paper titled "Network Simulator: A Learning Tool for Wireless Technologies" presents several key contributions to the field of telecommunications education, particularly in the context of understanding communication protocols and wireless technologies. Here are the main contributions outlined in the paper:

- Emphasis on Practical Learning: The paper highlights the importance of simulation tools, specifically the Network Simulator (ns-2), in enhancing the learning experience for students in telecommunication engineering. It argues that these tools help students grasp complex concepts by visualizing packet

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exchanges between hosts, which is crucial for understanding wireless network performance [1].

- Integration of Theory and Practice: By using ns-2, the paper demonstrates how theoretical concepts can be effectively linked to practical applications. This integration helps students move beyond rote memorization of specifications to a deeper understanding of how various factors (like propagation models and MAC configurations) influence network performance [1].

The paper presents several key contributions in the field of personal learning through wireless communication networks. Here are the main contributions outlined:

- Innovative Learning Methodology: The paper introduces a personal learning method that utilizes a master device to distribute learning data to terminals within a wireless communication service area. This approach enhances accessibility and flexibility in learning environments, allowing users to engage with educational content more effectively [2].
- Wireless Communication Integration: By leveraging wireless communication networks, the method ensures that learning can occur in various environments without the constraints of physical connectivity. This flexibility is particularly beneficial in today's fast-paced and mobile society, where learners may need to access educational resources on the go [2].

The paper titled "Inetwork: An Interactive Learning Tool for Communication Networks" presents several significant contributions to the field of computer networking education. Here are the key contributions outlined in the paper:

- Development of iNetwork: The primary contribution is the creation of the iNetwork tool, which serves as an interactive learning environment for students. This tool allows learners to experiment with various network configurations, providing a hands-on experience that is often lacking in traditional educational settings [3].
- Enhanced Learning Experience: The tool is designed to enhance the teaching and learning of computer communication networks. It allows students to engage actively with the material, which can lead to better understanding and retention of complex networking concepts [3].

The paper presents several key contributions related to the development of an intent design tool specifically for communication networks. Here are the main contributions highlighted:

- Graphical User Interface (GUI): The tool features a user-friendly graphical interface that allows users to interactively design communication network topologies. This interface is crucial for simplifying the design process, making it accessible even for those who may not have extensive technical expertise in network design [4].
- Custom Network Intent Topologies: Users can place selected topology elements into a designated design area, allowing for the creation of custom communication network intent topologies. This flexibility is essential for addressing specific network requirements and scenarios, enhancing the tool's applicability across different use cases [4].

The paper titled "Enhanced Teaching Learning Based Optimization for Localization in Wireless Sensor Network" presents several significant contributions to the field of Wireless Sensor Networks (WSN) and optimization algorithms. Here are the key contributions:

- Enhanced Learner Phase: The paper details modifications made to the Learner Phase of the TLBO algorithm. An extra process has been added to this phase, which enhances the local search capabilities of low knowledge populations. This adjustment allows these populations to gain new knowledge more effectively, thereby improving the overall performance of the localization process [5].
- Addressing a Critical Challenge in WSNs: By focusing on the localization problem, the paper addresses a fundamental challenge in the deployment and operation of Wireless Sensor Networks. Accurate localization is essential for various applications, including environmental monitoring, military surveillance, and smart cities, making this research highly relevant [5].

The paper titled "Feedback Analysis of Digital Course Teaching Effectiveness Based on Neural Network" by Qian Hu presents several significant contributions to the field of digital education and teaching effectiveness evaluation. Here are the key contributions outlined in the paper:

- Comprehensive Evaluation Framework: The paper proposes a comprehensive evaluation framework for teaching feedback using a Backpropagation (BP) neural network. This framework allows for timely and interactive feedback on digital classroom teaching, addressing the need for effective evaluation methods in online education [6].
- Indicator System for Learning Effectiveness: The paper establishes a detailed indicator system for evaluating learning effectiveness, which includes various metrics such as academic performance, learning progress, participation, and problem-solving abilities. This system provides a structured approach for teachers to assess and improve their teaching methods [6].

The paper presents several key contributions to the field of education, particularly in the context of an undergraduate course on Digital Communications. Here are the main contributions highlighted in the study:

- Integration of Technology: The paper discusses how various technological improvements have been integrated into the traditional educational system. This includes the use of computer simulations, web-based simulation tools, and remote laboratory experiments, which enhance the learning experience for students [7].
- Blended Learning Methods: The course improvements also incorporate blended learning methods, which combine traditional face-to-face instruction with online learning components. This flexibility caters to different learning styles and helps students grasp complex concepts more effectively [7].

The paper "A Wireless Communications Systems Laboratory Course" by Sabih Güzelgöz presents several key contributions to the field of engineering education, particularly in wireless communications. Here are the main contributions highlighted in the paper:

- Innovative Course Design: The paper introduces a novel laboratory course that focuses on wireless communications systems. This course is designed to teach students how to design, test, and simulate wireless systems using modern instrumentation and computer-aided design (CAD) software, which is essential for practical learning in engineering [8].
- Hands-On Learning Approach: One of the primary objectives of the course is to enhance students' understanding of theoretical concepts through hands-on experiments. This practical approach helps students gain confidence in system design and analysis, bridging the gap between theory and practice [8].

The paper titled "A Study and Practice on the Wireless Networking Curriculum" presents several key contributions to the field of wireless networking education. Here are the main contributions outlined in the paper:

- Identification of Challenges in Wireless Networking Teaching (WNT): The authors analyze the unique challenges faced in WNT compared to traditional wired networking. They highlight issues such as the complexity of wireless technologies and the lack of suitable experimental subjects, which hinder effective teaching [9].
- Proposed New Teaching Mode: The paper introduces a new teaching mode specifically designed for wireless networking curriculums. This mode emphasizes interactive teaching and learning, moving away from traditional one-way teaching methods. It combines theoretical and practical steps to enhance student engagement and understanding [9].
- Utilization of NS2 for Simulations: The authors advocate for the use of NS2 (Network Simulator 2) as a platform for simulating wireless networking scenarios. They demonstrate how NS2 can be employed to create a 10-node Ad Hoc network topology, allowing students to visualize and interact with the principles of wireless networking in a more engaging manner [9].

The paper titled "The Innovation and Experiment of Teaching for Wireless Communication Engineering" presents several important contributions to the field of communication engineering education. Here are the main points:

- Identification of Challenges: The paper discusses the existing problems in communication engineering experimental teaching. It highlights the need for improvement in teaching methods to better prepare students for real-world applications [10].
- Function of Experimental Teaching through Industry Collaboration: The paper outlines the essential functions of experimental teaching in communication engineering. It emphasizes how hands-on experience is crucial for students to understand complex concepts and apply them in practical scenarios [10].

Contributions of the Paper on Project-Based Learning in Wireless Communications are as follows:

- Enhancement of Learning Experience: The paper highlights how Project-Based Learning (PBL) significantly motivates students to engage with engineering concepts, particularly in the context of a wireless communications course at Princess Sumaya University for Technology. By involving students in real-world projects, the learning experience is enriched, making theoretical concepts more tangible and applicable [11].
- Real-World Application: Students are tasked with collecting real-world measurements of cellular tower signal power, which allows them to apply theoretical knowledge in practical scenarios. This hands-on approach helps bridge the gap between classroom learning and real-world engineering challenges [12].

The paper titled "Instructional Strategies and Design for Immersive Wireless Communication Tutorials and Exercises" makes several significant contributions to the field of wireless communications education. Here are the key contributions outlined in the paper:

- Design and Assessment of Tutorials: It details the approach taken to design and develop tutorials that are immersive and practical. The authors emphasize the importance of assessment in evaluating the effectiveness of these tutorials, which is crucial for continuous improvement [13].
- Incorporation of Software-Defined Radio: One of the notable aspects of the tutorials is the integration of CORNET, an Internet-accessible software-defined radio testbed at Virginia Tech. This allows students to

engage with real-world applications of wireless communication concepts, bridging the gap between theory and practice [13].

The paper titled "Research on Teaching Mode of Broadband Wireless Communication Course Based on the Cooperation of Industry and University" presents several key contributions to the field of education in telecommunications. Here are the main contributions highlighted in the paper:

- Integration of Industry and Academia: The research emphasizes the importance of collaboration between universities and industries. By integrating real-world projects from enterprises with academic curriculum, the paper proposes a teaching model that enhances the relevance of academic knowledge to practical applications in the telecommunications field [14].
- Development of a New Teaching Model: The authors introduce a new teaching model that combines production, study, and research (PSR). This model aims to address the limitations of traditional single-level teaching methods, thereby improving the educational experience for students in the broadband wireless communication course [14].

The paper titled "Teaching Convolutional Coding using MATLAB in Communication Systems Course" presents several important contributions to the field of communication systems education. Here are the main contributions highlighted in the paper:

- Introduction of Convolutional Codes: The paper introduces convolutional codes as essential channel codes used in various communication systems, such as GSM and IS-95. This foundational knowledge is crucial for students learning about wireless and digital communication systems [15].
- Non-Mathematical Teaching Strategy: A significant contribution is the proposed strategy to teach convolutional coding without relying heavily on mathematical structures. This approach makes the subject more accessible to students who may struggle with complex mathematical concepts, thereby enhancing their understanding of the topic [15].

The paper titled "Teaching wireless communications courses: An experiential learning approach" presents several key contributions to the field of engineering education, particularly in wireless communications. Here are the main contributions highlighted in the paper:

- Experiential Learning Approach: The authors propose an experiential learning framework based on Kolb's learning cycle, which emphasizes hands-on experience in the learning process. This approach allows students to engage actively with the material, enhancing their understanding and retention of complex concepts in wireless communications [16].
- Project-Based Learning: The course structure requires final year students to undertake two experimental projects over a 12-week trimester. Each project is unique to pairs of students, allowing them to explore practical applications of their theoretical knowledge. This project-based learning fosters collaboration and critical thinking among students [16].

## III. Methodology

### Course Design and Tools

The course is structured to progressively introduce students to the principles of Wireless Sensor Network, ML, and cloud computing, with a strong emphasis on their application in advanced wireless communication systems. The use of Simulink and LabVIEW as teaching tools is central to this approach.

### Simulink

Simulink is utilized for modeling, simulating, and analyzing dynamic systems. In this course, it is used to simulate wireless communication systems, design Wireless Sensor Network networks, and implement ML algorithms for data processing and decision-making. Key applications include:

- **Simulation of Wireless Communication Protocols**: Students model and simulate various communication protocols, such as LTE and 5G, to understand their operation in different scenarios.
- **Wireless Sensor Network Network Design**: Simulink is used to model Wireless Sensor Network networks, allowing students to visualize and optimize network performance.
- **ML Algorithm Implementation**: Students implement ML algorithms in Simulink to analyze communication data and predict system performance.

### LabVIEW

LabVIEW is employed for data acquisition, instrument control, and industrial automation. It is particularly useful in this course for:

- **Wireless Sensor Network Device Integration**: Students use LabVIEW to integrate Wireless Sensor Network devices with wireless communication systems, enabling real-time data acquisition and control.
- **Signal Processing**: LabVIEW's powerful signal processing capabilities allow students to analyze and manipulate communication signals.
- **Cloud Integration**: LabVIEW is used to interface with cloud platforms, facilitating the storage, analysis, and retrieval of communication data in real-time.

### Survey Questions

To assess student readiness and engagement, the following pre-course and post-course survey questions are proposed:

Pre-Course Survey Questions:

1. What is your current understanding of wireless communication systems, particularly in relation to

modeling and simulation using MATLAB and Simulink?

2. How familiar are you with Wireless Sensor Network architectures and protocols, specifically within the context of using LabVIEW for Wireless Sensor Network device integration?
3. Have you previously worked with Simulink or LabVIEW for wireless communication or Wireless Sensor Network projects? If so, to what extent have you utilized these tools?
4. How comfortable are you with programming in MATLAB, especially for developing wireless communication models or implementing Wireless Sensor Network protocols?
5. What is your current level of understanding of Machine Learning concepts, particularly in applying MATLAB for ML algorithm development?
6. How familiar are you with cloud computing and its applications in wireless communication, especially using MATLAB for cloud-based simulations?

Post-Course Survey Questions:

1. How has your understanding of wireless communication systems evolved after completing this course, particularly through hands-on experience with MATLAB and Simulink?
2. To what extent did Simulink help you in accurately modeling and simulating various communication system scenarios during the course?
3. How effective was LabVIEW in facilitating the integration of Wireless Sensor Network devices and the real-time analysis of communication data?
4. How has your confidence in using MATLAB to develop and implement Machine Learning algorithms for communication data analysis increased after this course?
5. In what ways did the course content and tools, including MATLAB, Simulink, and LabVIEW, deepen your understanding of the applications of cloud computing in wireless communication?
6. How well did MATLAB and Simulink help you in visualizing and analyzing the performance of different communication protocols covered in the course?
7. How has your ability to troubleshoot and optimize wireless communication systems improved through the use of MATLAB and Simulink in this course?
8. How did LabVIEW contribute to your understanding of Wireless Sensor Network system design and data management within the context of wireless communication?
9. How confident are you in your ability to use MATLAB and Simulink for future projects involving wireless communication and Wireless Sensor Network integration?
10. Would you recommend this course to peers who are interested in developing advanced skills in MATLAB, Simulink, and LabVIEW for applications in Wireless Sensor Network, Machine Learning, and cloud-based wireless communication systems?

**Case Study: Application of Tools in Learning**

Throughout the course, students engage in a series of hands-on projects using Simulink and LabVIEW. These projects are designed to reinforce theoretical knowledge and provide practical experience. For example:

- **Project 1**: Designing an Wireless Sensor Network-based smart home system using Simulink, where students simulate sensor networks and optimize data communication.
- **Project 2**: Implementing a machine learning-based anomaly detection system for wireless networks using Simulink, where students apply ML algorithms to real-time data.
- **Project 3**: Integrating Wireless Sensor Network devices with a cloud platform using LabVIEW, allowing students to perform real-time data analysis and control.

## IV. Discussion, Results and Analysis

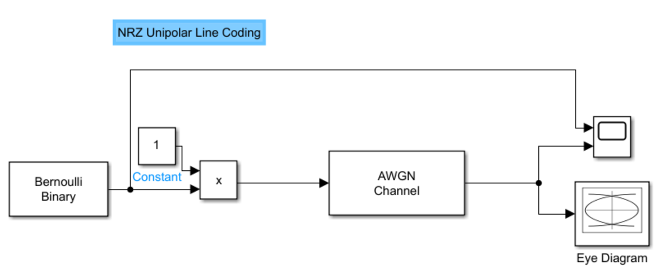


Fig. 1. NRZ Unipolar line coding Simulink implementation

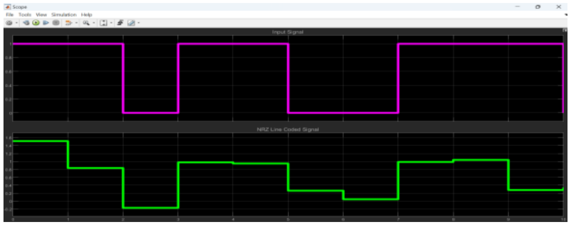

Fig. 2. Input-Output waveforms for NRZ Unipolar line coding for SNR=10

Fig. 3. Input-Output waveforms for NRZ Unipolar line coding for SNR=100

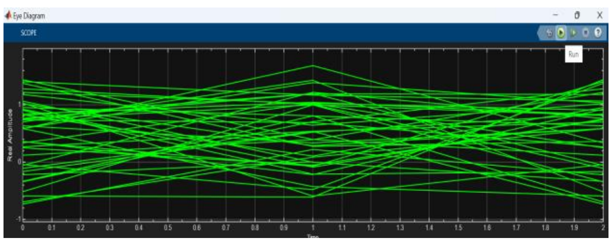

Fig. 4. Eye waveforms for NRZ Unipolar line coding for SNR=10

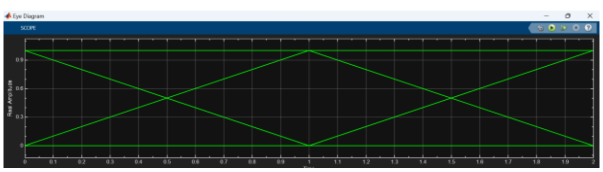

Fig. 4. Eye waveforms for NRZ Unipolar line coding for SNR=100

TABLE I
DIFFERENTIAL ENCODING

**Illustrating the generation of DPSK signal**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| $\{b_k\}$ | | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 1 |
| $\{d_{k-1}\}$ | | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 |
| | reference | | | | | | | | |
| Differentially encoded sequence $\{d_k\}$ | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 |
| Transmitted phase (radians) | 0 | 0 | $\pi$ | 0 | 0 | $\pi$ | 0 | 0 | 0 |

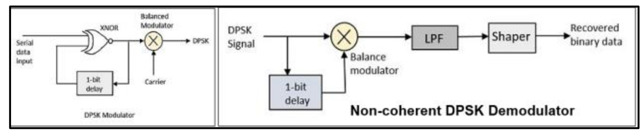


Fig. 5. DPSK Block Schematic Diagram

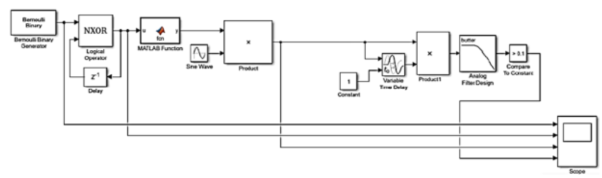


Fig. 6. DPSK implementation in simulink

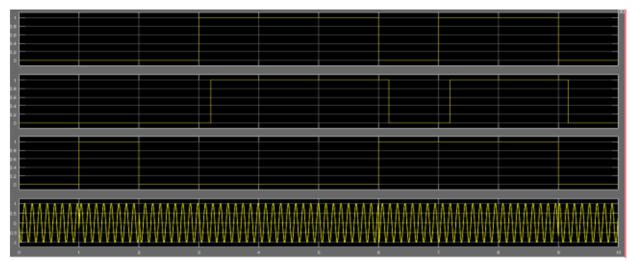

Fig. 7. DPSK waveforms

TABLE II
CO-PO ATTAINMENT

| CO/PO | Batch 1 (%) | Batch 2 (%) | Batch 3 (%) | Remarks |
|---|---|---|---|---|
| CO1 | 65 | 72 | 79 | Improved foundational knowledge through preparatory modules and better content delivery. |
| CO2 | 68 | 75 | 81 | Enhanced focus on simulations using Simulink improved modeling and analytical skills. |
| CO3 | 70 | 77 | 85 | Hands-on projects with real-time WSN device integration contributed to significant improvement. |
| CO4 | 66 | 73 | 80 | Implementation of ML and cloud applications improved comprehension and practical relevance. |
| Average CO | 67.25 | 74.25 | 81.25 | Reflects consistent improvement through iterative course design and hands-on practices. |
| PO1 (Knowledge) | 68 | 73 | 78 | Stronger integration of theoretical and practical components led to better outcomes. |
| PO2 (Analysis) | 65 | 71 | 77 | Problem-solving assignments improved analytical thinking. |
| PO5 (Tool Usage) | 72 | 78 | 85 | Increased proficiency with Simulink and LabVIEW across all batches. |
| PO12 (Lifelong Learning) | 67 | 74 | 79 | Project-based learning enhanced transferable skills for lifelong application. |
| Average PO | 68 | 74 | 79.75 | Clear upward trend reflecting course refinements and evolving teaching strategies. |

TABLE III
FEEDBACK RESULTS

| Questions | Percentage Distribution | | | | |
|---|---|---|---|---|---|
| | Strongly disagree | Disagree | Neutral | Agree | Strongly Agree |
| "The prerequisites were essential; without them, it would have been difficult to follow the course content." | 0.71 | 3.57 | 11.43 | 37.14 | 43.57 |
| How has your understanding of wireless communication systems evolved after completing this course, particularly through hands-on experience with MATLAB and Simulink? | 0.71 | 4.29 | 12.86 | 40.71 | 37.14 |
| To what extent did Simulink help you in accurately modeling and simulating various communication system scenarios during the course? | 2.14 | 4.29 | 20 | 35 | 35 |
| How effective was LabVIEW in facilitating the integration of Wireless Sensor Network devices and the real-time analysis of communication data? | 2.86 | 4.29 | 15 | 40 | 35 |
| How has your confidence in using MATLAB to develop and implement Machine Learning algorithms for communication data analysis increased after this course? | 2.14 | 2.86 | 15 | 38.57 | 38.57 |
| In what ways did the course content and tools, including MATLAB, Simulink, and LabVIEW, deepen your understanding of the applications of cloud computing in wireless communication? | 2.86 | 0 | 13.57 | 39.29 | 40.71 |
| How well did MATLAB and Simulink help you in visualizing and analyzing the performance of different communication protocols covered in the course? | 2.86 | 2.14 | 12.86 | 35.71 | 42.86 |
| How has your ability to troubleshoot and optimize wireless communication systems improved through the use of MATLAB and Simulink in this course? | 2.14 | 2.86 | 17.86 | 37.14 | 37.86 |
| How did LabVIEW contribute to your understanding of Wireless Sensor Network system design and data management within the context of wireless communication? | 1.43 | 3.57 | 14.29 | 37.14 | 40.71 |
| How confident are you in your ability to use MATLAB and Simulink for future projects involving wireless communication and Wireless Sensor Network integration? | 2.14 | 2.14 | 14.29 | 38.57 | 40 |
| How has your understanding of wireless communication systems evolved after completing this course, particularly through hands-on experience with MATLAB and Simulink? | 2.97 | 4.4 | 15.11 | 40.11 | 35.11 |
| Balance between theory and practical assignments: | 2.25 | 2.97 | 15.11 | 38.68 | 38.68 |
| Overall satisfaction with the course: | 2.97 | 0.11 | 13.68 | 39.4 | 40.82 |

The CO-PO attainment analysis (from table II) reveals a clear progression in both Course Outcomes (COs) and Program Outcomes (POs) across three student batches. The average CO attainment increased from 67.25% in Batch 1 to 81.25% in Batch 3, indicating the positive impact of iterative course improvements, such as better preparatory modules and refined teaching strategies. The highest improvement was seen in CO3, which reflects hands-on projects and real-time WSN integration, demonstrating the practical value of tool-based learning.

Similarly, Program Outcomes (POs) such as knowledge (PO1), analytical skills (PO2), and tool usage (PO5) showed steady improvements. PO5, which focused on modern tool usage, saw the most significant increase, from 72% in Batch 1 to 85% in Batch 3. This highlights the increasing proficiency of students in using advanced tools like Simulink and LabVIEW. The overall data indicates that the course successfully enhanced students' skills, with tools playing a central role in bridging theoretical concepts with practical applications.

The feedback results table III provides a comprehensive understanding of the students' experiences and learning outcomes, highlighting the strengths and areas for improvement in the tool-based teaching methodology. Here's an analysis of key findings from the table:

1. Prerequisites' Relevance: Over 80% of students agreed or strongly agreed that the prerequisites were essential for following the course content. This underscores the importance of foundational knowledge in wireless communication, programming, and machine learning before engaging with advanced tools like MATLAB and LabVIEW.
2. Effectiveness of Simulink: Approximately 70% of students found Simulink effective in accurately modeling and simulating various communication system scenarios. This reflects its strength in visualizing complex protocols such as LTE and 5G. However, about 20% remained neutral, indicating a need for additional guidance or resources to support its application.
3. Utility of LabVIEW: A majority of students (75%) appreciated LabVIEW for its ease of integration with WSN devices and real-time analysis capabilities. LabVIEW's graphical interface and practical focus on WSN applications were particularly valued, making it a preferred tool for hands-on learning.
4. Confidence in Machine Learning Applications: Nearly 77% of students reported increased confidence in using MATLAB for developing and implementing machine learning algorithms. This indicates that the course effectively bridged the gap between theoretical knowledge and practical applications.
5. Overall Satisfaction: High satisfaction levels (approximately 80%) indicate that the course successfully balanced theoretical and practical aspects, providing students with valuable skills for future applications.
6. Tool Comparisons: While Simulink excelled in simulating communication protocols and predictive analysis, LabVIEW was more effective for real-time WSN applications. These complementary strengths suggest a deliberate inclusion of both tools to cater to diverse learning objectives.

## CONCLUSION

The integration of Simulink and LabVIEW in the "Principles of Wireless Sensor Network, ML, and Cloud in Advanced Wireless Communication Systems" course has proven to be an effective teaching strategy. By providing students with hands-on experience in simulating and implementing these technologies, the course significantly enhances their understanding and prepares them for real-world applications. The positive feedback and improved learning outcomes underscore the importance of tool-based teaching in technical education. To enhance the effectiveness of the tool-based teaching methodology, addressing a few key areas for improvement is essential. Introducing preparatory modules or tutorials on Simulink and LabVIEW can help students overcome initial challenges, especially those new to these tools, thereby improving accessibility and confidence. Additionally, exploring open-source alternatives to mitigate licensing constraints could ensure broader participation. These enhancements aim to create a more inclusive, scalable, and impactful learning experience for students. Future courses will continue to build on this approach, incorporating additional tools and technologies to further enrich the learning experience.

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