Journal of Engineering Education Transformations ,
Volume 38 , No. 3 , January 2025 , ISSN 2349-2473, eISSN 2394-1707

10.16920/jeet/2024/v38i3/24249

Creating Interest On Microwave And Antenna Design Course Among Students Through Iovp Blended Teaching Method

K. S. Praveena[1*], K. Bhargavi[2], Mahadevaswamy[3], Chandrashekar M. Patil[4]
[1,2,3,4]Vidyavardhaka College of Engineering, Mysuru, Karnataka, India
[1*]praveenaks@vvce.ac.in,
[2]bhargavik@vvce.ac.in,
[3]mahadevaswamy@vvce.ac.in,

Abstract : In this era of rapid technological advancement, microwave engineering and antenna design play pivotal roles in the development of cutting-edge communication systems, radar systems, satellite technology, and beyond. Despite the critical importance of these subjects, attracting and retaining student interest can be a difficult task due to their observed complexity and perception. This study presents a systematic IOVP blended approach aimed at creating interest and fostering engagement among students during the introductory session of microwave and antennas course. This paper also outlines lab-based methods aimed at fostering enthusiasm for microwave and antenna courses through hands-on learning experiences, utilizing interactive simulations, and incorporating real-world applications. Furthermore, this study assesses the effectiveness of the approach through survey feedback from students who participated in the course. The results indicate a significant increase in student interest and engagement, as well as an improved perception of the course's relevance and importance.

K. S. Praveena
Vidyavardhaka College of Engineering, Mysuru, Karnataka, India
praveenaks@vvce.ac.in,

Keywords : IOVP, Microwave, Antenna, Blended learning, Virtual simulation, Project-based learning

1. Introduction

In today's increasingly interconnected world, the importance of microwave and antenna technology cannot be overstated. These technologies are the backbone of our wireless communication systems, enabling us to make phone calls, access the internet, watch television, and even navigate with GPS. Behind every smartphone, Wi-Fi router, and satellite communication device lies the complex science and engineering principles of microwaves and antennas. Creating interest among students in the realm of microwave and antenna technology is not just about teaching a set of theoretical concepts; it's about inspiring them to explore the limitless possibilities that this field offers. As they delve deeper into the subject matter, students will discover how microwaves, with their ability to transmit data at high frequencies, have revolutionized the way we communicate. They'll explore how antennas, by efficiently radiating and receiving electromagnetic waves, enable the wireless connectivity that we often take for granted. Moreover, microwave and antenna technology are not confined to communication alone. These principles find applications in radar systems, medical imaging, space exploration, and countless other domains. By igniting students' curiosity in this field, educators are not only preparing them for future careers in telecommunications but also opening doors to innovation across a spectrum of industries. In

addition to the technical aspects, a course on microwaves and antennas can provide students with hands-on experience with cutting-edge technology by emphasizing the practical applications of these concepts.

The teaching of electromagnetics (EM) in undergraduate engineering courses has traditionally relied on conventional methods, such as classroom lectures with a blackboard, repetitive problem-solving exercises, and the application of established mathematical formulas to address classical canonical problems. Occasionally, laboratory sessions are incorporated into the curriculum, depending on the availability of resources and time constraints. Unfortunately, this traditional approach to EM education has had a discouraging impact on most students, failing to ignite their interest in fields related to this subject. Instead, many students associate their EM coursework with challenging and abstract concepts, often considering it one of the most scary and challenging aspects of their engineering program. This prevailing perception of EM education as a demanding and less engaging discipline stems from several factors, as documented in prior studies. These factors include the students' often inadequate foundational knowledge in the subject, the lack of comprehensive and student-friendly textbooks, and the teaching approaches of instructors who may not be particularly enthusiastic or active in the field.

2. Literature Review

The teaching of electromagnetics in undergraduate engineering courses has been based on traditional resources such as blackboard and teaching. The universities usually teach one semester EM, within the first two years, using Physics textbooks. Students constantly emphasize their appreciation for hands-on opportunities, where their own abilities and ingenuity can be actively used on a real-world project. The authors in [Perotoni MB et al 2019] highlighted the methods to improve the motivation and physical insight of electromagnetic concepts in electrical engineering courses by utilizing real-world examples and a design cycle with handmade antennas. Teaching antennas and propagation as a course to students is a difficult task. The authors in [Ülker S. Antennas et al 2020] proposed an approach for teaching basic antenna theory and propagation to senior level undergraduate students in electrical engineering. This approach combines mathematical and theoretical studies with practical antenna design and laboratory measurements. The course structure includes teaching principles such as performing radiation calculations, making radiation pattern measurements, and designing antennas like microstrip patch antennas. Simulation-based teaching through Matlab software is used in [Priyakanth, R. et al 2023] to develop the Students' Exploration and Learning Skills. An interactive laboratory system can also be used to teach antenna course [Gómez-Tornero et al 2018, Moe, M. S. et al 2020] .This lab offers multidisciplinary virtual laboratory to provide students with the knowledge and practical skills by improving the learning and teaching processes in related sciences and technologies[Aydin et al 2010]. Showing animations on the electromagnetics topics in the class on day-to-day basis and building virtual simulation-based classes may help the students sustain interest on the course and to explore the practical applications [Yang et al 2020]. The authors proposed an innovative method in [Zhu et al 2021, Crilly et al 2014] comprising of online resource sharing, virtual construction, and project driven methods to develop the deeper interest among the students on EM course. To enhance student engagement in microwave and antenna design courses, authors in [Yang et al 2020] Suggests teaching reform in "Microwave Technology and Antenna" course by implementing an Internet-Engineering Education (IEE) blended teaching method. This approach combines traditional classroom teaching with online resources, such as virtual experiment platforms and network teaching platforms, to create a comprehensive learning experience. The authors in [Ponnapalli, V. S. 2022] elevates online learning engagement and tracking challenges in microwave engineering and focuses on challenges in understanding course, qualifying statistics, and recommendations. By aligning teaching objectives with outcome-based education principles and optimizing course content, students can develop practical engineering skills and innovative thinking [Wang, A. et al 2019]. Additionally, incorporating electromagnetic simulation tools can further enrich the learning process, making abstract concepts more tangible and engaging for students [Dou, Z et al 2023]. The paper [Yu, Y. et al 2020] focuses on implementing project-based learning in the Antenna and Wave Propagation course, benefiting students in various aspects. The project-based learning component supplements traditional classroom learning, encouraging students to apply textbook theory to real-world engineering problems. Facilitates meaningful collaborations among students and enhances self-learning capabilities. The authors in [Wu, W. et al

2020] introduced a new blended teaching mode for the Communication principle course, enhancing course content and student abilities which highlights the improved achievement of course targets and the training of individuals with innovative thinking and better competitive power through the new teaching method.

3. Iovp Blended Teaching Method

The IOVP blended teaching approach is a hybrid teaching comprising of a systematic Introduction+ Online resource Sharing + Virtual simulation + project-based learning. It is an efficient teaching technique used to teach microwave and antenna courses for undergraduate students who require a systematic approach to understand the subject in Electronics and communication Engineering.

A. Effective Introduction of the Course

A practical introduction to a course is like a warm welcome and a roadmap for students. It helps them understand what they will learn, why it's essential, and what's expected of them. It's like the starting point of an exciting learning journey where the teacher guides and students explore together. It's important because it gets everyone ready to learn and creates a friendly and helpful atmosphere in the class. In the introductory session of the course the following points were discussed with the students.

- Course objectives
- Need for study (Applications of the course)
- Employment areas & opportunities
- Course map of the subject

Talking about the course objectives at the beginning of the class is essential because it helps everyone know what they are supposed to learn and do.

The course objectives of the course are as follows:

CO1: To Explain the working and applications of microwave devices and Antennas.

CO2: To Apply the fundamentals theory of Microwave and Antenna to characterize the Microwave Network Devices and Antenna Parameters

CO3: To Analyze waveguides, antenna and its radiation patterns for different parameters.

CO4: To Design and simulate antennas for various applications using simulation software.

After discussing the course objectives, the need for the study of the subject was discussed. Discussing why a particular subject is being studied in class is considered vital because it helps in understanding why it matters. This makes learning more interesting and fosters a desire to learn. Furthermore, when the reason for learning something is known, greater attention is paid, and questions are often asked. Setting goals and selecting the right courses are also facilitated. Additionally, it demonstrates that care is given by the teacher for the students' success. Thus, the discussion of why a subject is studied in class is believed to contribute to improved learning and a more enjoyable school experience.

Discussing employment opportunities related to a Microwave and Antenna course in class is also essential because it is believed by many that when students are informed about potential career paths and job prospects, their motivation can be increased, and a connection between their education and real-world goals can be established. Furthermore, the relevance of what they are learning can be seen, and the commitment to their studies can be improved. It is understood that students can be guided in their choices of electives, specializations, or additional coursework by knowing potential employment areas.

Microwave anta antenna engineers have diverse career opportunities in:

Telecommunications: Microwave and RF engineers for wireless networks.

Aerospace and Defense: Radar engineers, antenna designers, and electronic warfare specialists.

Satellite Communications: Satellite engineers and payload specialists.

Consumer Electronics: Wireless device engineers and antenna integration experts.

R&D: Research scientists and product development engineers.

Broadcasting: Broadcast engineers and antenna installers.

Medical Devices: Engineers for medical equipment using microwave tech.

Wireless Tech: RF testing and hardware engineers.

Consulting: Freelance consultants and contract engineers.

Academia: Professors, instructors, and research assistants.

Entrepreneurship: Startups in antenna design and consulting.

Finally, providing the course map about the subject to students is like a roadmap for a class. It helps students and teachers know what will happen during the course. It shows what students are supposed to learn and what the teacher will teach. This map also has a indirect schedule, so everyone knows when assignments and tests will be conducted. It's important because it makes learning clear and organized. Students can plan their time better, and teachers can teach in a logical order. Plus, it helps teachers check if students are learning well and if their teaching is effective. So, a course map is like a guide that keeps everything on track and helps everyone do their best in the class.

A. Pre- and Post-Assessment Quiz

Pre- and post-assessment quizzes are very helpful for teachers and students during the learning process. At the beginning of every session (first 5 minutes), a pre-assessment quiz (5 – 10 questions) was conducted to understand the student's knowledge about the topic[Praveena, K. S. et al 2023]. On the other hand, at the end of the session (last 5 minutes), the same set of questions was asked to know the student's level of understanding about the topic. These pre- and post-assessment quizzes provide immediate feedback that will help the students understand and remember the material much better. The quizzes were asked through Socrative tool [Saeed Alharbi, A., et al 2020, Putri, D. M., et al 2023] (Socrative is an online application designed to facilitate real time classroom engagement and formative assessment). A sample set of questions

Table 1 :
The Course Map

Week	Topic	Content Covered	Assessment Methods
1-2	Introduction to Electromagnetic Waves	Electromagnetic Spectrum, Maxwell's Equations	Weekly Quizzes, Assignments
3-4	Microwave Transmission Lines	Types of Transmission Lines, Impedance Matching	Weekly Quizzes, Assignment
5-6	Microwave Passive Components	Microwave Filters, Couplers, Amplifiers	Midterm Examination
7-8	Microwave Active Components	Microwave Oscillators, Mixers, Diodes, Transistors	Weekly Quizzes, Assignment
9-10	Microwave Devices and Circuits	MICs, Waveguides, Resonators, Measurements	Weekly Quizzes, Assignment
11-12	Antenna Fundamentals	Antenna Basics, Types, Characteristics	Midterm Examination
13-14	Antenna Design and Analysis	Impedance Matching, Simulation, Testing	Weekly Quizzes, Final Project Report
15	Emerging Trends and Applications	Advanced Antenna Technologies, Applications	Class Presentation, Participation
16	Final Projects and Presentations	Practical Project Presentations	Final Project Presentation and Report

Table 2 :
Pre And Post Assessment Scores

Particulars	Pre-assessment			Post-assessment		
Marks Scale	0-3	4-6	7-10	0-3	4-6	710
No. of students scored (60)	50	08	02	7	15	38

are given below and pre- and post-assessment marks obtained by students (set of 60) are given in table 2. The results show the progress of the students and encouraging in understanding the concepts.

1. What is the definition of antenna gain?
2. What is the use of the radiation pattern of an antenna?
3. Define the term 'beamwidth' in the context of antennas.
4. What does VSWR stand for and why is it important?
5. What is the function of the antenna's impedance?
6. Explain the term 'directivity' of an antenna.\
7. What is an isotropic antenna?
8. What does polarization refer to in antenna terminology?
9. Define 'effective aperture' of an antenna.
10. What is antenna bandwidth?

B. Online resource Sharing

Sharing class content online has become increasingly common in modern education. This practice involves making course materials, such as lectures, assignments, readings, and multimedia resources, accessible to students via digital platforms or learning management systems. It allows students to access course materials conveniently, providing flexibility in their learning. Online content sharing enhances the learning experience, making education more accessible and adaptable to the needs of diverse learners. We have used Google classroom for sharing all the content related to the subjects like lecture

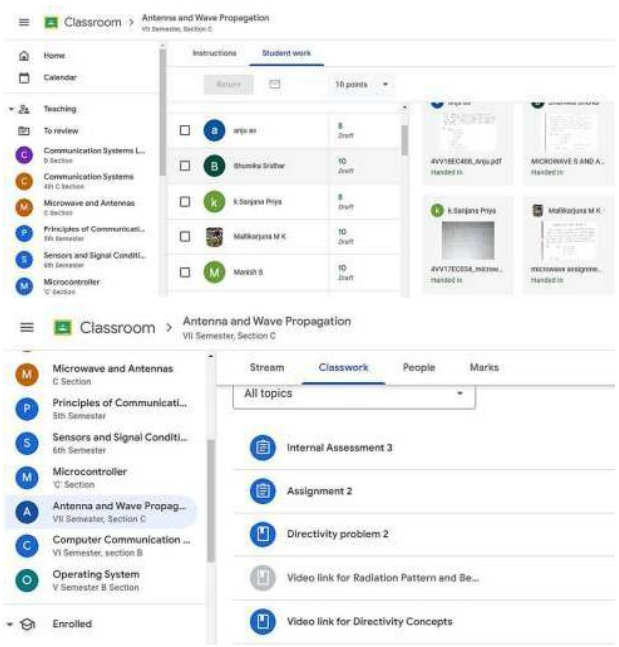

Fig.1 : Resource sharing through google classroom

videos, weekly Quizzes, Assignments, tests etc., as shown in figure 1.

B. Virtual Simulation

Using simulation software for antenna design in the classroom can be a valuable teaching tool, allowing students to gain practical experience and a deeper understanding of antenna design concepts. The simulation tool used is “Keysight Advanced Design system”. Advanced Design System is an electronic design automation software system produced by PathWave Design, a division of Keysight Technologies. Keysight ADS supports every step of the design process, such as schematic capture, layout, design rule checking, frequency-domain and time domain circuit simulation, and electromagnetic field simulation – allowing the engineer to fully characterize and optimize an RF design without changing tools. Initially, we Conducted training sessions by providing instructional materials to familiarize students with the simulation software. Also, tutorials, guides, and videos demonstrating how to use the software effectively were shared through google classroom. Then, we asked students to Design an antenna theoretically using design equations. We asked them to design a simple microstrip antenna for 3.5GHz frequency. Later, we allowed students to work hands-on with the simulation software during sessions. We also encouraged them to analyze the parameters like reflection coefficient, gain,

directivity, VSWR, efficiency etc., and experiment the design with different parameters and configurations.

D. Project based learning.

In the project-based learning phase, students are given the opportunity to create their own antenna. Students are educated on the process of designing the antennas including workings of antennas, their size and shape as shown in fig 3 & 4. The process of project allocation to implementation has three phases and the duration was 4 weeks [Yu, Y. et al 2020].

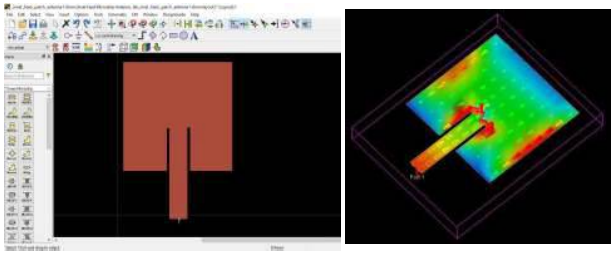

Fig. 2 : Designed antenna using simulation software

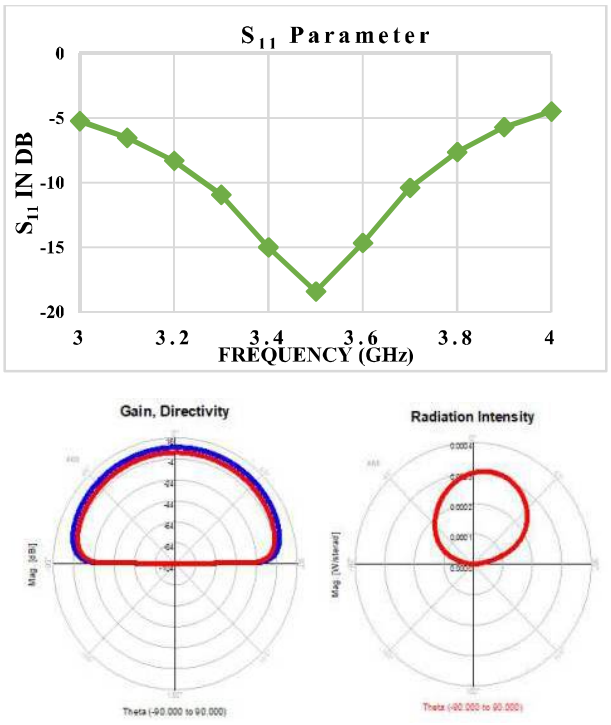

Fig. 3: Analysis of different parameters of the antenna

- Phase 1: Grouping and Project Selection

In the first phase, the class of 60 students were divided into 15 groups, and the grouping of the students was left to the students. Then the list of 16-17 projects titles were given to students and the titles were given by the subject teacher which were shortlisted by studying the literature papers from the standard databases like IEEE, Springer etc., The projects were allocated to students through picking up a title from the pool of projects anonymously.

- Phase 2: Project synopsis

In the second phase, the groups were asked to give a brief presentation on the selected project. The presentation should contain the necessary information such as basic ideas and objectives, flow of the project, simulation tools to be used, expected results and time required to complete the project. The suggestions were given to students for the necessary changes to be made on the given project.

- Phase 3: Progress of the project

In phase 3, each project group is asked to give a presentation on the current progress of the project implementation for 10 minutes. During this, other teams were selected as listeners and commentators for brainstorming the project which will helps the students for better understanding of the project.

- Phase 4: Final Presentation and Report

Following phase 3, the antenna is planned through the creation of antenna virtually using simulation software with specifications regarding its dimensions. This allows an assessment of its potential functionality without the need for physical construction. Adjustments can be made in the virtual model if it doesn't perform as expected. If possible, a physical version of the antenna is constructed using substrate materials like FR4. It is then subjected to testing to determine whether it fulfills the intended purpose. A comprehensive report detailing the project's progress and insights is compiled. Finally, the antenna is presented to classmates and the teacher. It's important to remember that any imperfections in the design are part of the learning process, and the focus is on both learning and enjoyment.

The assessment of the Antenna Design Project involves a thorough evaluation of various project components. Firstly, we examine the students' understanding of the given antenna design and its suitability for the intended purpose, assessing this against the clarity and completeness of their design plan.

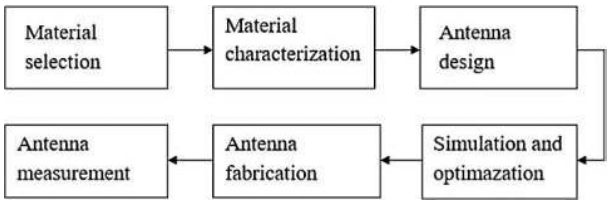

Fig. 4 : Antenna design process explained to students

Understanding antenna principles is crucial, and we look for evidence of a deep comprehension of how antennas function and the key considerations in their design. The use of simulation software and its effectiveness in optimizing the antenna's performance is another critical aspect. Testing results, both from simulation and physical prototypes, are scrutinized to determine how well they match the anticipated performance. In addition to these technical aspects, we evaluate the project report's quality in terms of clarity, organization, and the ability to convey the design process effectively. The oral presentation is assessed for its ability to communicate project details, and we look for creativity, problem-solving, teamwork, and the ability to learn from challenges as important learning outcomes of this project-based assessment. Ultimately, an overall evaluation is determined by combining scores (Total 30marks) across these categories to gauge each student's performance holistically as shown in the rubrics table 3.

Most of the students shown up to the simulation results because of the unavailability of the fabrication facility. Although, some best designed antennas were fabricated to show the complete cycle of antenna design for the students as shown in fig. 4.

Fig. 5 : Fabricated antennas (left) and Students presenting the fabricated antenna (right)

Table 3 :
Project Rubrics Used

Criteria	Excellent (5)	Good (4)	Adequate (3)	Limited (2)	Unsatisfactory (1)
Design Clarity & Details	Clear and comprehensive design with all specifications.	Clear design with minor omissions.	Adequate design but lacks some details.	Somewhat unclear with significant gaps.	Very unclear and incomplete design.
Simulation Effectiveness	Exceptionally effective use of simulation software.	Proficient use with minor room for improvement.	Adequate use with some room for optimization.	Struggles with limited optimization.	Ineffective use with no optimization.
Test Results & Analysis	Excellent results closely matching expectations.	Good results with minor deviations.	Acceptable results with noticeable deviations.	Limited results with significant deviations.	No meaningful results or analysis.
Documentation Clarity	Report is exceptionally clear and complete.	Clear report with minor omissions.	Adequate but may lack some details.	Somewhat unclear and lacks important details.	Very unclear and highly disorganized report.
Communication Skills	Exceptionally clear and engaging communication.	Clear with some areas for improvement.	Adequate but may lack clarity.	Somewhat unclear and less engaging.	Lacks clarity and structure.
Creativity & Problem-Solving	Demonstrates exceptional creativity and problem-solving.	Displays creativity with effective solutions.	Exhibits some creativity but with limitations.	Demonstrates limited creativity.	Lacks creativity and problem-solving skills.

Based on the rubrics used in table 3, the marks are allotted to groups, and it is observed that most of the students scored more than 90% (fig. 6) which clearly indicates that they comprehended the concepts well. At the end of the course, final feedback was taken on the course.

Total 198 students(from 4 sections) were participated in the survey and the survey questions with results are given in the table 4. From the results, It's evident that many of the students have a strong interest in antenna design course. The fact that most students either 'Agree' or 'Strongly Agree' with statements related to enthusiasm for the subject, the motivation to learn about antenna principles, and students' willingness to take on the challenges of antenna design projects is truly inspiring. This shows that students are not just here to pass the course; they are here because they are genuinely interested in the subject. The high mean scores (>4) in categories such as eagerness to learn, excitement about exploring different antennas, and enjoyment in simulation and optimization tasks are fantastic indicators of our positive outlook.

It's also encouraging to see that quite a few of the students find the idea of creating physical prototypes interesting and are motivated to understand the principles behind antenna operation. Moreover, the fact that a significant portion of students are open to considering a career in antenna design or related fields is exciting news. This reflects a growing passion in the students that extends beyond the classroom.

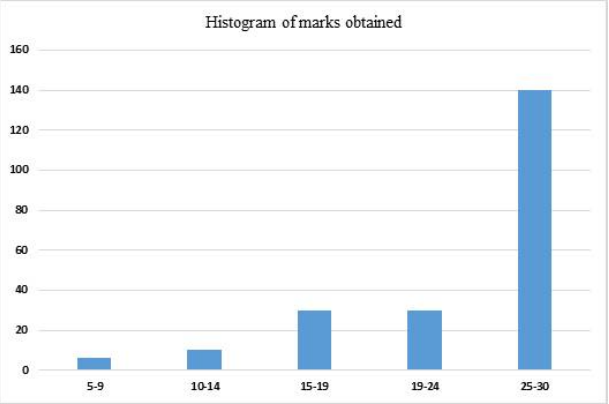

Fig. 6 : Marks obtained by the students.

Table 4 :
Students Feedback on the Course

Questions	Strongly Agree (5)	Agree (4)	Neutral (3)	Disagree (2)	Strongly Disagree (1)	Mean
Antenna design is an interesting subject for me.	130	40	20	8	0	4.47
I find myself eager to learn more about antenna design.	100	60	10	25	3	4.14
Exploring different types of antennas excites me.	80	100	5	12	1	4.24
I enjoy working on antenna simulation and optimization.	75	71	40	8	4	4.02
The idea of creating physical prototypes of antennas sounds interesting to me.	60	40	50	40	8	3.48
I am motivated to understand the principles behind how antennas work.	150	40	0	7	1	4.67
I look forward to the challenges involved in antenna design projects.	70	120	2	4	2	4.26
Antenna design is a subject that I am genuinely passionate about.	20	60	60	40	18	3.03
I find myself researching and exploring antenna - related topics outside of class.	70	115	2	5	6	4.17
I would consider pursuing a career in antenna design or related fields.	24	83	20	60	9	3.19

Conclusion

In this paper, an effective IOVP blended teaching approach used to create the interest on microwave and antenna subject is presented. The effective introduction of the course during the introductory class has ignited a spark in students' interest and motivation. Based on the feedback obtained, it's been clear that students are not only grasping the concepts but also discovering their passion for it. This keen interest not only bodes well for students' academic journey but also for the future of technological advancements in this field.

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