Teaching Case Analysis of Research Feedback Teaching in "Electromagnetic Field and Waves"

Yanhong Xu, Xuhui Fan, Can Cui, Rong Li[a]

College of Communication and Information Engineering, Xi'an University of Science and Technology, Xi'an, Shaanxi, China

[a]9331336@qq.com

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Abstract: Electromagnetic Fields and Waves "is a core foundational course for electronic information majors, which requires students to have a high level of spatial imagination and mathematical foundation.How to enhance students' interest in learning, integrate theory with practice, and use advanced electromagnetic theory as a basis for scientific research to support teaching is the key to this research topic.By analyzing practical cases in the field of electromagnetic fields, students can apply abstract theories to practice.Thus,students can fully understand the physical connotation of electromagnetic fields. In a word, their learning motivation can be stimulated, and their ability to recognize and solve complex engineering problems in the future can be improved.

1. Introduction

Electromagnetic Fields and Waves "is a fundamental course for electronic information majors, providing important support for the development of modern information science.This course is conceptually abstract and highly theoretical, requiring students' spatial imagination and mathematical foundation. It is widely recognized as a difficult to teach and learn course.And with the rapid development of electronic technology, new electromagnetic theories and methods continue to emerge.How to effectively link the teaching of basic theoretical courses with the electromagnetic problems faced in practical engineering is the key to stimulating students' interest in learning and achieving successful teaching of this course.Many key universities at home and abroad have established relevant case libraries for the teaching of this course[1].

In recent years, the "Electromagnetic Field Electromagnetic Wave" teaching team has achieved significant results in many fields such as new system array electromagnetic wave propagation, spatial coupling coding modulation theory, unconventional structure electromagnetic field analysis, and advanced electromagnetic analysis methods based on artificial intelligence algorithms.Our team has made initial attempts to gradually introduce the scientific research results mentioned above into the teaching process.At the same time, by combining other teaching methods, we aim to visualize abstract concepts, physically explain difficult formulas, systematize scattered knowledge, and establish a close connection between theoretical foundations and practical applications.The construction of an advanced electromagnetic theory case library will greatly benefit students in deepening their understanding of the essence of electromagnetic fields and waves. Students can be guided to explore learning and inspire them to think innovatively , thereby their ability to understand and solve complex engineering problems in the future should be enhanced.

2. Traditional teaching methods

1)Traditional teaching

Traditional classroom teaching mainly uses textbooks, blackboard writing, and courseware. For theoretical teaching, long-term teaching of abstract concepts and content will gradually cause students to lose their desire and interest in seeking knowledge, leading to poor classroom teaching effectiveness. Therefore, in the continuous reform of teaching methods and models, this traditional

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and passive teaching model is no longer favored by teachers. But there are also some characteristics in traditional teaching that cannot be replaced and cannot be ignored by new technologies and methods.Textbooks can provide a general overview of theoretical knowledge, and teachers' casual lectures and writing on the blackboard can make the abstract deduction process gradual and clear at a glance. At the same time, this teaching form is also more in line with the laws and habits of human learning[2].

2)Heuristic teaching

Using simple and easy to understand examples to illustrate cumbersome charts in classroom teaching, designing more inspiring questions, and introducing them to encourage students to learn through thinking,their interest in learning can be stimulated.

In addition to constructive heuristic teaching, simple and understandable examples can be used to explain cumbersome charts or concepts. For example, when talking about radio communication, we compare real-life logistics transportation examples to radio communication. Through the analogy of the process of loading transportation unloading, students can be taught to understand the process and functions of modulation and demodulation, and to distinguish and master the three easily confused concepts of modulation wave, carrier wave, and modulated wave.

3)Online teaching

With the rapid development of network technology in recent years, based on platform has become a new trend of teaching, such as XuetangX, Chinese universities, etc. On the one hand, the learning of online courses is not limited by time or location, and students can easily enjoy high-quality teaching resources brought by famous schools or teachers, effectively deepening their understanding and mastery of knowledge points. On the other hand, these high-quality online teaching videos cannot completely solve all the problems in teaching, such as the large number of viewers of online videos, which makes it difficult to effectively communicate and communicate between teachers, students, and students during the teaching process

4)The combination of online and offline teaching

Online or offline has its advantages and disadvantages respectively. teachers attempt to effectively integrate these two teaching modes in the course of "Fundamentals of RF Circuits", so that students can not only enjoy the convenience brought by online teaching, but also enjoy the real and accessible communication experience provided by face-to-face teaching, improving their ability to understand knowledge, self-learning, expression, and collaboration with other students. The teaching group has developed a specific teaching plan using a combination of online and offline methods.

(1) Online section.

In the vast amount of online resources, how to recommend suitable teaching videos for students is the key to the online teaching process. This job requires teachers to pay attention to and watch a large number of online videos, and make targeted choices based on the specific situation of students. Some interdisciplinary and professional students have not taken the introductory basic course of "high-frequency electronic circuits". Therefore, when choosing online courses for these students, they should avoid course resources that require higher knowledge in the communication field. For example, when selecting online teaching video resources for third year students majoring in drones, the author compensates for the students' lack of early communication knowledge by supplementing the "Communication Principles" course with an overview of communication systems at the beginning of the course.When introducing small signal amplifiers, the content on the derivation process of equivalent exchange between hybrid equivalent circuits and parameter equivalent circuits was deleted, in order to reduce the difficulty of students' learning. In summary, the basic principle for selecting online resources is to select content with moderate difficulty based on the requirements of different majors and their training programs.

(2) Offline part.

Traditional teaching methods mainly focus on teachers, textbooks, and classroom teaching. After adopting a combination of online and offline teaching methods, teaching has become an open teaching method that is student-centered and teacher led. In open teaching, teachers cultivate

students' awareness of participation and enhance their self-awareness in learning. In the process of combining online and offline teaching, the teaching design of the offline part is the key to teaching. The author has improved classroom teaching to "classroom teaching topic discussion", abandoning indoctrination teaching and shifting to several small topic discussions, allowing students to rethink the knowledge they have learned. This approach has to some extent deepened students' understanding of the knowledge points. For example, when arranging the teaching of high-frequency power amplifiers, the author first asks students to learn some online videos before class to master some basic knowledge points.In classroom teaching, the main focus is on individual modules.① Consolidate knowledge.Use questioning to help students consolidate the knowledge points of online learning ②Key guidance. When discussing the dynamic characteristics of high-frequency power amplifiers, students can be guided to think about "how to use dynamic characteristics to adjust the equipment if it does not achieve the ideal working state or output results in practical use" .③Throwing a problem.After students have a comprehensive understanding of the knowledge they have learned, questions will be timely raised to guide students to conduct independent analysis and explain their own viewpoints. For example, in two different application scenarios of airborne equipment and ground equipment, students will be guided to discuss the selection principles of conduction angle, and discuss the relationship between efficiency and output power in combination with specific applications. This type of discussion can also be extended to extracurricular activities, allowing students to complete relevant discussion assignments by consulting materials. Regularly conducting such small topic discussions not only helps students develop the habit of active thinking and learning, but also provides them with opportunities to showcase and exercise. By stating viewpoints and debating and communicating with other students, students can improve their comprehensive abilities and cultivate their confidence in overcoming difficulties.

5)combination of theory with practice

“RF Circuit Fundamentals”is a course based on experiments, and most of the theories described in the course need to be verified through experiments. The mastery of circuit experimental knowledge also reflects students' ability to apply theory and practical skills. Therefore, most schools and majors allocate a certain amount of experimental hours when offering this course. The existing hardware conditions and experimental hours in traditional experimental teaching cannot meet all the needs of students for experiments. From years of teaching practice, the course of "High Frequency Electronic Circuits" is closely related to actual circuits. The core content of the course is circuit analysis methods based on circuit and high-frequency theory, derivation of working principles, circuit design analysis and its applicable conditions, constraint rules, approximate ellipsis, etc. It is also a key content that students need to learn and master. However, due to the complexity of high-frequency circuits, many analyses and derivations are based on approximate estimates in specific environments. In actual circuits, adjustments need to be made according to specific circumstances, and the performance characteristics and specific circuit components of the circuit also need to be verified in actual experiments, requiring high flexibility in the experiment. The content of modulation and demodulation is difficult for students to understand, and the annual test paper analysis report also shows that students lose more points in this part of the exam. Therefore, the author encourages students to conduct hands-on verification in teaching, hoping that they can achieve a deeper understanding of knowledge through more emotional means, but it is difficult to achieve in traditional experimental teaching models.

3. Research feeds back teaching

Based on advanced electromagnetic theory, Students' understanding of basic theories can be strengthened by analyzing relevant research cases.The teaching cases proposed by our teaching team include four aspects: new system array electromagnetic wave propagation, spatial coupling coding modulation theory, unconventional structure electromagnetic field analysis, and advanced electromagnetic technology based on artificial intelligence. Using scientific research students'

interest in learning is stimulated.

(1)New system array electromagnetic wave propagation

Starting from the basic principles of frequency diversity, this article systematically elaborates on the spatial electric field distribution of one-dimensional frequency diversity linear array antennas as a function of frequency step, distance, angle, and time.On this basis, for one-dimensional frequency diversity planar array antennas, frequency diversity technology is only applied in the azimuth dimension to conduct spatial electromagnetic characteristic analysis and research of the system. A corresponding three-dimensional beam-forming theoretical model of azimuth elevation distance can be established.The one-dimensional frequency diversity planar array antenna can achieve full spatial beam coverage by combining azimuth frequency diversity beam control technology with elevation phased array antenna technology.

(2)Theory of Space Coupled Coding Modulation

As a type of channel coding technology with performance close to the Shannon limit and low implementation complexity, Low Density Parity Check (LDPC) codes have achieved rich results in the design and application research of various communication scenarios.However, how to theoretically prove the excellent performance of LDPC codes has always been an unsolved problem.As an important branch of LDPC codes, spatially coupled LDPC codes have become a hot topic due to their "threshold saturation" characteristic.Theoretical research has shown that the Belief Propagation (BP) threshold of SC-LDPC codes can reach the Maximum a Posterior (MAP) threshold of grouped LDPC codes.And as the node degree increases, the MAP threshold can reach the Shannon limit, opening up a new way to design codes that can reach the Shannon capacity limit based on the theory of spatial coupling.

(3)Analysis of unconventional structural electromagnetic fields

A template free beam pattern synthesis method is proposed to in terms of the issue of template infeasible settings in beam pattern synthesis. This method aims to maximize the effective illumination efficiency of array antennas in the main lobe region while suppressing strong interference invading from the side lobe region.This method innovates from design criteria and provides a new design approach for beam synthesis.

(4)Advanced Electromagnetic Technology Based on Artificial Intelligence

A encoder decoder based artificial neural network framework is proposed to address the shortcomings of existing array synthesis methods,such as lack of generality and flexibility,high computational burden and low convergence speed,and little consideration of non ideality of arrays and environments.This framework is used to synthesize linear arrays with arbitrary array geometries.In this framework two cascaded artificial neural networks are used as array synthesizers and analyzers,respectively.By minimizing the reconstruction loss between the target and the true radiation pattern,it can obtain array excitations that meet the design specifications.Meanwhile,the proposed framework can consider amplitude only,phase only,and amplitude phase control of array excitation,and achieve fast linear array synthesis under ideal conditions and non ideal conditions considering mutual coupling effects.This framework has high flexibility,generality,and computational efficiency.

4. Innovation

The case selection is based on the latest research results of the national level project of team teachers, introducing academic and cutting-edge elements to enhance the academic quality of teaching.So, students' enthusiasm for learning can be inspired and their innovative thinking can be cultivated.

(1)The case covers relevant content in the interdisciplinary fields of information and communication engineering and electronic science and technology.Transforming high-quality scientific research resources into distinctive teaching resources is very helpful in expanding students' knowledge horizons

(2)Successful cases of scientific research not only have demonstrative value, but also have strong persuasiveness and guidance.Students’ confidence can be enhanced in proposing corresponding

solutions to practical engineering problems by showing the importance of basic professional knowledge .

5. Conclusion

The teachers of this team are committed to using scientific research to support teaching, and the project of transforming scientific achievements into teaching resources case library has clear teaching objectives, distinctive characteristics, feasible research methods, and good promotion value.

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References

[1] Lin Chen,Linhao Huang. Research on the "TAKES" Teaching Methods of the Electromagnetic Field and Microwave Course for Integration and Students [C].Research and Exploration in Laboratory,2024.7:129-135.

[2] Zhi-Li Lin. Exploration and Reflection on the Construction of Excellent Course Relevant to Electromagnetic Theory[C].Education Teaching Forum,2017.4:189-191.