Teaching Strategies and Practices to Enhance Research Data Analysis Skills Among Civil Engineering Graduate Students

Taochun Yang*, Mingqiang Lin, Yongli Li

School of Civil Engineering and Architecture, University of Jinan, No.336, Nanxinzhuang West Road, Jinan, China

*cea_yangtc@ujn.edu.cn

Abstract. In the course on research data analysis and processing for civil engineering graduate students, current teaching practices exhibit limitations, such as a lack of diverse teaching methods and insufficient case studies. These shortcomings hinder the development of students' data analysis capabilities and the quality of research output. This paper proposes innovative teaching strategies and practices aimed at improving students' research data analysis skills. It introduces a hierarchical case library, a diversified teaching approach that integrates theory with practice, and elaborates on the implementation process through specific teaching cases. The results indicate that these strategies effectively enhance students' data analysis abilities and their capacity to address real-world research problems.

Keywords: Civil Engineering; Graduate Education; Data Analysis; Teaching Strategies; Case Library Development.

1 Introduction

With the rapid advancement of technology and the increasing complexity of engineering practices in the field of civil engineering, research data analysis and processing have become indispensable components of graduate education. Civil engineering graduate students must not only possess a solid theoretical foundation and professional skills but also demonstrate strong data analysis abilities to tackle the growing number of complex engineering problems. Data analysis skills are not only a key indicator of research proficiency but also a critical element driving innovation and development in the civil engineering field. [1,2,3]

However, traditional teaching methods [4,5] in the 'Research Data Analysis and Processing' course often leave students struggling to deeply understand the principles and methods of data analysis, and they are unable to effectively apply the knowledge to real-world research projects. This educational shortcoming directly limits the development of students' research capabilities, leaving many ill-equipped to handle complex data, thus impacting the quality and quantity of research outcomes.[1]

D. Hu et al. (eds.), *Proceedings of the 2024 5th International Conference on Modern Education and Information Management (ICMEIM 2024)*, Atlantis Highlights in Social Sciences, Education and Humanities 29,
https://doi.org/10.2991/978-94-6463-568-3_31

Although universities both domestically and internationally have made certain progress in cultivating graduate students' data analysis abilities, there are still notable research gaps and pressing issues that need to be addressed. Firstly, existing teaching methods tend to focus excessively on the imparting of theoretical knowledge, neglecting the importance of practical teaching. This results in students struggling to flexibly apply what they have learned when confronted with actual research data. Secondly, there is a scarcity of teaching case resources, particularly those closely related to the field of civil engineering, which limits students' in-depth understanding and mastery of data analysis skills. Lastly, the absence of a scientific, systematic, and effective teaching strategy to comprehensively enhance graduate students' research data analysis abilities has impacted the quality and quantity of their research outputs.

Therefore, exploring effective teaching strategies to enhance the research data analysis skills of civil engineering graduate students is of paramount importance. This paper aims to analyze the current problems in teaching, align with the actual research needs in civil engineering, and propose a set of effective teaching strategies. The specific objectives are to provide students with comprehensive and systematic learning resources, ranging from basic to advanced levels, through the construction of a hierarchical case library. Additionally, by adopting diversified teaching methods that integrate theory with practice, the aim is to strengthen students' ability to apply theoretical knowledge to solve practical research problems. These strategies are designed to help students better master data analysis skills, improve their research literacy, and lay a solid foundation for future academic research and professional development. The findings from this study offer new ideas and methods for graduate education in civil engineering, promoting the enhancement of teaching quality and research standards.

2 Current Situation Analysis

From a global perspective, the cultivation of data analysis skills has become a focal point in graduate education. In Western countries, especially in developed nations like the United States and the United Kingdom, there has been a long-standing emphasis on systematically enhancing graduate students' data analysis skills. Universities in these countries have successfully improved students' data analysis capabilities and research innovation abilities by offering dedicated data analysis courses, building comprehensive case libraries, and incorporating advanced data analysis tools and techniques. Their experience demonstrates that integrating data analysis skill development throughout the entire graduate education process is crucial for advancing academic disciplines and improving the overall quality of graduate education.

The recent years have seen research on data analysis teaching strategies expand beyond the realm of civil engineering, encompassing disciplines such as medicine, economics, computer science, and more [9,10]. Studies have revealed that effective data analysis teaching strategies commonly share several key features: firstly, they underscore the significance of case-based teaching, incorporating real-life research or engineering cases to enable students to grasp data analysis skills while solving specific

problems. Secondly, they prioritize the tight integration of theory and practice, enhancing students' practical abilities through a variety of instructional formats, including classroom lectures, experimental operations, and software applications. Thirdly, they emphasize the blend of autonomous and collaborative learning, encouraging students to proactively explore learning resources and collaborate in teams to accomplish tasks, thereby fostering independent thinking and teamwork skills. Notably, in fields like economics and computer science, the introduction of big data analysis techniques and advanced data analysis software has significantly bolstered students' data analysis capabilities and innovative thinking. The successful application of these strategies in other disciplines offers valuable insights for data analysis teaching in civil engineering, highlighting the importance of incorporating modern information technology and leveraging advanced technological tools to enhance teaching outcomes.

In China, with the advent of the big data era and the progress in 'Double First-Class' university initiatives, more and more cilvil engineering institutions are prioritizing the development of graduate students' data analysis abilities [1,3,6]. In recent years, research on fostering these skills has increased, focusing on curriculum development, teaching method innovation, and the creation of practical platforms. Among these, case-based teaching has gained widespread application in data analysis courses as an effective pedagogical method [7,8]. By introducing real engineering cases, students can master the principles and methods of data analysis through problem-solving, which not only enhances their interest and engagement but also significantly improves their practical and innovative abilities.

Furthermore, the integration of theory and practice in teaching strategies has also played a crucial role in developing data analysis skills among graduate students [2,5]. Some civil engineering universities have adopted teaching models that combine theoretical instruction with experimental teaching, allowing students to not only grasp theoretical knowledge but also engage in hands-on data analysis practices. This approach deepens their understanding and retention of theoretical concepts. At the same time, teaching that incorporates modern data analysis software and techniques enables students to keep pace with industry developments, mastering cutting-edge tools and methods.

However, despite the progress made in cultivating graduate students' data analysis abilities, significant challenges remain. On one hand, the course offerings in data analysis at some universities still lack comprehensiveness and specificity. On the other hand, the implementation of case-based teaching and the integration of theory with practice face several challenges, such as insufficient case resources and limited practical teaching conditions. These issues restrict the further enhancement of students' data analysis skills.

Based on the above analysis, this study aims to explore a more scientific, systematic, and effective teaching strategy by deeply examining the current issues and challenges in teaching. Specifically, the study will focus on the implementation paths and evaluation mechanisms of key strategies, such as the development of a hierarchical case library and the adoption of diversified teaching methods that combine theory and practice. The goal is to provide robust support for enhancing the research data analysis skills of civil engineering graduate students. Additionally, this study will address the gaps in

existing research, offering suggestions for improvement and directional insights for future research.

3 Construction of a Hierarchical Case Library

3.1 Case Library Structure Design

The construction of the 'Research Data Analysis and Processing' case library follows the principle of progressing from basic to advanced levels in a step-by-step manner. It is divided into three tiers: Basic Visualization, Intermediate Theory, and Advanced Application. Each level contains multiple specific cases to ensure comprehensive coverage of the entire process from basic graphical representation to complex data analysis.

- Basic Visualization: This level focuses on the basic graphical representation and interpretation of research data. It includes two cases: 'Graphical Representation and Visualization of Civil Engineering Research Data' and 'Study on the Deformation Process of Building Structures under Wind Load Based on Experimental Data.' Through these cases, students gain an initial understanding of graphical representation methods in data analysis, laying a solid foundation for subsequent data processing.
- Intermediate Theory: This level aims to equip students with the fundamental theories and methods of research data analysis. It includes five cases, such as 'Curve Fitting and Application of Reflective Shock Wave Overpressure Variation with Incident Overpressure' and 'Discrete Data Distribution Characteristics of Wheel Pressure on Road Bridges.' These cases cover various data processing techniques like variance analysis, regression analysis, and curve fitting, helping students grasp the statistical principles and physical significance underlying the data.
- Advanced Application: This level focuses on applying data analysis to complex research problems. It includes five advanced cases, such as 'Analysis of Hysteresis Curves and Skeleton Curves of Concrete Beam-Column Joints under Seismic Action' and 'Experimental Data Analysis of Reinforced Concrete Beams under Drop Weight Impact Based on Origin Software.' These cases involve real-world problems in civil engineering, requiring students to apply multiple data analysis skills to solve complex issues, thereby enhancing their research innovation capabilities.

3.2 Case Content and Methods

Each case is meticulously detailed, outlining its specific content, the primary theories involved, and the processing techniques used. For example, in the case 'Curve Fitting and Application of Reflective Shock Wave Overpressure Variation with Incident Overpressure,' students learn how to establish functional relationships between variables using multi-parameter curve fitting methods after obtaining experimental data, and conduct quantitative analysis and application. By studying such cases, students not only master specific data processing methods but also deeply understand their application value in actual research.

3.3 Features and Innovations of the Case Library

To achieve the desired educational outcomes, the construction of the course's case library should emphasize the following features and innovations:

1. Practicality: All cases in the library are closely related to real-world problems in civil engineering, ensuring that students can apply what they learn to solve practical issues, thereby enhancing their problem-solving abilities.
2. Frontier Relevance: The case content keeps pace with the latest developments in the field, introducing the most recent theories and methods in data analysis, helping students stay aligned with industry trends.
3. Interdisciplinary Integration: The case library encourages the integration and application of interdisciplinary knowledge, cultivating students' comprehensive analytical skills.
4. Innovation and Flexibility: The hierarchical case library design provides flexibility, allowing students to gradually advance from mastering basic techniques to solving complex research problems.

4 Comprehensive Teaching Methods

4.1 Theory-Practice Integration

The teaching strategy adopts a theory-practice integrated approach, emphasizing the connection between theoretical knowledge and practical application. This is achieved through combining classroom lectures, laboratory sessions, and fieldwork. By alternating between theory and practice, students can immediately apply the concepts they have learned, reinforcing their understanding and retention.

4.2 Diversified Teaching Techniques

To cater to different learning preferences and enhance engagement, the course employs diversified teaching techniques, including multimedia presentations, group discussions, and hands-on experiments. These methods promote active learning, collaboration, and critical thinking, enabling students to approach problems from multiple angles.

4.3 Assessment and Feedback Mechanism

The course integrates a continuous assessment and feedback mechanism, where students' progress is monitored through various forms of evaluation, such as quizzes, project reports, and peer reviews. Regular feedback is provided to help students identify their strengths and areas for improvement, guiding them towards achieving better learning outcomes.

5 Conclusion

The study presented in this paper underscores the importance of enhancing research data analysis skills among civil engineering graduate students. By constructing a hierarchical case library and adopting a comprehensive teaching strategy that integrates theory with practice, the course effectively addresses the current gaps in teaching. The proposed strategies not only improve students' data analysis capabilities but also equip them with the skills necessary to solve complex research problems in civil engineering. Moving forward, these findings can serve as a reference for further improving graduate education quality and research standards in the field.

Acknowledgements

The study was supported by Shandong Province Professional Degree Graduate Case R epository Construction Project (2021, SDYAL21119;2022, SDYAL2022103). Any op inions and conclusions expressed in this paper are those of the writers.

References

1. Liu Chenhui, Xie Yao. Research on cultivating data analysis ability of graduate students majoring in transportation engineering based on "promoting learning through competition and promoting application through learning" [J]. Journal of Higher Education, 2024, 10(19): 88-91.
2. LUO Xia, WANG Wenping, CHEN Xiang; Fujian University of Technology. Research on Embedded Teaching Reform of Data Literacy for Graduate Students Majoring in Civil Engineering [J]. The Guide of Science & Education, 2023, (29):39-41.
3. Wei Hui, Yuan Ziyang. Thoughts on improving the data processing capabilities of road engineering professionals [J]. Science and Technology Wind, 2023, (01): 13-15.
4. Hou Xiangyang, Wang Xiao, Department of Chemistry and Chemical Engineering; Yan'an University. Research and Exploration on Classroom Teaching of Experimental Design Analysis and Data Processing [J]. Guangdong Chemical Industry, 2019, 46(15): 225-226+228.
5. Feng Lichao, Liu Chunfeng, Yan Shaohong, et al. New discussion on the teaching model of "Mathematical Statistics" for graduate students in the era of big data [J]. Science and Technology Innovation Herald, 2017, 14(34):153-154.
6. YANG Yue, ZHANG Meili, QIN Qiong; Department of Basic Sciences; Dalian Naval Academy. On Mathematical Statistics Teaching Reform Based on Data Analysis Ability Training of Postgraduates[J]. Studies in College Mathematics, 2023, 26(04):111-114.
7. Ding Changjiang, Song Zhiqing, Chen Hao, et al. Teaching reform and practice of "Experimental Design and Data Analysis" course based on scientific research drive [J]. Science and Technology Wind, 2024, (15): 129-131.
8. Huang Xianying, Liu Chao, Lu Ling. Exploration research on the construction and case design of case database for professional degree graduate students - taking the direction of big data analysis as an example [J]. Industry and Information Technology Education, 2021, (09): 91-94.

9. Zeng Zhuanping, Liu Xudong, Liu Li, et al. CONSTRUCTION AND EVALUATION OF CASE LIBRARY FOR MEDICAL RESEARCH DATA MANAGEMENT AND ANALYSIS [J]. Big Data Time, 2024, (06): 66-71.
10. Zhang Jingyi. Reform of Practical Teaching in College Financial Accounting Majors under the Background of Big Data [J]. Time-Honored Brand Marketing, 2024, (16): 228-230.