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Case Library Construction and Teaching Reform Practice of Advanced Fluid Mechanics Course

Zhou Hongyi, Cao Zhengzheng*, Lin Haixiao, Cheng Liangyan
School of Civil Engineering, Henan Polytechnic University, Jiaozuo 454003, Henan, China
**Corresponding Author*

Abstract: Aiming at the problem of integration of theory and practice and shortage of case resources in advanced fluid mechanics course teaching, this study proposed and implemented the construction of course case base and its application in teaching reform. Based on the newly constructed case base, the research carried out a case-driven teaching reform practice, integrating practical engineering cases into classroom teaching, strengthening students' understanding of the theory of convection and improving their innovative thinking and practical ability. Through the quantitative evaluation and feedback analysis of the teaching effect, the validity and practicability of the case base construction and teaching reform strategy of advanced fluid mechanics course are confirmed, which provides an important practical reference and theoretical basis for the improvement of the teaching quality of fluid mechanics course in engineering education in China.

Keywords: advanced fluid mechanics, case library construction, teaching reform practice

1. Introduction

In the current background of higher engineering education, fluid mechanics, as a core course, is of great importance for cultivating engineering students' theoretical literacy and practical innovation ability [1,2]. However, in practical teaching, how to effectively combine profound theoretical knowledge with practical engineering applications and how to solve the problem of lack of case resources have become the key challenges restricting the improvement of the teaching quality of this course[3,4]. In order to cope with this situation, this study is committed to exploring and implementing a new teaching reform mode of advanced fluid mechanics curriculum, that is, by constructing a comprehensive, scientific and representative curriculum case base, and integrating it into classroom teaching practice.

Based on the newly constructed case base, this study carried out the case-driven teaching reform and deeply integrated practical engineering cases into classroom teaching, aiming to strengthen students' understanding and application of theoretical knowledge of convection and stimulate their innovative thinking and practical operation skills. Through the quantitative evaluation and feedback analysis of teaching effect, the validity and practicability of case base construction and teaching reform strategy of advanced fluid mechanics course are confirmed.

2. Case Library Construction of Advanced Fluid Mechanics

(1) Definition and significance of case base

Advanced fluid Mechanics Case database is a collection and collation of cases in the field of advanced fluid mechanics, which contains a variety of real or simulated fluid mechanics problems and their solutions, application scenarios and experimental data and other information. These cases can cover knowledge in various areas of fluid mechanics, such as fluid dynamics, turbulence, radiative heat transfer, etc., as well as applications in different engineering and scientific fields, such as aerospace, energy, environment, etc.

The construction of advanced fluid mechanics case database is of far-reaching significance and multi-dimensional [5]. At the level of education and teaching, case library, as an important auxiliary tool for advanced fluid mechanics education, can combine abstract and complex theoretical knowledge with specific realistic situations, help students to deeply understand and effectively apply the principles of fluid mechanics, and improve their ability to solve practical engineering problems. In terms of academic exchange and cooperation, the case library provides a broad space for teachers, researchers and engineers in the field of fluid mechanics to clash ideas and learn from experience, and promote cooperation and knowledge innovation within and across disciplines. In terms of scientific research reference value and engineering practice guidance, the case database provides an effective reference for the verification and development of fluid mechanics models and theories, and is also a treasure house for solving practical engineering challenges, providing engineers and designers with successful solutions and references for optimizing engineering design processes.

To sum up, the construction and continuous update of the advanced fluid mechanics case base plays a key role in education, teaching, academic exchanges, scientific research and engineering practice, and has great

strategic significance and practical value in promoting the development and progress of the whole fluid mechanics discipline and expanding its practical application fields.

(2) Case selection

In the process of constructing the case base of advanced fluid mechanics course, case selection is a crucial task, whose quality and comprehensiveness directly affect the practical value and teaching effect of the case base. Reasonable case selection aims to cover the core theories, typical phenomena and a wide range of application fields of fluid mechanics, so as to ensure that the case base can meet the diverse needs of teaching and research practice.

This article takes the Boeing 737Max aircraft crash as an example: In 2018 and 2019, two major aviation accidents occurred on Lion Air Flight 610 in Indonesia and Ethiopian Airlines Flight 302, respectively, resulting in a large number of casualties. An exhaustive investigation revealed that the common thread between the two tragedies was a serious design flaw in the Maneuvering Characteristics Augmentation System (MCAS), a key autopilot feature on the Boeing 737 Max. Its failure to fully consider and accurately adapt to the aerodynamic characteristics of the aircraft caused the aircraft to malfunction and lose control under certain flight conditions.

Aiming at this core problem, the key role of aircraft aerodynamic design is deeply discussed. Advanced fluid mechanics knowledge points out that the aerodynamic design of an aircraft covers the shape optimization and surface treatment of various parts of the structure from the wing, fuselage to the tail, as well as the aerodynamic performance of these components at different speeds, altitudes and angles of attack. These complex aerodynamic interactions are critical to the overall stability and handling quality of the aircraft.

Further focus on the working principle of MCAS system, which is designed to automatically adjust the position of the horizontal stabilizer by perceiving the attitude information of the aircraft in real time to enhance the maneuvering performance of the aircraft and prevent the stall. However, due to the inaccuracy of the prediction of the complex aerodynamic characteristics of the aircraft during the design phase, the MCAS system failed to accurately judge the risk of the aircraft stall under certain flight conditions, resulting in the incorrect adjustment of the aircraft's control surface, which in turn caused the aircraft to lose effective control.

Therefore, the Boeing 737 Max accident underscores the critical importance of comprehensive and accurate consideration of aerodynamic characteristics in the design process of modern aircraft. The application value of advanced fluid dynamics analysis in the field of aircraft design and flight safety has been significantly demonstrated. Through detailed and in-depth research on the aerodynamic characteristics of the aircraft, combined with the analysis of the working mechanism of the flight control system, it can effectively prevent the recurrence of similar accidents and effectively improve the overall flight safety level.

3. Teaching Reform Practice of Advanced Fluid Mechanics

(1) Analysis of current situation and problems of teaching mode

Fluid mechanics, as a basic and widely used science subject, has been taught in universities for quite a long time. However, the existing teaching mode mainly follows the traditional three-stage teaching structure of "pre-class preview - classroom teacher teaching - after-class teacher review". Although this mode ensures the systematic transfer of knowledge to a certain extent, it gradually reveals some limitations and deficiencies.

First of all, under this mode, students' learning process is often characterized by passive acceptance. In the preview stage, they mainly have a preliminary understanding of the content of the textbook, while in class they mainly listen to the lecture. After class, homework and tests are mostly to reproduce and consolidate the content of the classroom. It may lead to students' ability to actively think and explore problems can not be effectively exercised and improved.

Secondly, this model lacks effective design to stimulate students' enthusiasm for learning. Fluid mechanics is a subject with strong practice and broad application fields, but in the current teaching practice, the combination of theory and practice is not close, and students' participation and sense of experience are relatively low, which is difficult to arouse their interest and enthusiasm for in-depth exploration.

Moreover, the existing teaching mode is not enough to cultivate students' practical ability. Practical activities such as fluid mechanics experiment and simulation calculation are the key ways to understand and master the essence of this discipline. However, under the current model, these practical links have not been fully paid attention to and effectively integrated, resulting in a certain degree of disconnect between students' theoretical knowledge and practical operation.

To sum up, in view of the above problems existing in the teaching of fluid mechanics, it is urgent for us to innovate the teaching model and introduce more diversified teaching methods such as active learning, project-driven and practical operation into the course design, so as to better stimulate students' learning interest and improve their practical and innovative ability. Finally realize the overall improvement of fluid mechanics teaching quality.

(2) Teaching reform concept and practice based on case teaching

The teaching reform concept and practice of case-based teaching is highly respected in the current education field, especially for the discipline of fluid mechanics, which is closely linked with theory and practical application, and has significant innovation value and promotion significance.

First of all, the introduction of case teaching method in the course of fluid mechanics can effectively change the traditional teacher-centered knowledge infusion mode. Students are no longer just passive recipients, but through the process of analyzing concrete engineering examples and solving practical problems, they take the initiative to build and improve their own knowledge system, and improve their ability to understand and apply the principles of fluid mechanics. This makes the learning process more lively and interesting, and helps to stimulate students' enthusiasm and commitment to the content of the course.

Secondly, case teaching emphasizes the combination of theory and practice, which can integrate abstract and complex fluid mechanics theories into intuitive and concrete cases, so that students can deepen their understanding and enhance their ability to solve problems in the process of case analysis. For example, through the study of wind tunnel experiments, dam design, aircraft wing aerodynamic characteristics of the case, students can more deeply understand the basic law of fluid flow and calculation methods in practice.

In addition, case teaching can develop students' teamwork and communication skills. In the process of discussing and analyzing cases, students need to exchange ideas and share experiences with each other, which is not only conducive to the formation of a good academic atmosphere, but also exercises the spirit of cooperation and practical skills they need in future work scenarios.

In summary, the teaching reform based on case teaching plays an important role in promoting the optimization of the teaching mode of fluid mechanics courses.

(3) Teaching effect evaluation

In order to grasp the effect and existing problems of the teaching reform practice of the advanced fluid mechanics case base, a "Questionnaire on students' course Recognition" was prepared[6]. The survey objects were grade 22 undergraduates in the School of Civil Engineering, Henan Polytechnic University, and the number of respondents was 96. The questionnaire was distributed before and after the case and collected statistics respectively. The questionnaire includes the following questions: (1) Not only master professional knowledge, but also put it into practice; (2) Meet the basic requirements for course credits, but not more in-depth study (meet the requirements); (3) Attach importance to course results (attach importance to grades); (4) Disinterest (indifference) in the course. In the beginning stage of the course, students generally reflected that the theory of fluid mechanics had high abstractness, and there was a certain cognitive difficulty in understanding and grasping it deeply, and some students even showed a lack of interest in the course content. However, after systematic teaching practice, students' knowledge grasp has been significantly improved. They have a deeper cognition and understanding of fluid mechanics principles, which were originally thought to be abstract and complex, and gradually internalize them as part of their academic literacy, which provides a solid foundation for subsequent engineering practice activities. Through the collection and analysis of teaching feedback data, we found that with the deepening of the course, students' recognition of the course of convection physical science showed an obvious upward trend. Specifically, the statistical results of the understanding degree, application ability and interest stimulation of the knowledge of convection physicsall show positive changes. The chart directly reflects the students' attitude change and ability improvement in the process from their initial knowledge of fluid mechanics to in-depth exploration, and further verifies the effectiveness of the teaching reform measures of this course in improving students' acceptance and learning effect of the course of fluid mechanics.

To sum up, although students' cognition of convection mechanics was abstract and difficult in the early stage, the implementation of targeted teaching strategies and methods successfully guided students to overcome cognitive barriers, realized the effective transformation of convection physics knowledge from simple to deep, from theory to practice, and finally significantly improved the knowledge recognition and learning effectiveness of the whole curriculum group.

4. Conclusion

The establishment and application of fluid mechanics case base for teaching can significantly improve students' ability to understand and analyze complex fluid flow phenomena, and cultivate students' practical and innovative ability to solve problems by using fluid mechanics principles from practical problems. At the same time, the case teaching method promotes classroom interaction, stimulates students' learning interest and initiative, and is conducive to developing teamwork and critical thinking skills. However, case base construction and teaching reform is not an overnight process, it needs to be continuously optimized and perfected. For example, the selection of cases should follow the forefront of scientific and technological development, reflect the characteristics of interdisciplinary and engineering application; The teaching methods should be flexible and

varied, and the modern information technology means should be used to improve the teaching effect. The evaluation system should also pay attention to process assessment, and comprehensively evaluate students' knowledge mastery and practical operation skills. To sum up, the case base construction and teaching reform practice of advanced fluid mechanics course is a systematic project, which is of great significance for improving teaching quality and training innovative talents meeting social needs, and is worthy of further research and promotion.

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