



Hydrodynamic Numerical Calculations Case Design as Teaching Reform

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INTRODUCTION

With the rapid development of China's shipbuilding industry, the requirements vis-à-vis profile design, performance prediction, and safe navigation have become more stringent. The shipbuilding industry is an important force in the national defence construction, which protects the national maritime homeland security. In addition, the shipbuilding industry also plays an important role in promoting the export of foreign exchange and the development of foreign trade. As one of the main modes of transportation of goods, ships can transport goods from all over the world back to China, and also transport domestic goods to all countries in the world.

After years of development, China's shipbuilding industry has made great progress in all aspects. China's shipbuilding industry has become an important part of the international shipbuilding industry, with sufficient international competitiveness. Therefore, ship practitioners with sufficient professional ability are conducive to the development of the ship industry.

The professional knowledge required by China's shipbuilding industry includes mathematics, mechanics and design principles of ship and ocean engineering. Among them, ship hydrodynamics plays a very important role in the professional knowledge of the ship industry. Hydrodynamics is a branch of mechanics, and its teaching purpose is to study the laws of motion of water and other liquids and their interactions with the boundary. Hydrodynamic calculation is developed in practice, and it has been applied in all aspects of life and industry, such as ship industry, machinery manufacturing, hydropower engineering and petrochemical industry.

For the staff in the shipbuilding industry, it is an indispensable skill to be able to calculate the corresponding values by using hydrodynamics theory and method. The correct prediction of the relevant data calculated by simulation can effectively improve various performance of the ship. This is particularly significant for the teaching of hydrodynamic numerical calculations. As a major course of China's educational industry, hydrodynamic numerical calculations course is established in university to introduce the distinction of ship types and development of shipbuilding technology for college students. In real practice, numerical calculation technique can integrate advanced technology between military products and civil products, so that it shows a significant application in national marine engineering. In the status quo teaching process in China, there are problems such as strong professionalism, an emphasis on abstract concepts, and considerable separation from the practical applications of classroom teaching (Liu et al., 2022). Students frequently report that their courses are difficult and boring.

In the previous course of hydrodynamic calculation, teachers mainly teach formula theorems and their derivation process. Although students can sort out and recite the knowledge they learned in class, they have no way to start once they encounter practical problems. Therefore, we should change the singleness of traditional teaching and combine theory with practice to strengthen the cultivation of students' comprehensive abilities. Theory and practice are closely related and cannot be separated in any way. Despite the close relationship between theory and practice, the conflict between theory and practice has always existed. There has been a debate about the importance of theory and practice. The combination of theory and practice is one of the universal methods of human cognition or learning activities, and is a criterion that must be followed in teaching activities. A large number of educators and philosophers have theoretically discussed this requirement. In ancient China, Xun Kuang once

said, "If you simply learn knowledge but don't practice, you will encounter difficulties when you finish learning and apply it. Only in practice can we truly understand knowledge."

However, in ancient times, books were seriously divorced from reality because of social customs and people's actual ideas. At that time, people only focused on rote memorization of book knowledge, but ignored the application of book knowledge. Eventually, the knowledge learned could not be applied in practice, and people quickly forgot the knowledge gained from theoretical learning.

In modern teaching, there is also a problem that the learning content of the course is separated from the practical application. In order to solve this problem, teachers need to combine examples with the knowledge in the book in teaching process (Gutierrez and Zamora, 2015). The teaching of combining examples with theory should be guided by learning basic knowledge, and students could understand knowledge from the connection between theory and practice. Teachers should pay attention to using knowledge to analyse and solve problems, this can help students to learn associate with reality through examples, understand the relationship between knowledge points, and develop a good learning attitude. First of all, teachers should consider whether the examples selected in the teaching process are related to the knowledge of this teaching. Then, flexible use of multiple ways to show examples, such as multimedia or actual operation. Only by closely combining examples with theories can abstract book knowledge be easily understood by students. Every time students review the theoretical knowledge, they will think of examples related to theoretical knowledge, so that theoretical knowledge can be fully mastered by students. In addition, teachers should pay attention to students' ability to use knowledge. Students should not simply watch the demonstration of examples, but operate on them if conditions permit. In ordinary courses, teachers can improve students' ability to use knowledge through classroom tests, surveys and group reports (Guo and Sun, 2021).

At the same time, in order to meet the demand for technical talents, the school has strengthened the intensity of training students' professional skills, which has led to the continuous reduction of the class hours of basic theory courses such as hydrodynamics. Teachers need to highlight the key and difficult points of the course in the limited teaching time, and complete the teaching task of the course with high quality, which urges teachers to improve the teaching method of classroom teaching. As a new teaching mode, case teaching can effectively shorten book content through animation demonstration and scene assumption, which combine the theoretical knowledge of fluid mechanics with students' majors and flexibly quote practical examples from the perspective of teaching content and improving teaching methods (Ma, 2020; Zhu, 2021; Ma et al., 2020). The case teaching can lay a good foundation for students to learn subsequent professional courses. It is worth noting that case teaching

refers to the teaching method of applying cases to teaching and improving students' theoretical level and practical ability. The professional textbooks for undergraduates in colleges and universities are the basis for teachers to teach. The quality of the professional textbooks directly affects teachers' classroom effect and students' learning effect. Therefore, choosing suitable cases as teaching content is the key to improve teaching quality (Sholiah et al., 2020). After the development for many years, case teaching has been successfully applied to many disciplines such as business, economics, medicine and engineering. The United Nations Educational, Scientific and Cultural Organization once conducted a survey on case teaching. The statistical results show that the case teaching method ranks first in terms of improving students' theoretical level and practical ability. In fact, case teaching method has become a very widely used teaching method in China's higher education.

Traditional teaching only imparts theoretical knowledge for students. Its content may not be practical in practice, which to some extent damages the enthusiasm and learning effect of students. However, in case teaching, no one will tell students what to do. We guide students to think and create by themselves, making boring courses lively. In the later stage of case teaching, each student should exchange ideas and discuss with other students. Through this exchange of experience, students can learn from each other and improve their interpersonal communication ability (Supriana, 2019). In response to the above problems, and drawing on my own years of teaching experience, I propose a new pedagogical model for the teaching of hydrodynamic numerical calculations through case design. By using specific cases I have sought to bring theory and practice together. The model is simple, and abstract concepts are presented as experiments to help students better understand and benefit from the course.

CASE DESIGN

Typical case design

We typically start from basic concepts, formulae, and fluid mechanics principles, combined with ship structure design, to solve practical engineering problems such as hull-line optimisation and hydrodynamic performance prediction. The case design incorporates computational fluid dynamics (CFD) technology to visualise the flow field of a ship's motion in the form of a simulation, allowing students to experience the evolution of water flow and the use of hydrodynamics through direct observation.

In designing a typical case study, the use of CFD technology to predict the sailing resistance of a KCS ship type was chosen as a teaching example. This case is very close to the textbook content and is based on the detailed introduction of the design of a real ship, ensuring the realism and typicality of the case. The hydrodynamic theory and numerical simulation methods involved in the case echo the classroom teaching and avoid the theory being detached

from the reality. The content of the cases covers a number of typical marine disciplines such as profile design, 3D geometric modelling, mesh generation, hydrodynamic simulation and drag prediction. The course also makes use of modern simulation software as a training tool, so that the case studies do not lag behind the development of the subject, ensuring that the teaching content is up-to-date and that the skills learned by the students can meet the future job requirements and social needs.

Introduction of case demonstrations

The use of audio-visual technology such as picture display, sound play and animation demonstration can not only significantly improve the effectiveness of classroom teaching, but also increase students' interest and encourage them to participate more actively in classroom interaction (Zhong and Wang, 2017). Taking the use of CFD technology to predict the resistance of a KCS ship model as an example, the introduction of a demonstration function to this case can more effectively solve the problems encountered by students in the learning process, as shown in Figure 1. For example, if the boundary layer concept is difficult for students to understand, they can draw the boundary layer in CFD software based on KCS ship parameters so that they can observe boundary layer separation in detail. If students are not sure how the hull profile affects the change of drag, they can analyse the principle of drag reduction by observing the flow line and comparing the movement of the water after it passes through the hull shell.

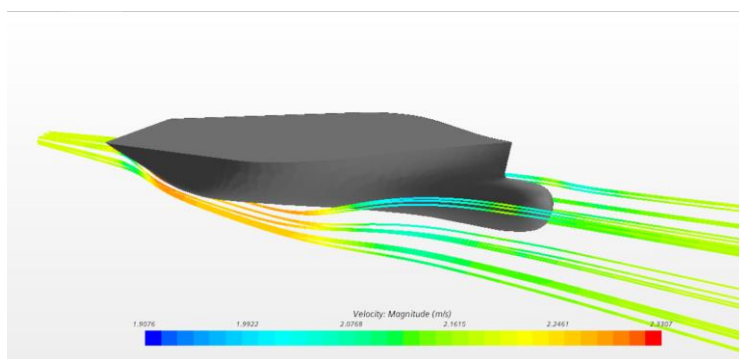


Fig. 1. Case demonstration.

In traditional classroom teaching, some conceptual or phenomenal knowledge points can only be illustrated by simple diagrams, resulting in a rather rigid understanding, with learning seriously affected by individual differences (Zhang et al., 2020). The introduction of case demonstrations can effectively solve such problems, giving full play to the efficiency of case teaching, drawing theoretical knowledge into engineering practice and helping students to learn. Through case presentations, the teacher enables students to form a preliminary understanding of the main points of this course, which allows them to understand theoretical formulae and abstract concepts more easily in the subsequent learning process, greatly enhancing learning efficiency. Students consolidate their foundation and deepen their

understanding and are able to assimilate new knowledge points quickly. Figure 2 shows a comparison of the effectiveness of the case design teaching model with the traditional teaching model, where 'good' is 5, 'moderate' is 3 and 'poor' is 1.

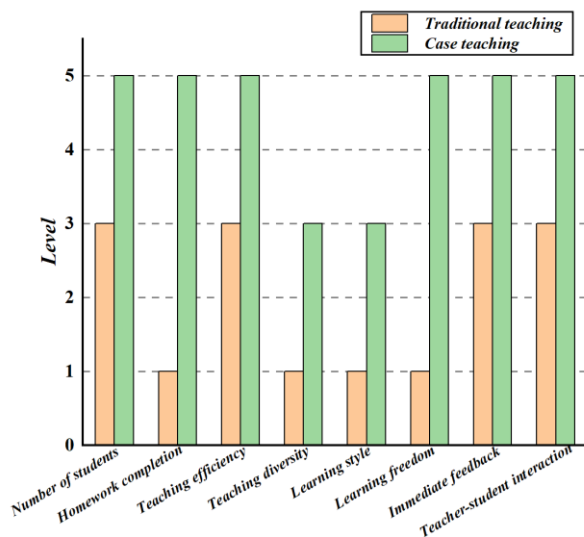


Fig. 2. Comparison between the traditional teaching model and the case teaching model.

As can be seen from Figure 2, the teaching model using case design has greater advantages than the traditional model, especially in terms of learning freedom and homework completion. Case design teaching mobilises students' enthusiasm and allows them to participate more actively in the classroom; the homework completion rate is also higher. This suggests that case study teaching promotes student interest in content and encourages them to actively complete their assignments, thus enriching their knowledge base rather than causing them to treat the completion of assignments as a mere chore.

Reform of the assessment process

The purpose of course assessment is to check students' theoretical knowledge and mastery of practical skills. For a long time, course assessment in most universities has been through a final examination, in which students achieve their final grade through a 100-minute test. Sometimes there are courses with an additional laboratory course assessment, which results in an overall grade. Such an assessment does not really develop students' practical skills or their ability to solve practical problems. The hydrodynamics numerical calculations course is characterised by both theoretical and practical components, so that assessment methods are different to those in theory-oriented courses. In addition to the traditional assessment items, class discussions and quizzes have been added. The grade ratios are allocated as follows Table 1.

Table 1. Grade ratio distribution for hydrodynamics numerical calculations course.

Attendance	Experiments	Homework	Class discussions	Quizzes	Final examination	Total points
10%	10%	10%	10%	20%	40%	100%

Total student score after the implementation of case design teaching for the 2019-2020 and 2020-2021 semester is set out in Figure 3 and Figure 4. A total of 34 students took the examinations in the 2019-2020 semester and 32 passed, representing a 94% pass rate. A total of 39 students took the examinations in the 2020-2021 semester and 36 passed, representing a 92% pass rate. Score in both academic years follows a normal distribution pattern, and the assessment results are satisfactory.

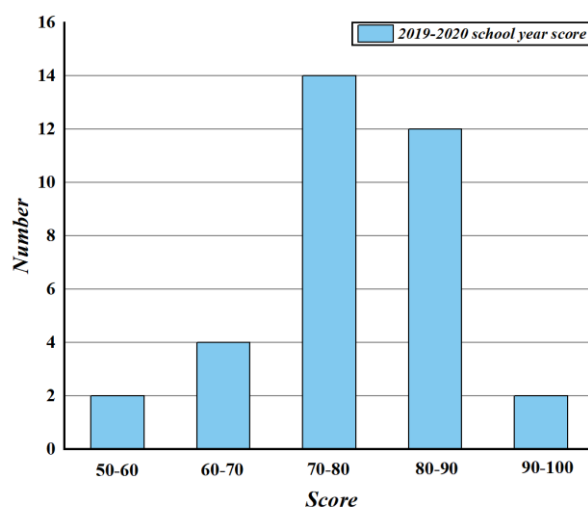


Fig. 3. Total student score in the 2019-2020 semester.

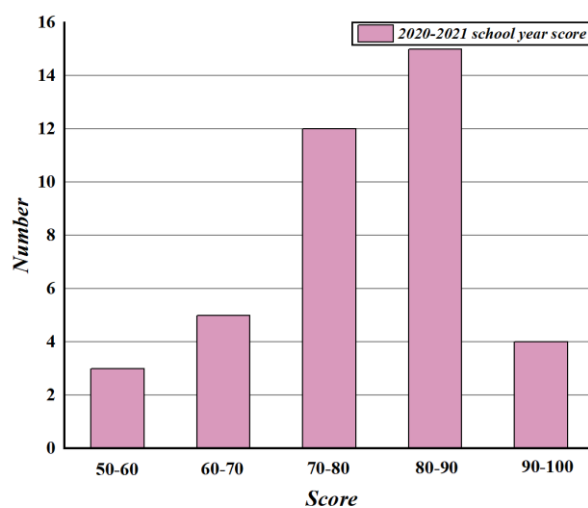


Fig. 4. Total student score in the 2020-2021 semester.

KEY KNOWLEDGE OF CASE DESIGN

Basic fluid mechanics equations

Theoretical knowledge is the most essential element of case study teaching and is the key to students' mastery of the course essentials. In contrast to the traditional teaching philosophy, case study teaching introduces theory with more emphasis on practical integration, and for marine courses, the theoretical approach requires a more applied and concrete presentation. Therefore, in the process of implementing case study teaching, the basic theory of fluid mechanics and CFD control equations are combined to avoid any disconnection between theory and application, while the control algorithm is revealed to students with the help of computer software, making it easier to understand.

Considering the complexity of numerical calculations, it is not appropriate to choose a more theoretical formula for teaching. Before the computer practice, teacher need extract the formula involved in the simulation and explain it to the students, which can strengthen the impression of students. Students will come across these formulas again when they use CFD technology, and they can quickly understand the definition of parameters. Especially when the calculation is completed, students will understand the specific application of the formula, which will help them to translate abstract concepts into real life applications. Altogether, case design teaching breaks the limitation of learning by rote in traditional teaching and pays more attention to transforming theory into practice.

Hull lines design

Hull lines design is one of the most widely used skills in the marine sector and the vast majority of the key points of knowledge in hydrodynamic calculations are covered in it. The implementation of case studies is also a key element of the course in order for students to understand and master the principles of ship design. Good hull lines design directly determines the hydrodynamic performance of a ship, so in engineering practice, various dimensional parameters must be restricted to ensure that the design meets the constraint requirements. The theoretical basis of ship hull lines design is characterised by a strong practical component and moderate complexity, ensuring that students learn advanced content while attaining a certain level of theoretical depth, making it a very typical case study.

In hull lines design, students change the ship's original data point to obtain a series of homologous ship forms. Focusing on the hydrodynamic characteristics of homologous ships, students find the best ship form with the least resistance. Under condition of the results are unknown, students need to think about how to design ship parameters, how to calculate the resistance of different ship types, and how to compare resistances between different ships. Excellent ship lines determine good hydrodynamic performance of ships, so that learning of

hull lines design can help students to grasp the essential of case, then develop thinking to create their own application scenarios, finally learn techniques that can solve real problems. In addition, taking ship form design as a typical case of case teaching can not only consolidate professional knowledge and lay a foundation for students' further study, but also inspire research ideas and provide students with in-depth research directions in their further postgraduate stage.

Standard process of CFD resistance calculations

The CFD resistance calculation standard process is the core of this course. This part of the knowledge framework is complex and involves the intersection of many disciplines such as ship drag, ship propulsion and hydrodynamics. In order to facilitate students' understanding and improve the quality of teaching, computer practice is used as the main teaching tool to improve students' operational awareness through the interplay of classroom teaching and computer teaching. Thereafter, students can proficiently use CFD simulation technology to solve practical problems. Case teaching is not only an exploration of CFD technology in marine applications, but also a major breakthrough in computer teaching. Students can feel the vividness and realism of the case first-hand through the functions demonstrated by the computer. This stimulates their enthusiasm for learning. As the standard process of resistance calculation is complex and the teaching tools are mainly CFD software, it is difficult for students who do not have a basic knowledge of CFD operations to get started with a simulation. Figure 5 shows the standard flow chart for CFD resistance calculations.

The simulation steps are as follows:

- (1) Importing geometry: students need to directly import geometric models or coordinate points in CFD software to lay a good foundation for subsequent operations. In this step, students can learn to master the basic knowledge of 3D modelling.
- (2) Creating computing domain: The computing domain is the area considered for fluid computing, and the area beyond the computing domain is not considered by the solver. Students can use CFD software to create the geometric model of the computational domain. The most common method for creating computational domains is Boolean operation.
- (3) Setting boundary conditions: In order to obtain the results of resistance calculation, students must set various parameter values at the boundary of the calculation domain in advance. After dividing the imported surface and assigning the relevant boundary to the domain, students can set the boundary conditions in the region tab.
- (4) Refining mesh: students must refine the mesh in the computing domain for faster calculation. The mesh generator in CFD software generate meshes automatically.
- (5) Setting physical model: students need to choose steady or unsteady calculation according to the actual situation. The use of incompressible fluid can make the calculation faster.

(6) Selecting solver: appropriate solver can automatically match the current algebraic operations according to the characteristics of physical law evolution.

(7) Monitoring results: students can make the renderings show more information through post-processing after the calculation is completed. In general, students use the pressure/velocity cloud diagram and streamline diagram to visualize the calculation results.

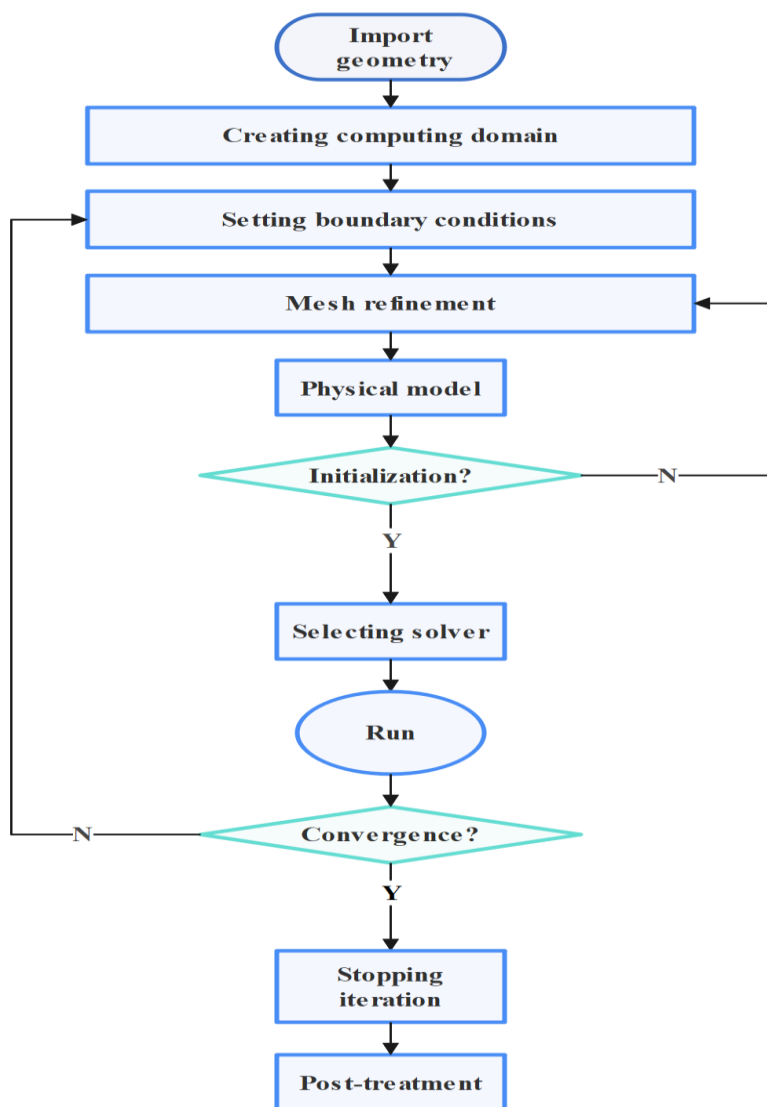


Fig. 5. Standard flow chart of the ship resistance calculation via CFD method.

TEACHING STEPS FOR CASE DESIGN

Selection of high-quality teaching cases

The hydrodynamics numerical calculations course is complex, covering a wide range of knowledge, and there is some crossover with other disciplines, which makes the selection of teaching cases difficult. The case content is set according to three requirements, namely, that it

be inspirational, comprehensive, and practical. Inspiration is key to case teaching content. Vivid cases actively mobilise students' initiative and help them think and analyse matters independently. Comprehensiveness means that the teaching perspective is open, and the teaching content is comprehensive, not limited to conservative and dogmatic cases, making full use of developed network information, integrating the strengths of more classical materials, and ensuring that the case teaching topics are novel. Practicality refers to the fact that the content of case teaching should be closely related to actual practice and not biased towards theory so that students can gain hand-on experience.

We must choose appropriate cases when using the case teaching method. All cases have their own significance. Teachers need to read a lot of cases to find the cases students need. Cases serve different teaching purposes and will naturally bring different teaching effects. Teachers should also pay attention to the problem awareness, theoretical background, calculation methods and popularity of the selected cases. The goal of case teaching is to inspire students to think, argue and further explore the real problems. The core feature of this teaching method is based on problems and exploring problems. Cases with different themes emphasize different theoretical backgrounds and also reflect different theoretical requirements. Some cases may aim to apply certain theoretical viewpoints to make decisions or judgments. Some cases are used to illustrate the application value of some theories, while others need to question some theories and guide students to reflect on divergent ideas. In addition, it should be noted that different cases use different calculation methods and problem-solving angles, which are very flexible in the application of teaching.

Creating a good atmosphere for classroom discussion

Classroom discussions can have a positive effect, enhancing the students' experience and improving the effectiveness of classroom teaching. During the discussion, the teacher should hand over the right to speak to the students, creating a classroom atmosphere in which the students' statements are the main focus. As different students have varying levels of expression and responsiveness, teachers should take into account the feelings of each student by letting them speak as much as possible. Through encouragement and support, students can build up their self-confidence and make better use of their language skills. For students who are emotionally stressed, attention is paid to easing their minds by starting initial discussions around their interests and then leading them to speak freely.

The topics for discussion in the classroom should be diverse and open so that students can form opposing camps to discuss. Teachers should not focus on the results of the discussion, but guide students not to deviate from the theme in the discussion. Students do not pay attention to the discussion of the win or loss, be sure that everyone involved in the discussion, everyone's views are clearly expressed, so as to obtain the recognition of other students. A successful

classroom discussion can enable both sides to get inspiration from each other's point of view, so as to reflect on whether their own content has room for improvement, and whether the quality of their own content can be more convincing to others. This mutual penetration and influence, not only to discuss the topic more and more, the depth of the discussion is also growing, and ultimately let the students remember the content of this lesson by self-reflection. Through classroom discussion, students can improve their thinking ability and debate ability, learn to cooperate with others, and find solutions from specific problems.

Strengthening the sense of close connection between theory and practice

Theoretical explanations and practical exercises in case study teaching are complementary, and the two interpenetrate and complement each other to help develop students' theoretical understanding and operational skills. The emphasis is on the transformation of theoretical results into practice. Students accumulate a certain theoretical basis through the teacher's lectures, combine what they have learnt with independent analysis and thinking to arrive at reasonable judgements and make their own decisions, which are then verified in practical applications, deepening their understanding of theory, and consolidating their level of computer use.

In case teaching of hydrodynamic numerical calculations course, the means of combining theory with practice is computer operation by using CFD method. In time allocation, classroom teaching should take up less part, and more time should be devoted to simulation learning. Students in the computer operation will appear a lot of problems, teachers need to be targeted to answer. In addition, teachers need to set aside some time for students to self-training, consolidate the use of CFD skills, deepen their impression of the simulation operation. Students need to understand the meaning and purpose of each step in the simulation, and should not blindly copy the operation of the tutorial. Case teaching must ensure that each student can get exclusive calculation results, and make them clear the causes and process of the results, so as to ensure that the theory and practice of interlocking, to help them form a theory with practice mode of thinking.

Doing a good job of evaluation and taking stock

Doing a good job of evaluating and summarising case teaching is the key to ensuring quality. The teacher makes an objective assessment of the results reported by the students, points out correct methods, encourages the students to make further efforts, and gives corrections to any shortcomings so that the students can deepen their impressions and better grasp the essentials of learning. The evaluation and summary of case study teaching is an important medium for information feedback between teachers and students. Teachers assess the quality of teaching based on students' reports, after which they improve their teaching methods and develop solutions that are more beneficial for students' learning, while students

reflect on problems in the learning process based on their teachers' guidance and take the initiative to think of solutions for improving learning efficiency.

The assessment of students in this major can be carried out through diversified evaluation methods. Comprehensively evaluate students' performance by referring to students' classroom performance, completion of after-school exercises, activity of participating in online teaching interaction, practical ability and other aspects. This can not only reduce the pressure of students' review, but also facilitate teachers to understand students' knowledge in time, and can also be targeted to adjust the teaching schedule and methods.

CONCLUSION

A response to excessive emphasis on theory, case design is introduced into classroom teaching to enhance its practical nature. Through case studies, students not only master professional knowledge, but also become familiar with industrial processes and design specifications, grasp the connection between theoretical content and practical operations, and form a learning mindset of independent thinking, analysis, and decision-making, thus truly benefiting from their studies. From the results of this assessment, it is clear that the case design teaching has achieved the expected effect, with students' motivation and learning abilities significantly improved. For hydrodynamics numerical calculations, the new model of teaching by case design is successful and should be promoted.

The advantages of applying case design teaching to the numerical calculation of ship hydrodynamics course can be reflected as follows. (1) For teachers, it can achieve efficient management of the whole teaching cycle of the course, so they can maximise the value of the entire cycle, including project design, numerical simulation and experiments. (2) For students, it enables parametric and visual design, multi-disciplinary collaborative design, optimisation of group work, model-based interoperability in the emulation and simulation processes, coordination between the built model and the data, feasibility assessment, engineering volume statistics, and design validation. (3) For students' employers, joint training between schools and enterprises can be achieved, so that students can adapt to the enterprises' needs for professional skills more quickly, their hands-on ability can be greatly improved, and they will have a better understanding about the process of enterprise production management. (4) For universities, good teaching quality can be obtained.

They can also utilise the readily available human and material resources to provide immediate technical support for the course and promote the course to a higher-level platform. Then, the course can be displayed on online learning platforms such as MOOC to other

national institutions so as to continue quality improvement and promote education reform. (5) For software and tank experimental equipment suppliers, they can better provide maintenance and training for numerical simulation software and tank experiment platforms, help students and teachers to keep abreast of the status of technological updates and provide timely technical services. The case design teaching model unifies the pre- and post-teaching stages of the course and enables significant improvement in the speed, efficiency, accuracy and safety of information exchange during the course between students and teachers, and even the whole education system.

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