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Discussion on Requirements and Training Strategies of Programming in Ocean Engineering

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ABSTRACT
The development of the ocean is receiving more and more attention. To train a group of high-quality ocean engineering talents is a goal of current higher engineering education. Programming ability, as an important skill required for the development of computer technology since the 21st century, has a wide application in the advantage technology of ocean engineering. In this article, the key requirements of ocean engineering for programming skills are discussed. In response to these needs, we have proposed a series of reforms in the lecture notes and teaching material. The optimization of the teaching plan is given. At last, research projects and internships are used as two incentives to promote students' initiative in learning. They are proposed to help students to accept the training of programming
Keywords: *Programming; Ocean engineering; Teaching; Train strategy*

1. INTRODUCTION

With the development of computer technology, computer software that can assist in solving engineering problems is getting more and more attention. Among them, Computer-aided engineering (CAE) is the broad usage of computer software to aid in engineering analysis tasks. With different software, the finite element analysis (FEA) [1], computational fluid dynamics (CFD) [2], and multibody dynamics (MBD) [3] problem can be solved by the computer. A lot of manual labor can be saved and then thereby the efficiency of engineering design and analysis can be improved.

In all engineering fields, ocean engineering problems are usually difficult to handle because they involve complex fluid motions [4] and dynamic response [5]. At the same time, the sea is the same as the sky, it is difficult for us to directly conduct a field test on it. Therefore, it is necessary to utilize computer software to solve such problems.

However, in practical engineering, we always face various problems, and they always have a certain pertinence. Sometimes, there may not be a suitable software that can help us. The self-built program should be compiled by ourselves [6]. On the other hand, we usually need to process a large amount of data when dealing with engineering problems, and the systematic analysis of these data [7] is a necessary step for us to obtain the desired results and to show them beautiful [8]. Therefore, programming ability becomes one of the necessary skills for ocean engineering students and engineers. Although the programming ability has been outstanding by some educational institutions [9-10]. However, programming training in China is lacking in higher engineering education. Because traditional ocean engineering courses have paid more attention to the basic knowledge and skills. In modern ocean engineering higher education, it is urgent to strengthen the training of programming ability.

2. REQUIREMENTS

In this part, the requirements of programming ability in the ocean engineering discipline will be given. We will explain the above requirements from three aspects: the required programming abilities, appropriate courses and teaching and learning objects (teachers and students/engineers).

2.1. Required programming abilities in Ocean engineering

In ocean engineering, it is inevitable to use computers to complete some tasks due to the needs of teaching and research. For example, there are a large number of environmental factors that need to be considered in ocean engineering, such as wave, wind, current and seabed topography. Among them, the wind, current and wave need to be counted for a long time statistical analysis to get their characteristics. Usually, scientists used computer programs to write special codes to complete such an analysis. The advantage of the program in big data processing was used. Besides, the wave is a kind of signal and it has varying amplitude and period. In particular, the irregular wave is a random combination of a series of wave trains. Digital filtering technology was a common way to process the wave series. With the development of computer technology, the numerical simulation method was widely used in ocean engineering. The interaction of the wave and structure, the wave deformation and propagation near the coastal zone and other ocean dynamic problems can be investigated through solving the governing equation of moving fluid.

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The Naiver-Stokes equations [11] are the governing equation of the numerical simulation. They are a set of partial differential equations that describe the motion of viscous fluid substances. As they are used to solve the pressure and velocity of the flow, while the relationship between them is very complicated. It is almost impossible to solve the above equation without the help of the program. Last but not least, in all engineering fields, intuitive and vivid pictures and animations are important materials for expressing our views and conclusions. With the computer program, the above scientific drawings can be displayed automatically and efficiently.

2.2. Courses that need to combine programming skills

It can be found that a lot of programming skills are needed in ocean engineering, both in education and research. In the following part, the related courses that can be combined with programming training will be listed:

2.2.1. Mathematics

As a basic course, many mathematical problems can be solved with the help of computer programs. Among them, the most important function is the use of computer programs to solve equations, which include the solution of equations, matrix transformation and calculation, the simplification of high-order equations, the iterative calculation of complex equations, etc.

2.2.2. Numerical calculation method

It is a numerical approximate solution method to calculate complex equations and solve practical problems. Its objects include Calculus, linear algebra, differential equations. The commonly used calculation methods mainly include interpolation and fitting, numerical differentiation and numerical integration, and iterative methods, calculation of matrix eigenvalues and eigenvectors, and numerical solutions of ordinary differential equations.

2.2.3. Computational fluid dynamics

This course mainly uses the above numerical calculation methods to solve fluid mechanics problems. For example, the Navier-Stokes equations can be solved by using the numerical solution of ordinary differential equations. And in the process of solving the above equations, both the numerical differentiation and iterative methods are usually use.

2.2.4. Wave theory

The parameters used to describe waves include wave length, wave period, wave number, wave height and so on. Among them, there is a dispersion relation between the wave length and the wave period:

$$L = \frac{gT^2}{2\pi}\tanh\left(\frac{2\pi}{L}d\right), \quad (1)$$

where L is the wave length, g is gravity acceleration, d is the water depth, T is the wave period. It can be seen that both ends of the equation contain L, and therefore the result cannot be solved directly. The iterative methods need to be used to get the solution. The code written by python was list as bellow:

```
def dispersion(T, h):
    L0 = 9.81*T**2/(2.*np.pi)
    L = L0
    for i in range(0,100):
        Lnew = L0 * np.tanh(2.*np.pi/L*h)
        if(abs(Lnew-L)<0.001):
            L = Lnew
            break
        L = Lnew
    return L
```

Figure 1. Dispersion function for calculating the wave length by Python

2.2.5. Digital signal processing

As mention above, a wave sequence contains a lot of information, and we usually analyze the waves statistically to obtain some characteristic information. Among them, the significant wave height Hs is an important value used to evaluate the wave height. It means the highest third of the waves. Although it is possible to count the wave height data artificially and select the highest third of the waves. This process is boring and error-prone. In particular, we may often need to count Hs for different waves. At this time, we can use a pre-compiled program to finish this job, which can improve our efficiency and help us understand the principles of wave statistics.

2.2.6. Numerical simulation and structural design

Combining programming methods with numerical simulation teaching is a helpful attempt because it can help students and teachers understand the simulation principle and process. A typical numerical simulation process usually includes modeling, calculation domain setup, boundary conditions and initial value setting, solution

algorithm selection and post-processing. Each of the above steps corresponds to a part of the mathematical equation. Without the simultaneous explanation of the steps of the numerical solver, the users may only remember the operating steps of the software instead of the analytical method.

3. STRATEGIES AND SOLUTIONS

Based on the above demand for programming training in ocean engineering education, the development strategy and some available implementation plans are discussed.

3.1. Customized lecture notes and complementary teaching material

Firstly, the customized lecture notes are necessary in order to adapt to the training of programming skills in the course. Because the current textbooks rarely teach programming knowledge and basic knowledge at the same time, this work is usually unprecedented. Teachers may need to gradually prepare the notes of each chapter according to their abilities and knowledge points of the course. At the same time, there may be only one chapter that can be combined with the programming training in a course. This is allowed, and it is also a necessary stage that the curriculum reform must undergo. In addition, abundant extracurricular example training is also a good way to promote students to understand the relationship between programming skills and basic knowledge.

3.2. Systematic course framework for programming module

Because different courses have different requirements for programming skills, we should not suddenly and comprehensively promote programming training in all courses. This may bring huge pressure to teachers and students, and may get the opposite teaching effect. Therefore, we need to propose the programming training step by step and keep the continuity of the training when making arrangements and curriculum design in universities. For example, basic computer language and logic can be arranged in the freshman year, appropriate training can be taught with mathematics courses. Through one year of training, more programming skills can be added to professional courses step by step, and the computer application ability of the students can be gradually improved. In the final year, more courses can be offered that are in line with future jobs. The students can choose the courses they need. In these courses, the intensity of programming training can be customized according to the needs of the corresponding job position.

3.3. Incentive measures to reinforce the importance of programming

In teaching, the best results usually come from students' active learning. It may not be recognized by students if we only offer programming training and emphasize the importance of programming thinking. We need to dig out the application of programming ability in students' daily life and show it to students. For example, the teachers can allow students to participate in their research projects or encourage students to participate in school innovation competitions so that students can understand the importance of programming skills in the implementation of projects. Besides, the internship experience of senior students is also a good way to let students realize the significance of programming ability in related fields. When they are faced with some complex tasks and taste the sweetness in the process of using computer programs to solve these problems. They will naturally realize its importance and tend to learn actively.

4. RESULT AND DISCUSSION

According to the above solutions, some attempts were carried out to train the programming ability of the students in ocean engineering.

In Fig. 2. the note template for shallow water deformation in ocean engineering was designed. With the introduction of the outline of the module. The principle of shallow water deformation, analytical theory model and schematic diagram were listed separately. The Matlab function for solving the corresponding theory model was provided. Finally, the conclusion of this module was summarised. Based on the above template, more slides can be made and the theoretical knowledge and programming ability can be trained simultaneously.

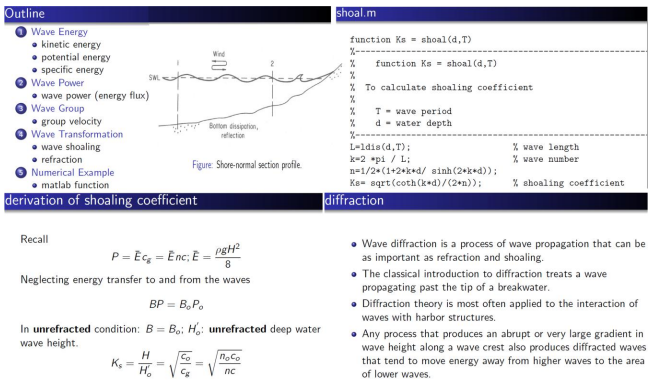

Figure 2. Outline of the lecture note for shallow water deformation in ocean engineering and its Python function

While the joint teaching of course knowledge points and programming training is not universal for different types of courses. In section 2.2, different courses have raised the demand for programming skills. While, training methods

need to be designed separately for Mathematics, Wave theory or Numerical simulation and structural design. Fig. 3 has given the methods and intensity levels of programming training for different courses.

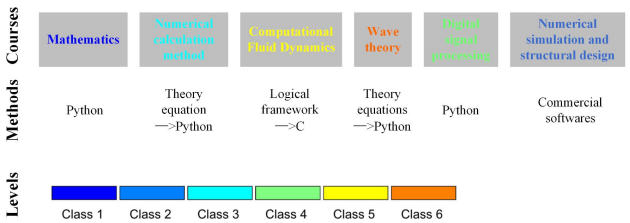

Figure 3. Methods and intensity levels of programming training for different courses

Finally, the popularity of the practical value of programming abilities is investigated among teachers and students in ocean engineering subject.

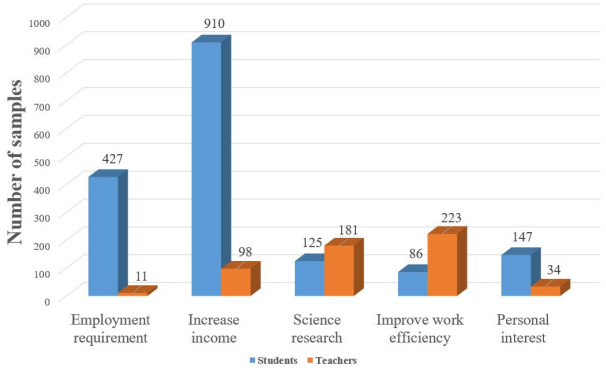

Figure 4. Methods and intensity levels of programming training for different courses

It can be seen that the need for motivation among teachers and students varies significantly in Fig.4. For a student, the income level and the job requirement were their main motivation. Therefore, the best way to encourage students to actively study programming skills is to associate programming skills with the needs of future jobs. On the other side, an appropriate introduction is necessary to improve students' understanding of the value of programming such as scientific research and efficiency improving, then interest in learning programming can be stimulated. For the teacher, the results showed that they have focused more on science research needs and work efficiency improvement. So, to combine knowledge teaching with their research work can promote their willingness to promote programming teaching. Meanwhile, the example based on teachers' engineering problems can also help students understanding the value of programming skills well.

5. CONCLUSION

In this article, the importance of programming skills in ocean engineering education is discussed. With the analysis, it is found that the many advantages of computer programs can play a great role in professional course teaching. At different stages of ocean engineering education, the urgency of the requirements for computer programs are not exactly the same, and the functions of the programs used in courses are also different.

Due to the importance of programming ability and the demand for professional teaching, strategies and solutions for ocean engineering higher education was proposed to meet the above demands. Firstly, the customized lecture notes with the coding module and complementary teaching material with a programming example were necessary. Then, the traditional syllabus needs to be improved to meet the different requirements of different courses for programming ability in ocean engineering higher education. Last but not least, reasonable incentive measures for students and teachers may need to reinforce their awareness of the importance of programming.

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