Research on Engineering Exemplification Teaching Method in Linear Algebra Teaching

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Abstract. Linear Algebra is a very useful subject, which is widely used in many fields, such as cryptography, Computer graphics. Traditional teaching generally adopts deductive teaching method, which is not suitable for the cultivation of innovative talents. By comparing deductive and inductive teaching methods, this paper used a new teaching method—Engineering Exemplification Teaching Method. Starting from actual cases to help students construct new knowledge by themselves, and then applied it to real life, thus completing the transfer and sublimation of knowledge. Finally, through a specific content, we discussed the specific implementation of engineering exemplification teaching method.

1 Introduction

Linear algebra theory has a long history and rich content. In recent years, with the development of science and technology, as one of the important mathematical tools, the application of linear algebra has penetrated into various fields, such as natural science and engineering technology. As a compulsory course for higher education, learning linear algebra is not only to acquire basic theoretical knowledge, but more importantly to master methods and apply them flexibly to practice, thus laying a foundation for the subsequent study of professional courses. However, in the current linear algebra teaching, there are more concepts, theorems, abstract content, and very few theoretical applications. The teaching focuses on introducing obscure basic theorems and tedious logic deductions [1]. As a result, the classroom atmosphere is depressing, students often doze off in class, and many students lose interest in learning linear algebra, and even feel bored [2]. How to improve teaching methods and improve the quality of personnel training is an urgent problem to be solved.

2 Deductive teaching method and inductive teaching method

2.1 Deductive teaching method

The traditional linear algebra teaching generally adopts deductive teaching method. This is a method from generalization to concrete. It first builds abstract theoretical knowledge for students, and then uses facts to explain theoretical knowledge, or uses theoretical knowledge to solve practical problems. This method can help students to avoid detours and directly inherit the knowledge accumulated by their predecessors, but it is not conducive to
the cultivation of innovative ability [3], and in this mode, students only know that linear algebra is useful and beneficial to professional courses, but they don't understand the specific use of linear algebra. However, seeing so many theorems, words, and mathematical symbols, they are bored and do not understand why they have to spend so much effort to learn those difficulty theoretical knowledge. Therefore, they are full of repulsion for linear algebra.

3.2 Inductive teaching method

E Jin Nebius once said: "First describe a theorem, and then introduce some examples, this teaching method is actually the opposite." Different from the deductive teaching method, the inductive teaching method is based on a specific case. A set of data to be analysed or a practical problem to be solved. If students want to analysed data or solve problems, they must have new knowledge and skills. At that time, teachers help students build new knowledge on the basis of existing knowledge, so as to complete the transfer of knowledge. Under this teaching mode, students can not only experience the usefulness of linear algebra, but also deepen their understanding of knowledge, which enhances their learning enthusiasm and initiative. Inductive teaching method includes a series of teaching methods: inquiry teaching, problem-based teaching, project-based teaching, case-based teaching, discovery teaching and instant teaching, etc[4].

3.3 Engineering exemplification teaching method

Relying solely on deductive teaching method is not conducive to cultivating students' creativity and initiative in learning. However, due to the limitation of students' knowledge level and thinking ability, if we abandon the deductive teaching method completely, the advantages of inductive teaching method cannot be fully exploited [5]. In fact, there is no pure induction or deduction, either in teaching or in learning. In the teaching of linear algebra, we can adopt engineering exemplification teaching method which combines induction and deduction. First, select appropriate cases, guide students to analyse the scientific knowledge needed by the cases, naturally lead to the learning of new knowledge content, deepen students' understanding and mastery of the knowledge learned, and finally apply the knowledge to practical problems to complete the practical transformation of theoretical knowledge.

3 Implementation of engineering exemplification teaching method

3.1 Implementation strategy

3.1.1 Case selection

In the whole teaching process, the selection of cases is very important. We should follow the following principles: firstly, targeted, the case must be consistent with the specific teaching content and objectives, secondly, realistic, the cases should close to life, close to social hot spots, and keep pace with The Times, thirdly, professional, the cases should be as relevant to students' major as possible [6].
3.1.2 Classroom teaching

In teaching process, especially in the analysis of cases, teachers should make a detailed analysis and in-depth interpretation of the cases, and must analyze and clarify the deep theoretical problems contained in the problems. In the discussion, teachers should always grasp the direction of the discussion and the rhythm of the debate, so as to prevent the discussion from deviating from the topic. At the same time, teachers should pay attention to collect students' different approaches to the problem, select a better solution method, and then review the solution of the case.

3.1.3 After-class summary

After each class, teachers should reflect on the teaching effect, summarize the advantages and disadvantages in the teaching process, and constantly improve the teaching method to improve the teaching quality [7].

3.2 Image compression and diagonalizing a matrix

Next, we take matrix diagonals as an example to discuss how to use engineering exemplification teaching method to select and analyze cases. Digital image processing is an important part of computer and electronic science. It is the central research content of analog recognition and artificial intelligence theory. Image compression is one of the important contents, and a method to achieve image compression is digital image compression technology based on SVD, whose basic principle is as follows.

A digital image, usually represented by a matrix. Figure1(a) is a black and white image with a pixel of 3000x3000 and a size of 1.98M, which corresponds to a matrix A of 3000x3000. In the process of image transmission, 9000000 data need to be transmitted together, which is very large and time-consuming. Therefore, we can try to send less data on the sending side and reconstruct the image on the receiving side. So we're going to do something to matrix A. Through SVD decomposition, the matrix A can be decomposed into the following matrix:

\[ A = USV^T \]  

(1)

Where U and V are orthogonal matrices and S is a diagonal matrix, the diagonal elements are arranged from the largest to the smallest.

In this way, the matrix A is corresponding to a diagonal matrix S which contains only a few non-zero elements. The matrix with large amount of data is corresponding to a small matrix. Thus, the data compression is realized.

In fact, the number in the matrix s has large and small. For the smaller number, it has less impact on the image. If we omit some particularly small numbers in S and only keep the first k large numbers, the corresponding is to keep the first k columns of matrix U and the first k columns of matrix V, when transferring images, only 6001k data need to be transferred, which is far less than 9000000 data of the original image, and the image compression ratio \[ \rho = \frac{9000000}{6001k} \].

Using MATLAB, SVD decomposition can be realized and the number in matrix S can be filtered.

When k=2, compression ratio \[ \rho \approx 750 \], the compressed image is shown in figure 1(b). When k=4, \[ \rho \approx 375 \], it's shown in Figure 1(c). k=9, \[ \rho \approx 167 \], which is shown in
\( k = 30, \ \rho \approx 50 \), it’s shown in figure 1(e). While \( k = 100 \), compression ratio \( \rho \approx 15 \), the compressed image is shown in Figure 1(f), in this case, the size of the image is 46.3kb, which is very close to the original image (a), but the size is only about 1/50 of the original image.

![Image comparison before and after data compression.](image)

Figure 1. Image comparison before and after data compression.

It is easy to decompose SVD by MATLAB. What is the theoretical basis behind it? How to find the matrix \( U, S, V \), that is, how to turn matrix A into a diagonal matrix. Through the knowledge learned before, for a matrix \( A \), a symmetric matrix \( AA^T \) can be constructed, and the problem is transformed into the diagonalization of the symmetric matrix.

Through the actual case, students can clearly understand the practical problems that can be solved by matrix diagonalization, arouse students' interest in learning this section, increase their enthusiasm and initiative in learning; next, teachers are required to guide students to construct the relevant theoretical knowledge of matrix diagonalization. Finally, teachers guide students to summarize the whole process of solving problems, clarify the ideas of finding problems, analyzing problems, finding methods, checking calculation and solving problems, so as to realize the systematic mastery and practical transformation of knowledge, and achieve the effect of drawing inferences from one instance.

4 Conclusion

In this paper, we discussed the inductive teaching, case-based teaching and deductive teaching method in depth, found a new teaching method—engineering exemplification teaching method, which is suitable for linear algebra teaching. The implementation of engineering exemplification teaching method is discussed combined with a specific course content. This teaching method can obviously improve the disadvantages of traditional teaching, effectively improve the teaching effect, and provide reliable theoretical basis and model research basis for linear algebra teaching, improve teachers’ teaching work, and promote the smooth progress of linear algebra teaching reform.
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