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Exploration of the Cultivation Path of Computational Thinking in Linear Algebra Curriculum

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Abstract: In the era of artificial intelligence and big data, computational thinking, as a way of solving problems and processing information, is particularly important for the development of college students. Computational thinking has become a basic thinking skill that every college student should possess. Linear algebra, as a branch of mathematics, mainly studies concepts such as systems of linear equations, vector spaces, and matrices, which have a natural connection with core elements such as problem-solving, abstraction, and modeling in computational thinking. This article explores several training paths for computational thinking in linear algebra courses, such as strengthening understanding of basic concepts and operation rules, cultivating students' abstract and modeling abilities through application cases, emphasizing logical reasoning and proof, introducing computer and programming tools to handle practical problems, organizing group discussions and cooperative learning, etc. Furthermore, it provides an assessment method for the effectiveness of computational thinking training.

1. Introduction

The concept of computational thinking originated in March 2006, when Professor Jeannette M. Wing, the director of the Department of Computer Science at Carnegie Mellon University in the United States, presented it in the authoritative computer journal Communications of the ACM and defined computational thinking. Professor Wing believes that computational thinking is a series of thinking activities that apply fundamental concepts of computer science to solve problems, design systems, and understand human behavior, covering the breadth of computer science; She believes that computational thinking is a fundamental skill for everyone, not just for computer scientists. Every child should also learn computational thinking while developing analytical skills [1].

Computational thinking, as a way of solving problems and processing information, emphasizes the application of principles and methods of computer science and information technology, and solves problems through thinking processes such as analysis, abstraction, logical reasoning, and algorithm design. The core of computational thinking is to abstract problems into computable forms and apply algorithms and principles of computer science to process and solve problems.

Computational thinking is crucial for the development of college students. Firstly, computational thinking can enhance problem-solving abilities. Computational thinking helps college students break down complex problems into a series of smaller and more manageable sub problems. This decomposition method helps to systematically analyze problems, identify the key points of the problem, and thus more effectively find solutions. Secondly, computational thinking emphasizes logic and accuracy, which helps college students form rigorous logical thinking. This is crucial for them to make reasonable decisions in academic research and daily life. Again, computational thinking can enhance students' innovation and interdisciplinary application abilities. Computational thinking encourages college students to approach problems from a new perspective and seek non-traditional solutions. This way of thinking helps cultivate the innovative consciousness and ability of college students, creating more possibilities for their future career. College students who master computational thinking can better integrate computer science knowledge with other disciplines, achieving interdisciplinary applications and innovation. Finally, computational thinking can help college students better adapt to the information society. With the rapid development of the information society, computational thinking has become one of the basic literacy in modern society. College students with computational thinking can better adapt to the requirements of the information society and lay a solid foundation for their future career development.

From the perspective of the current education status of computational thinking at home and abroad, the cultivation of computational thinking has been included in the information technology curriculum standards of compulsory education in primary and secondary schools. In the university education stage, computational thinking is a teaching task of computer courses in universities. However, Weintrop et al. pointed out that computational thinking should be mutually beneficial and symbiotic on the basis of practicing the concepts and knowledge of computer science, mathematics, and science [2-4]. It can be seen that mathematics is indispensable in cultivating computational thinking.

In the era of artificial intelligence and big data, especially with the emergence of new engineering majors such as big data, cloud computing, artificial intelligence, blockchain, virtual reality, intelligent science and technology, computational thinking has become a basic thinking skill that every college student should possess. Especially with the release of ChatGPT and GPT-4 in the United States, it has posed a challenge to the mathematics education model that is still stuck in solving problems. Therefore, in the context of today's era, it is more urgent to cultivate the computational thinking ability of college students in university mathematics courses.

2. How to cultivate computational thinking in linear algebra courses

2.1 The course of linear algebra contains rich computational thinking

Linear algebra, as a branch of mathematics, mainly studies concepts such as systems of linear equations, vector spaces, matrices, etc. These concepts have a natural connection with core elements such as problem-solving, abstraction, and modeling in computational thinking.

Firstly, matrix operations and determinant calculations in linear algebra require rigorous computational thinking. When solving linear algebra problems, students need to use logical thinking and reasoning abilities to abstract and model the problem, transform the actual problem into a linear algebra problem, and then use the theory and methods of linear algebra to solve it. This process requires rigorous calculation and reasoning, which helps cultivate students' computational thinking.

Secondly, the theory and methods of linear algebra can also be applied to solve practical problems in computational thinking. For example, in fields such as computer graphics and machine learning, it is often necessary to handle a large amount of data and matrix operations, which are the strengths of linear algebra. By applying knowledge of linear algebra, these problems can be solved more efficiently, improving computational efficiency and accuracy.

In addition, concepts and methods in linear algebra also contribute to cultivating students' abstract thinking and innovative abilities. For example, by learning concepts such as vector space and linear transformations, students can gain a deeper understanding of the essence and principles of mathematics, and improve their abstract thinking abilities. Meanwhile, some problems in linear algebra can also stimulate students' innovative thinking and guide them to explore new solutions and ideas.

In summary, there is a mutually reinforcing relationship between linear algebra and computational thinking. By learning linear algebra, students can develop their computational thinking, logical thinking, and innovative abilities; Meanwhile, computational thinking can also help students better understand and apply knowledge of linear algebra. Therefore, in the teaching process of linear algebra, emphasis should be placed on cultivating students' computational thinking and problem-solving abilities, guiding them to apply the theories and methods of linear algebra to solve practical problems.

2.2 The cultivation path of computational thinking in linear algebra

In the course of linear algebra, cultivating computational thinking is an important teaching goal. In order to more effectively cultivate students' computational thinking, the following aspects can be approached:

Firstly, teachers should strengthen students' understanding of basic concepts and operational rules. During the teaching process, teachers should ensure that students have a deep understanding of basic concepts such as vectors, matrices, and linear equations, as well as their operating rules, and encourage students to explore different problem-solving methods, compare their efficiency and applicability; Through practice questions and practical questions, students can practice these concepts and operations to deepen their understanding.

Secondly, teachers should cultivate students' abstract and modeling abilities. In the teaching process, teachers should guide students to abstract practical problems into linear algebraic models, such as using matrices and vectors to represent data, using linear equations to represent constraint conditions, etc. Through case analysis and discussion, students will experience how to transform practical problems into linear algebra problems, and further develop their mathematical modeling skills through extended assignments.

Thirdly, teachers should focus on logical reasoning and proof. In the teaching process, teachers should emphasize the importance of logical reasoning and teach students how to use logical reasoning to verify and solve linear algebra problems. Encouraging students to participate in the proof process can improve their logical reasoning ability and mathematical literacy.

Fourthly, computers and programming tools can be introduced. Using computers and MATLAB for linear algebra calculations and simulation experiments can enable students to experience the automation and efficiency of calculations. Teaching students to write simple programs to solve linear algebra problems can cultivate their programming skills and computational thinking.

Fifthly, group discussions and collaborative learning should be organized. Encourage students to share their problem-solving ideas and methods through group discussions and collaborative learning. During this process, students can also learn new computational thinking skills from their peers. Teachers provide guidance and feedback to help students deepen their understanding and application of computational thinking.

Sixthly, it is necessary to cultivate students' ability to solve problems. Teachers design challenging problems and projects, such as image compression, geometric transformation of shapes, beautification of mobile phone photos, image decomposition and reconstruction, etc., allowing students to apply their knowledge of linear algebra and computational thinking to solve practical problems. Teachers should encourage students to engage in critical and innovative thinking and seek new solutions and methods.

Through the above methods, students can effectively cultivate their computational thinking in linear algebra courses, help them better understand and apply linear algebra knowledge, and improve their logical thinking, innovative thinking, and problem-solving abilities.

3. Evaluation of the effectiveness of cultivating computational thinking

In order to comprehensively evaluate the mastery and application ability of students in computational thinking, we adopt the following assessment methods, as shown in Figure 1.

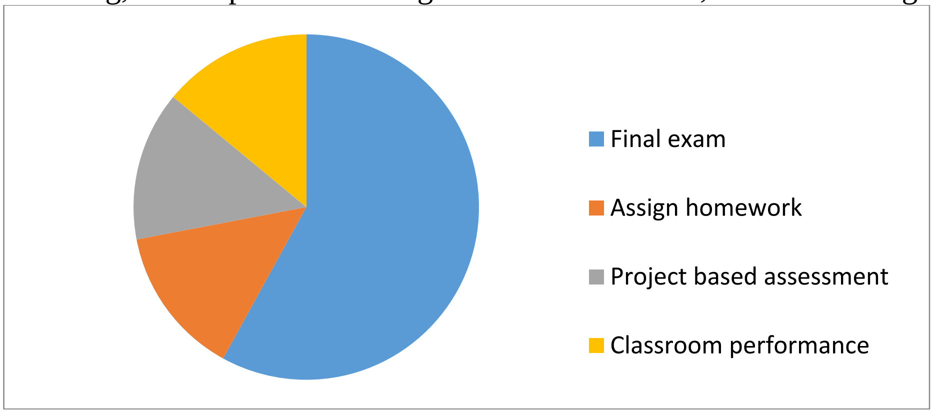

Figure 1: Composition of computational thinking evaluation methods

Firstly, in the final exam, calculation questions, proof questions, comprehensive questions, and application questions should be set to test students' basic calculation skills, comprehensive calculation ability, and application ability of the learned knowledge.

Secondly, by assigning homework, students are assessed for their ability to apply computational thinking to solve practical problems. Each chapter sets a certain number of application questions as designated homework to assess students' ability to describe and solve practical problems in mathematical language. Based on the completion of homework, students are assessed for their practical application ability in computational thinking.

Thirdly, project tasks can be set for assessment. Teachers assign open-ended project tasks and require students to work together as a team to complete the task requirements. The method of solving problems is not only definite, nor limited to textbook knowledge, but also emphasizes that students should consult information to obtain knowledge, design problem-solving strategies, use computer software to complete tasks, and summarize and report during the problem-solving process. Project based assessment effectively cultivates students' computational thinking ability, execution ability, as well as teamwork and communication skills.

Fourthly, teachers can assess computational thinking by observing students' performance and questioning situations in the classroom. The level of student participation, quality of questioning, and presentation of problem-solving strategies in the classroom can all reflect their understanding and mastery of computational thinking.

In addition, college mathematics competitions and mathematical modeling competitions are also important means of assessing students' computational thinking. These competitions typically involve complex mathematical problems and scenarios that require the use of computational thinking for solving. By participating in competitions, students can be evaluated for their depth and breadth in computational thinking. Because not all students participate in math competitions, this score is only used as an important reference indicator.

In summary, the assessment of computational thinking in mathematics courses can be conducted through various methods, which can complement each other and comprehensively evaluate the level of students' computational thinking ability.

4. Conclusions and Discussion

Linear algebra can effectively cultivate students' core abilities such as abstract thinking, logical thinking, algorithm design and optimization, improve their ability to solve practical problems, and cultivate interdisciplinary application skills, team collaboration and communication skills. It is crucial for the cultivation of computational thinking and is of great significance for students' future learning and career development. How to cultivate students' computational thinking better in the teaching process will be a topic we have been researching.

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