

New teaching approach to the course *3D Math Primer for Graphics and Game Development*

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ABSTRACT: The course, 3D Math Primer for Graphics and Game Development, one of the professional basic courses for undergraduates of the digital media specialty, focuses on the mathematical knowledge associated with computer graphics and game development. The course is characterised by abstract theory but the students have weak basic mathematical knowledge. To improve the quality of teaching and its effect, it is necessary to carry out teaching reform of this course, reflecting the students' aptitude. The reform of the course is described in this article, including the teaching content and methods, examinations and practical teaching. The reform is highly significant to the development of engineering and technology education. It can be stated that the reform improves the teaching of the course, enhances students' ability to innovate, and also strengthens their practical ability.

INTRODUCTION

The course, 3D Math Primer for Graphics and Games Development (*3D Math Primer*) provides an important foundation for the digital media major, and it is also the basis for game development and animation design. The course mainly introduces the mathematical knowledge required by computer graphics and game development, as well as focusing on 3D mathematics.

The course covers the basics of algebra and geometry, such as vectors, matrices, quaternions and geometric transformation. It also introduces the theory and methods related to collision detection of geometric primitives, the realisation of triangular mesh and the determinant of visibility. 3D Math Primer closely integrates theory and practice, as well as principles and application.

The students taking the course are mainly from the digital media specialty and who plan to be engaged in game development or animation design. The teaching goal is to make students familiar with the basic mathematical principles and method used in computer game development and to lay the foundation for students in their further study of advanced development technology.

As a professional foundation course of the digital media major, 3D Math Primer focuses on the mathematical knowledge and principles involved in game development and animation design. The course is characterised by abstract theory and numerous mathematical formulas. However, students of the digital media major usually are weak in basic mathematical theory. Therefore, how to teach the course effectively is the key driver of teaching reform [1-3]. In considering the current teaching and years of teaching experience, the reform of teaching content, methods, examinations and practical teaching is also covered in this article.

TEACHING CONTENT REFORM

Taking into consideration teaching material, teaching plans and the characteristics of the students, several aspects of teaching reform are analysed below:

Pay attention to the applicability of the teaching content: 3D Math Primer is a course that has strong practical applicability because it is the basis for game development and animation design [4]. To arouse the enthusiasm of students before the teaching of it, students are introduced to the application background and practical problems that can be solved after completing the course. For example, to introduce the concept of *linear transformation*, a short computer program is written and demonstrated showing the effects of linear transformations (a screenshot of the program is shown in Figure 1).

Students are surprised at the changes and the authors ask: *How can we make such interesting changes?*, which successfully stimulates student discussion. The authors tell the students that all these amazing changes can be implemented based on some transformations, and the linear transformation is the most fundamental. Although many mathematical formulas included in the lesson of linear transformations are very complex and difficult, all the students then show heightened interest, because they recognise that highly significant results can be achieved when the complicated formulas are applied.

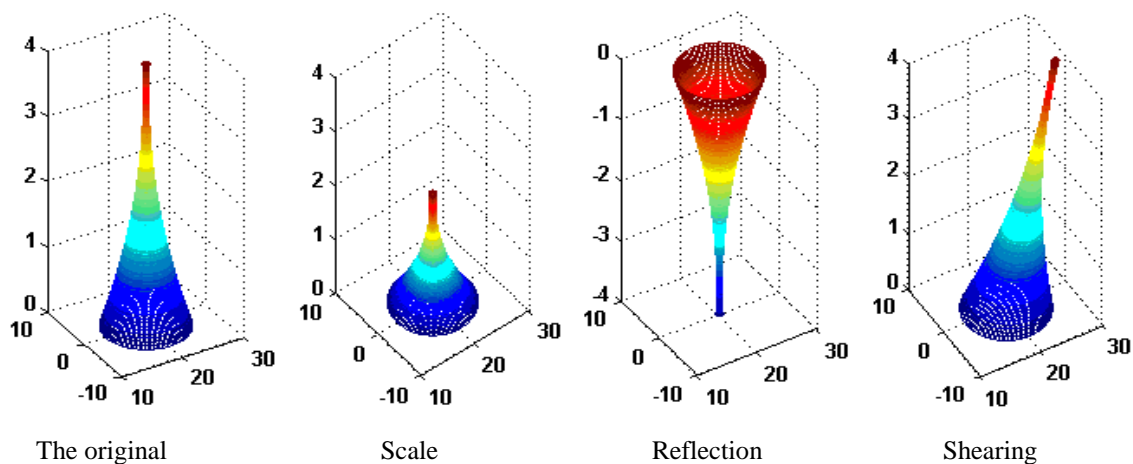


Figure 1: The demonstration of linear transformations.

Hence, based on a brief introduction to the applicability of the teaching, the students can understand that the learning they achieve is useful and applicable, and this will make them active participants in class.

Pay attention to the concrete and visual descriptions of abstract theory: it is often stated that *mathematics comes from life and is the abstraction of many vivid examples*. However, many textbooks cover theory and ignore application. This causes a number of students to feel that the teaching content is boring. So, more attention should be paid to the application of abstract theories. For instance, when students are taught how to express the range using the Euler angle, an animation model from the network gives them a visual understanding of *heading-pitch-bank*. At the same time, a simple plane model is made and demonstrated in class.

Based on these demonstrations, most students feel that mathematics is a tool with which to solve practical problems. Hence, using concrete and visual examples to explain some abstract problems is a very effective way for students to overcome their *mathphobia* and arouse their interest in the course.

Pay more attention to the geometric meaning of mathematical concepts: 3D Math Primer is designed to focus mainly on explaining game development and animation design. Hence, people pay more attention to the geometric explanation of the mathematical formulas in the teaching, such as the relationship between determinant and the volume, triangular mesh and image expression.

Meanwhile, one places little emphasis on the mathematical meaning of these formulas, which saves a lot of time and also keeps the students from being dragged into the quagmire of mathematical theory. From feedback, the teaching is good and the students' interest in learning is increased.

Pay more attention to theoretical derivation than to the memorising of mathematical formulas: although there are many mathematical formulas in the course, it is difficult as well as unnecessary for students to memorise all of them because, in practice, all these formulas can be referenced from a book. So, the authors do not encourage students to spend time remembering formulas. By contrast, the process of theoretical derivation is a good way for students to enhance their logical thinking ability and mathematical literacy. Therefore, in the classroom, the authors think it is more important to guide the students in their exploration of the unknown based on theory.

TEACHING METHODS REFORM

Combine modern with traditional teaching methods [5]: do not completely deny the traditional teaching methods, but use often some traditional means, dependent upon the teaching content. Take the derivative, for example, if the derivative is demonstrated in the multimedia courseware, it is very difficult for the students to understand, because it is introduced too quickly. It is better if the derivative is demonstrated on the blackboard.

Questions are raised in order to guide students in their study: 3D Math Primer is a course that has strong applicability. However, many textbooks have few application examples because of space restrictions and this, therefore, makes the

course complicated and boring for the students. So, the authors, for example, ask practical questions to guide the students' thinking and to inspire them to acquire knowledge. As an example: when the section on light and atomisation is taught, the authors firstly ask a question, such as *how do you render?* and *how do you achieve the desired result?* Thinking about these questions can mobilise the students' desire to seek knowledge and, thus, enhance their learning.

TEACHING REFORM

3D Math Primer is a ubiquitous course [6]. Improvement of the teaching can help students understand the abstract theories and methods in the course and improve their practical ability [7]. In terms of teaching reform, the authors have the following experience:

Pay more attention to in-class demonstrations: class demonstrations deepen the student's understanding of theory. But also, by the exploration of the programs, provide a comprehensive understanding of programming languages.

Pay more attention to the combination of experimental methods: the course is characterised as having rich practical content, with limited teaching hours. Therefore, it is impossible for the teacher to complete all the teaching in-class. Hence, the authors use various ways in order to complete the teaching as follows:

- Research-based experiments. The authors pose a question and the students utilise their learning to solve the problem. For example, the authors ask: *how to render a picture?* The students would solve the question based on their knowledge of light and atomisation.
- Daily life-related experiments. Some questions about daily life can be solved by the students with the knowledge they have learned. For example, linear transformations can be used to deal with questions about pictures.
- Computer experiments. The students solve some questions of game development in the laboratory.

REFORM OF ASSESSMENT

There are many mathematical formulas in the course and the students of digital media are usually weak in basic mathematical knowledge. The students would have to memorise many formulas if the examination were closed-book. Therefore, the authors' assessment method is a combination of an open-book examination with other regular gradings [8]. The detailed assessment scheme is shown in Table 1.

Table 1: The assessment scheme of 3D Math Primer.

Assessment content	Specific requirements	Score	Credit
Regular grade	Attendance	10	3
	Class discussion	10	
	Homework	10	
Final examination	Open-book examination	70	

The final examination is open-book and accounts for 70% of the total assessment. Usually, the questions on the examination paper are problems that require students to apply the formulas in their textbook to solving some practical problems. So, the teaching material becomes the tool by which to solve such problems. This testing method can save the students from the pain of memorising complicated formulas and improve their practical ability to solve problems.

The regular grade (see Table 1) accounts for 30% of the total assessment, and includes class attendance, homework and classroom performance. There is a quantitative assessment of class attendance and homework. Classroom performance is evaluated based on in-class discussion and question-answering of students. Taking classroom performance into the evaluation encourages students' participation in class.

ANALYSIS OF THE REFORM

The practical results show that these reforms can stimulate students' interest in learning and cultivate their hands-on capabilities. The comparison made before and after the reform is shown in Figure 2. The data in Figure 2 cover four semesters. There are two semesters before the reforms and two after. There are two classes in each semester. The completion rate of homework measures the assignments, and the teacher evaluation scores indicate the students' evaluation of teaching effectiveness. Figure 2 shows that all indicators have shown improvement after the reform. This shows that there is a significant improvement in the teaching.

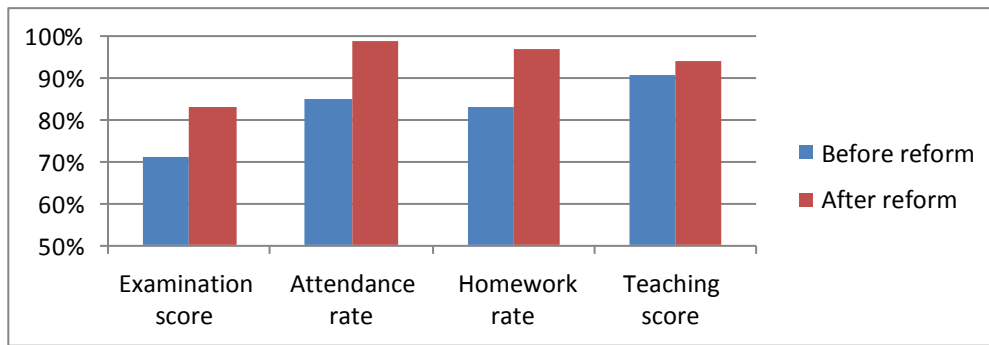


Figure 2: Comparison of results.

CONCLUSIONS

The teaching reform of the 3D Math Primer course was discussed in this article, and it includes teaching content, methods, examinations and practice teaching. The results show that these reforms can stimulate students' interest in learning and cultivate their hands-on capabilities and experience.

Of course, the task of teaching reform is an arduous one. More discussion and resulting actions are needed to further improve the teaching of this course.

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