Application of Differentiated Instruction in FEM Course for Graduate Students

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Abstract

Finite element method (FEM) course is a very important specialized elementary course for many graduated students of different majors and it has been a challenge for teachers to find teaching strategies that cater for such a variety of students. A paradigm that is gaining ground in many educational circles is differentiated instruction, which maximizes learning by considering students' differences. This paper describes differentiated instruction, discusses the reasons for applying it in FEM course, and suggests how to apply it. The results confirm that it is feasible and beneficial for teachers to apply differentiated instruction in courses for students of different majors.

Keywords: Differentiated instruction, FEM course, graduate students teaching

1. Introduction

Differentiated instruction is a teaching theory based on the premise that instructional approaches should vary and be adapted in relation to individual and diverse students in classrooms [1]. It applies an approach that gives students multiple options for taking in information and making sense of ideas. Many teachers and teacher educators have recently identified differentiated instruction as a method of helping more students in diverse classroom settings achieve success.

Finite element method (FEM) is a numerical technique which is probably used for the analysis of every major and probably in every branch of scientific studies [2]. As a result, many schools have set FEM course for graduate students, while the major of the students might be quite different. The "one-size-fits-all" approach does not provide optimum learning opportunities for such diverse student population [3]. In order to meet the diverse needs of students in FEM course, differentiated instruction could be a good choice for teachers.

2. What is Differentiated Instruction?

Differentiated instruction is a philosophy of teaching and learning which recognizes that each learner is unique [4]. Differentiated instruction is a response to that uniqueness, and it is an effective way for teachers to offer meaningful instruction delivered around challenging content and designed to meet the needs of students at their appropriate levels and to help them achieve maximum growth.

In order to prepare for differentiation, sound teaching principles must be honored and a quality curriculum must be in place [5]. Applying standards while designing and organizing instruction, a teacher must be clear on what all students need to know, understand, and be able to do at the end of the unit. The teacher should be familiar with student differences that affect the unit and build on these differences, making adjustments in the content of the unit, the multiple ways students process the content, and the various products they create in order to demonstrate what they have learned. To enhance learning for all students, the goals of differentiated instruction include:

establishing a balance between a student-centered and teacher-facilitated classroom, providing opportunities for students to work in a variety of formats, developing instruction around the standards and the "big picture" concept of the unit, designing challenging and respectful tasks for all, and meeting curriculum standards and requirements while maximizing student growth and individual success.

3. Why Apply Differentiated Instruction in FEM Course?

A simple answer is that students in the FEM course vary greatly, and if teachers want to maximize their students' individual potential, they will have to attend to the differences.

- The majors of the graduate students in FEM course are different, including aircraft design, civil engineering, fluid mechanics and electromagnetism.
- The knowledge backgrounds of the graduate students in FEM course are different. For example, the foundation courses learned by graduate students of the aircraft design major and the graduate students of the civil engineering major are not the same.
- The research areas of the graduate students in FEM course are different, such as metal structure, composite material, concrete, electromagnetic field, thermal field and fluid flow.
- The FEM software used by the graduate students of different majors is different. There are hundreds of FEM software, and each major has its own appropriate software. The famous FEM software includes Abaqus, LS-Dyna, Marc, Nastran, Patran, Fluent, ANSYS, ADINA and so on.
- The interests of the graduate students in FEM course are different. Some may be interested in static analysis, while others may be interested in dynamic analysis, modal analysis, or fatigue analysis.
- The learning profiles of the graduate students in FEM course are different. A number of variable comprise a student's learning profile including the desire to work alone or in groups, preferring hands-on activities over developing logical-sequencing activities, and demonstrating a strong musical-rhythmic intelligence.
- Another reason for differentiating instruction relates to teacher professionalism. Expert teachers are attentive to students' varied learning needs [4], to differentiate instruction, and then, are to become more competent, creative, and professional educators.

4. How does Differentiated Instruction Apply to FEM Course?

Differentiation is not about creating an individualized daily lesson plan for each and every student. Due to class sizes, state and district mandates, and many other factors, few teachers realistically have time, resources, or energy to differentiate to that degree. Differentiation is about understanding the needs and abilities of your class and providing alternatives within multiple, but manageable constraints. The following strategies provide some options for differentiating instruction in FEM course for graduate students.

4.1. Getting to know students

Teachers need to know as much as possible about their students to teach them well. One way for teacher to know the students in FEM course is to ask the stu-

dents to complete questionnaires. Table 1 is the questionnaire table designed for FEM course.

Table 1 Questionnaire table

Personal Information Survey

Name _____ date _____.

- My major is _____.
- My undergraduate school is _____.
- My major in undergraduate school is ____.
- Courses I have learned in undergraduate school are:____.
- Knowledge I wish to learn in FEM course is _____.
- The FEM software usually used in my research area is:_____.
- The FEM analysis type in my research area is:_____.
- The research object in my research area is:_____.

4.2. Reorganizing the content of FEM course

According to the differences of the students in FEM course, we have to reorganize the content of the class.

Some essential supplemental knowledge should be introduced in class if any of the students have not learned in their undergraduate school course, even when some students may have learned it. For example, the functional extreme value problem, Rayleigh-Ritz method, principle of minimum potential energy and variation are all have to be introduced;

The common knowledge in FEM, which is suitable for all majors, should be paid much more attention to, such as geometric equation, physical equation, geometric matrix, elastic matrix, mesh generation, element stiffness matrix, isoperimetric element, coordinate conversion, whole stiffness matrix, nodal load column matrix, displacement boundary condition, displacement function, etc.

Just introduce the public knowledge of the FEM software.

The content in our FEM course is shown in Table 2.

Table 2 FEM course content

Topic title	Content
FEM theory	Supplemental knowledge
	Basic FEM theory
	Element stiffness matrix
	Isoparametric element
	Coordinate conversion
	Nodal load column matrix
	Displacement boundary condition
	Whole structure balance equation
Reports about the application of FEM	Crack propagation characteristics and residual strength study of lugs using FEM
	Finite element analysis of a joint specimen
	Study on the buckling performance of composite stiffened plate using MSC.PATRAN/NASTRAN
FEM software	Introduction of FEM Software
	Common Dialog Coordinate
	Conventions of Coordinate System
	Conventions of Element
	Common Dialog Vector
	Common Dialog Plane
	FEM Software Notes

4.3. Differentiating the teaching process

Since the students in the FEM course are diverse, a flexible teaching process should be applied.

The teaching mode should be multiple, including intensive teaching, seminar, curriculum of literature reading discuss, inviting speeches, student report, design course, etc.

Students should be provided plenty of opportunities to participate in the teaching process.

Lectures on special topics of the typical use of FEM in some actual problem will be given by invited guests, and students can discuss with the invited guests freely.

Students will be divided into several groups according to their major, so that teachers can assign different tasks to different groups.

The class period distribution of our FEM course is shown in Table 3.

Table 3 Class hour distribution

mode	*hours*	*Percentage*
Intensive teaching	20	33%
Seminar	14	23%
Literature reading	4	7%
Design course	10	17%
Inviting speeches	6	10%
Student reports	6	10%

4.4. Differentiating the assessment model

In differentiated instruction, assessment is ongoing and diagnostic to understand how to make instruction more responsive to learner needs. Assessment may be formal or informal, including interviews, surveys, performance assessment, and more formal evaluation procedures.

In our FEM course, the testing and evaluating modes comprise five parts, including written examination, literature reading, seminar, course paper and self design and exploitation. The assessment time, check content, weight of these five parts are shown in Table 4.

Table 4 Assessment model of our FEM course

Mode	Written examination	Literature reading	Seminar	Course paper	Design and exploitation
Time	At the end	During class	During class	At the end	During class
Same/different	Same	Different	Different	Different	Different
Weight	30%	10%	30%	10%	20%

5. The Effect of Applying Differentiated Instruction in FEM Course

According to the survey results of the students in our FEM course, all students have mastered the common knowledge of FEM and the average point of written examination is 91. Besides, students of different majors have got the FEM knowledge in their own research area, and can apply the FEM software used in their major. 80% of the students wrote their first academic paper using FEM after they learned our FEM course.

6. Summary

Differentiated instruction is an important tool for engaging students while providing for individual needs. It is important to note that differentiation is not a single instructional strategy but rather a methodology that blends a variety of strategies. Diversity in assignments, products, and pacing allow students to work at their own level of challenge and achieve their own levels of success.

The majors of the graduate students in FEM course are quite different. As a result, differentiated instruction is a good choice for teachers to meet the diverse needs of students in FEM course. This paper describes differentiated instruction, discusses the reasons for applying it in FEM course, and suggests how teachers can start implementing it. The results confirm that it is feasible and beneficial for teachers to apply differentiated instruction in courses for students of different majors.

7. References

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