ISSN 2663-8169 Vol. 6, Issue 2: 7-10, DOI: 10.25236/IJNDE.2024.060202

Exploration of Hierarchical Teaching in Digital Signal Processing Course

Yuan Hong[1,2], Gao Jiayi[1]

[1]School of Mathematics and Statistics, Linyi University, Linyi, Shandong, China
[2]Philippine Christian University, Manila, 1004, Philippines
yhian@163.com

Abstract: *With the proposal of the "Internet+" concept, a new form of teaching, hierarchical teaching, has emerged as one of the innovative teaching methods. The hierarchical teaching model is an important means to improve the quality of teaching. In this paper, based on the characteristics of the course of digital signal processing, after determining the teaching objectives, it specifically elaborates on how to construct hierarchies within the class, and further provides corresponding suggestions in four dimensions: matching students and teaching content, classroom teaching, extracurricular assignments, and assessment and evaluation.*

Keywords: *Hierarchical teaching; Digital signal processing; Matching*

1. Introduction

The course of digital signal processing is an important foundational course for majors such as information and computer science, electronic information engineering, etc., at the university level. Deepening the course reform directly relates to the cultivation of high-quality and high-level talents. Adjusting the difficulty of teaching content for different levels of students and achieving hierarchical teaching is a problem faced by teachers [1]. Due to the differences in students' knowledge reserves, learning literacy, and learning attitudes, coupled with the differences in professional training objectives, a single, uniform teaching mode for all students is difficult to meet the needs of modern education. It is urgent to find suitable teaching methods that fit the learning patterns of students.

2. Literature Review

Hierarchical teaching is based on the theory of teaching in accordance with students' aptitude, and it is a method of implementing different teaching methods and teaching methods according to the differences of students in the teaching process, allowing students to make the greatest progress in different learning environments. Currently, most of the literature on hierarchical teaching focuses on the entire school [2][3], and most of the hierarchical teaching models for different courses are based on different textbooks and classroom content [4][5], and are based on different syllabi according to the professional training program, and are based on differences in teaching objectives and student levels to carry out class-based hierarchical teaching [6]-[8].

3. Description of the Study

Given that the digital signal processing course is basically taught in small classes, and the subjects of this study are frontline ordinary teachers, further discussion is needed on how to implement hierarchical teaching within the class when there are significant differences among students under the conditions of determining teaching objectives and content.

3.1. Stratified Classification of Students

Stratified classification of students is the basic work of hierarchical teaching. This process can help teachers understand students and can also help students understand themselves and the content of the course. The hierarchical classification of students can be divided into three aspects:

ISSN 2663-8169 Vol. 6, Issue 2: 7-10, DOI: 10.25236/IJNDE.2024.060202

3.1.1. Knowledge reserves

In many schools, even in the same major, different students have differences in the content and quality of the courses they have studied in the first and second years. For example, in the digital signal processing course, some students say they have not studied some of the content from the signal and system course, which is often used. Only when teachers understand these differences can targeted teaching be implemented; only when students understand these differences can they correct their learning attitudes and set appropriate learning goals during the learning process.

3.1.2. Learning ability

Digital signal processing is a highly theoretical course, involving numerous mathematical derivations and computations. Some students grasp abstract concepts quickly, while others have strong analytical abilities. Some students rely heavily on teachers for understanding, while others have deep programming skills. These differences result in varied individual capabilities and will lead to different achievements in the future. However, during the learning process, different learning methods are needed, and teachers should provide differentiated learning content.

3.1.3. Learning objectives

Some students aim for further education, some strive to achieve success in their professional field, while others simply aim to graduate smoothly. Different learning objectives will affect students' learning interests and attitudes. Accordingly, teachers should provide different teaching methods based on these differences.

These stratifications can be carried out in the form of a questionnaire, which does not need to be too extensive, consisting of 15-20 questions. It can be completed in just a few minutes before the first class. Subsequently, students can be categorized into A, B, and C based on different aspects. By employing a pre-class questionnaire survey method (Figure 1 shows the statistical results of a questionnaire survey conducted by students on the learning objectives they aim to achieve in the course), both students and teachers can quickly understand the situation.

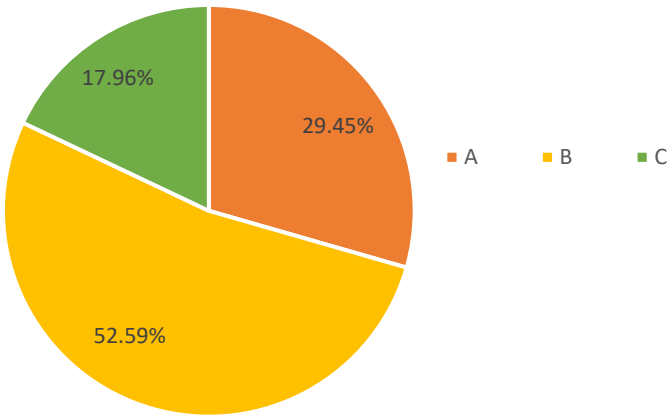

Figure 1: Statistics of the questionnaire survey on Learning Objectives for Students

3.2. Hierarchical differentiation of teaching content difficulty

Since the teaching syllabus for each class is predetermined, the teaching content and objectives are the same. Even the difficulty of the teaching content is reflected in the syllabus. Therefore, our hierarchical teaching can only be formulated based on the syllabus, which outlines the minimum requirements. In general, the syllabus sets several levels of requirements for the teaching content, such as understanding, comprehension, and mastery. However, for students with a higher level of proficiency, it is easy for them to meet the requirements of the syllabus after learning, so they can be challenged with higher requirements. On the other hand, for students with lower proficiency, it may be difficult for them to meet the syllabus requirements. In this case, in the design of teaching and experimental simulations, lower-level achievement goals can be set for them. Only after reaching a certain level of proficiency

ISSN 2663-8169 Vol. 6, Issue 2: 7-10, DOI: 10.25236/IJNDE.2024.060202

should they strive to meet the syllabus requirements. To achieve hierarchical differentiation of teaching content, several tasks need to be accomplished:

3.2.1. List all the knowledge points and syllabus requirements

Summarize the knowledge points according to the teaching outline and textbook. For example, in the section on Discrete Fourier Transform (DFT), we can extract the following knowledge points: the definition of DFT, the relationship between DFT and Discrete Fourier Series (DFS), the relationship between DFT and Z-transform (with a focus on understanding the interrelationships among the three), the implicit periodicity of DFT[9], the relationship between the number of sampled points and the sampling frequency within one period, etc.

3.2.2. Design teaching objectives for the same teaching content based on different requirements

Different teaching objectives require different designs for the same teaching content. For example, in the concept of frequency domain sampling theory[10], if the objective is awareness, students need to understand the specific theoretical content and its simple applications. If the objective is understanding, students also need to comprehend the differences in output waveforms when performing inverse discrete Fourier transform with different frequency domain sampling points, such as 16 points and 32 points. If the objective is mastery, further considerations need to be given to temporal aliasing distortion generated by different sampling points. The depth and breadth of explanation should vary based on the different levels of understanding of the same knowledge point among students.

3.2.3. Design teaching based on different teaching objectives.

According to different teaching objectives, teaching design includes classroom teaching design, extracurricular assignment design, and assessment design. If the design of teaching objectives is to answer the question of what to teach, classroom teaching design is to answer the question of how to teach. Extracurricular assignment design includes pre-class assignments and post-class assignments. Pre-class assignments are used to assess students' mastery of preparatory knowledge and self-learning abilities, while post-class assignments are intended to assess students' mastery of classroom teaching and serve as a form of self-assessment for students [11]. Assessment design is conducted by teachers to assess students' mastery of knowledge and whether they have achieved the learning objectives.

3.3. The implementation of hierarchical teaching

After the students and teaching content have been stratified, the final step is to implement hierarchical teaching.

3.3.1. Matching student stratification with teaching content stratification

After stratifying students and teaching content, it is necessary to recommend students to choose teaching content corresponding to their level. If students find it relatively easy to achieve the learning objectives at a certain level during the learning process, they can adjust accordingly. Conversely, if students find it challenging, they can focus on the learning objectives at a lower level. Students can adjust their learning based on their individual progress. For instance, we designate learning module A for teaching content with higher learning objectives, learning module B for teaching content with moderate learning objectives, and learning module C for teaching content with lower learning objectives.

3.3.2. Hierarchical classroom teaching.

Due to the constraints of time and location in classroom teaching, it is not always feasible to implement hierarchical design in the classroom. Therefore, it is necessary to provide teachers with recorded supplementary teaching videos. Typically, each knowledge point that can be covered in ten minutes in the classroom is considered a unit. If a topic requires more time, it needs to be further divided. For example, in the case of common spectrum analysis methods, FFT resolves storage and real-time processing issues, overcoming the drawbacks of FT in calculating spectra. In this scenario, during classroom time, we present the discrete spectrum of speech signals, involving sampling, fast Fourier transform, and filter design. Each subtopic may require the creation of two or three short videos. This way, if a student aims to achieve an understanding of the topic, they would need to watch two videos, and for mastery, all three videos would be required. While classroom teaching adheres to the curriculum requirements, to meet the diverse needs of students, they are required to watch the supplementary teaching videos outside of class.

Teaching videos allow students to autonomously choose and schedule their learning time, content,

ISSN 2663-8169 Vol. 6, Issue 2: 7-10, DOI: 10.25236/IJNDE.2024.060202

and pace in fragmented periods. Additionally, they can engage in online or offline discussions surrounding specific doubts or practical application issues, which not only deepens their understanding of their own questions but also greatly enhances their innovative consciousness and abilities through the collision of different viewpoints and ideas.

3.3.3. Hierarchical extracurricular assignments

Pre-class assignments can be standardized as they primarily test students' preparatory knowledge and preview of basic classroom content. Post-class assignments need to be pre-designed and can be divided into three sets of different levels. The second set of questions meets the requirements of the syllabus and is suitable for the majority of students. The first set focuses more on testing foundational knowledge and is suitable for slower-paced learners. The third set of questions increases in difficulty and is suitable for students with more advanced abilities[12].

3.3.4. Hierarchical assessment and evaluation

Hierarchical assessment requires a departure from a single assessment model of regular assessments plus final exams. It necessitates an increased emphasis on process assessment. Since the final exam papers for the same class are identical, teachers can only control regular grades and process assessment grades. Different levels of importance can be assigned to the final assessment for different groups of students. Module A places more emphasis on the final exam, while Module C places more emphasis on the process. Students in Module C receive higher process grades for the same performance during the learning process. This approach encourages high-performing students to prioritize their studies and prompts average students to focus on the learning process.

4. Reflection on the hierarchical teaching model

Hierarchical teaching plays a crucial role in educational reform, not only significantly enhancing student motivation and development but also improving the teaching quality of educators. However, there are some shortcomings in practical application. First, it places higher demands on teachers' abilities and qualities. Second, as hierarchical teaching requires a substantial amount of preliminary work, collaboration among numerous teachers is necessary for resource development. Third, the refinement of hierarchical work and evaluation is an ongoing, long-term process.

References

[1] Yuan, W. L., & Qiu, J. Research and thinking on the reform of digital experiment teaching. Experimental Technology and Management, 2011, 38(7): 138-140.
[2] Li, C. X., Yang, S. G. Exploration and practice of hierarchical teaching in advanced mathematics. Graduate Education Research, 2007, 3(6): 30-35.
[3] Wang, D., Liu, C., Liu, Y., Lu, Q., & Feng, X. Exploration of course classification and hierarchical teaching mode in digital signal processing. Experimental Technology and Management, 2013, 30(2): 31-33.
[4] Liu, J., & Wang, X. A hierarchical teaching model based on the flipped classroom approach for undergraduate programming courses. IEEE Access, 2019, 7: 142129-142139.
[5] Li, J., & Zhong, Y. Application of a hierarchical teaching model in the course of digital signal processing. IEEE Transactions on Education, 2018, 61(1): 58-65.
[6] Zhang, X., Li, J., & Li, S. A hierarchical teaching model for undergraduate software engineering education. IEEE Transactions on Education, 2017, 60(3): 175-182.
[7] Wu, Y., & Li, S. Design and implementation of a hierarchical teaching model for the course of database systems. IEEE Transactions on Education, 2016, 59(3): 168-174.
[8] Zhang, Y., & Li, S. A hierarchical teaching model for undergraduate computer network courses. IEEE Transactions on Education, 2015, 58(2):94-100.
[9] Gao, X. Q., & Ding, Y. M. Digital Signal Processing (5rd ed.). Xi'an: Xi'an University of Science and Technology Press, 2022.
[10] Chen, H. S., Wu, D.Z., & Gao, X. Q. MATLAB and its application in electronic information courses. Beijing: Electronics Industry Press, 2004.
[11] Wang, Y. F., & Wang, G. Reform and practice of digital signal processing in information profession. Journal of Electrical and Electronic Education, 2004, (1):37-39.
[12] Yu, Y., Xiao, J., & Liu, S. B. Exploration and practice of teaching reform in digital signal processing courses. Journal of Donghua University, 2011, 30(3):294-296.