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Teaching Reform and Practice of Data Structure Course Based on Smart Teaching Platform

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Abstract: With the rapid development of information technology, smart teaching platforms have become important tools for higher education teaching reform. As a core course of computer science and technology-related majors in higher education, the data structure course lays a solid foundation for students' professional learning and plays an important role in promoting their future success in technology, research, and industry. This study conducts an in-depth analysis of the pain points faced by the data structure course, and explores a teaching reform and practice of integration of theory and practice based on the system application of a smart teaching platform before class, during class, and after class. The reform practice shows that this teaching mode improves students' learning initiative, learning motivation, and practical skills. Students not only achieved better results in knowledge mastery but also significantly improved in problem analysis and solution.

Keywords: Data Structure; Teaching reform and practice; Smart teaching platform; Higher education

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1. Introduction

With the rapid development of information technology, smart teaching platforms have gradually become important means of digital teaching reform in higher education [1]. More and more university teachers integrate smart teaching platforms into classroom teaching. With the help of advanced information technology means, such as the Internet, big data, cloud computing, and artificial intelligence, it provides more abundant and flexible tools for teaching and learning, realizes the optimal allocation of teaching resources and the intelligent management of teaching process, and greatly improves the interactivity and personalization level of teaching [2,3].

Data Structure course is one of the core courses of computer science and technology-related majors in higher education [4], which is of great significance for cultivating students' programming ability and algorithm design and analysis abilities. However, in the traditional teaching mode, the course of Data Structure is often faced with problems such as the disconnection between theory and practice, the

asynchronous development of teaching content and technology, and the lack of students' active learning ability. These problems restrict the improvement of students' core competitiveness and need to be solved through teaching reform.

In recent years, some colleges and universities have applied smart teaching platforms to most course teaching, enhancing students' learning experience and participation through online videos, interactive exercises, and other forms [5,6]. For example, Wu *et al.* [4] discussed the teaching reform goal of integrating outcome-based education and classroom ideology, expounded the supporting relationship between learning content and ability and literacy, and designed teaching cases with the help of Rain Classroom tools, which proved that students' active learning ability, practical skills, and ability to solve practical problems had been improved. Based on the Rain Classroom teaching platform, Zhang *et al.* [7] proposed an online and offline hybrid teaching model, which strengthened the interaction between teachers and students, promoted the close combination of information technology and teaching, cultivated students' engineering thinking mode of analyzing and solving problems, stimulated students' learning initiative, enhanced students' unity, collaboration, and innovation ability, and met the requirements of applied talents training. Wu *et al.* [8] explored the blended teaching mode by combining the online teaching tool Rain Classroom. The teaching practice showed that the comprehensive use of the above teaching methods was helpful to cultivate students' higher-order cognitive ability, and then improve students' computational thinking ability.

However, the above literature research focuses on the use of a single smart teaching tool, which may not be able to comprehensively evaluate students' learning effectiveness and provide multi-angle feedback [9]. In addition, the teaching reform method proposed by Zhang *et al.* [7] has not formed a comprehensive and hierarchical teaching system for practical teaching and lacks an in-depth analysis of students' learning process and the design of personalized teaching paths. The teaching reform method proposed by Wu *et al.* [6] lacks a perfect and scientific evaluation mechanism, which is not conducive to an objective and fair evaluation of students, nor can it better help teachers to reflect on the teaching process. In view of this, this study aims to deeply analyze the background and pain points of the teaching reform and practice of the Data Structure course based on a smart teaching platform, and explore a set of teaching reform strategies for the Data Structure course based on a smart teaching platform. This study focused on how to use the smart teaching platform to improve the teaching quality and learning effect of the Data Structure course, how to build a teaching model that meets students' personalized learning needs, and how to realize the accurate analysis and effective intervention of students' learning process through the smart teaching platform. Through these explorations, this study is expected to provide a theoretical basis and practical guidance for the teaching reform of the Data Structure course, and contribute to the cultivation of high-quality computer professionals.

2. Conducting an in-depth analysis of the learning situation and clarifying the existing problems in teaching

Based on the statistics and comparison of the data of Data Structure course objective report in the past three years, and the comprehensive analysis of students and teachers, this paper concludes that there are four prominent problems in the traditional teaching mode of data structure course:

(1) Single teaching method and poor teaching effect [10]: In the traditional teaching mode, teachers mainly rely on PowerPoint courseware to teach, and the learning process is mostly explained by teachers

while students passively accept, which limits the opportunity for students to take the initiative to participate and think independently. As a result, students often lack enthusiasm and initiative for the course content. Teaching is often carried out in accordance with the predetermined teaching plan, rather than adjusting the teaching content according to the actual understanding and mastery of students, which is far from the teaching concept of "student-centered and results-oriented," resulting in unsatisfactory teaching results [11].

(2) Boring teaching content and insufficient ideological and political elements in the course: The Data Structure course is a very theoretical course, which requires students to have good abstract thinking and understanding skills. In traditional teaching practice, teachers focus on the imparting of knowledge points, which is often out of touch with the current time background and technology development, resulting in students' difficulty in understanding and absorbing what they have learned in time, and may lead to students' boredom and fear of the course content over time. In addition, the ideological and political elements of the course are insufficient in traditional teaching, and the teaching process lacks the link of values and outlook on life education for students in teaching, which is inconducive to guiding students to form a correct world outlook and values.

(3) Emphasis on theoretical teaching and weak experimental links: In the traditional teaching mode, teachers often pay attention to theoretical knowledge explanation, ignoring the training of experimental links. The course of Data Structure is divided into theoretical courses and experimental courses. The proportion of experimental and theoretical class hours is unbalanced, and there is a certain time interval between them, which makes it difficult for students to apply theoretical knowledge to practice in time, and affects the consolidation and in-depth understanding of knowledge. At the same time, due to the lack of experimental class hours and strict requirements for students in the experiment, there is a procrastination phenomenon among students and each experiment cannot be completed on time, which not only affects the cultivation of students' ability to solve practical problems but also weakens the effect of experimental teaching.

(4) Imperfect evaluation mechanism and slow feedback mechanism: In traditional teaching models, student assessment usually relies on attendance and final exam scores. Teachers use inefficient methods such as oral roll calls and manual recording of scores to assess students, which not only consumes a lot of time and energy but it is also difficult to ensure the accuracy of the assessment results. The imperfection of the evaluation mechanism leads to the delay of teaching feedback, which is not conducive to teachers' timely reflection and adjustment of teaching methods and strategies, affecting the improvement of teaching quality.

3. Constructing reform ideas to solve pain points

In order to deal with the four pain points in the traditional Data Structure course teaching, this study adopts a "student-centered" reform strategy, aiming to solve these pain points. This paper focuses on the construction of a teaching model with the core of smart teaching platforms (Learning Access, Rain Classroom, and PTA), which covers four stages of "pre-class preparation," "classroom interaction," "after-class review," and teaching evaluation and improvement, forming a complete teaching process. The object protagonists of the "pre-class preparation" and "after-class review" stages are students, and the "classroom interaction" stage are teachers and students. In addition, through the establishment of an effective teaching evaluation system,

the smart teaching platform can be continuously optimized and improved, and the teaching effect can be fed back in real time. The reformed teaching mode is shown in **Figure 1**.

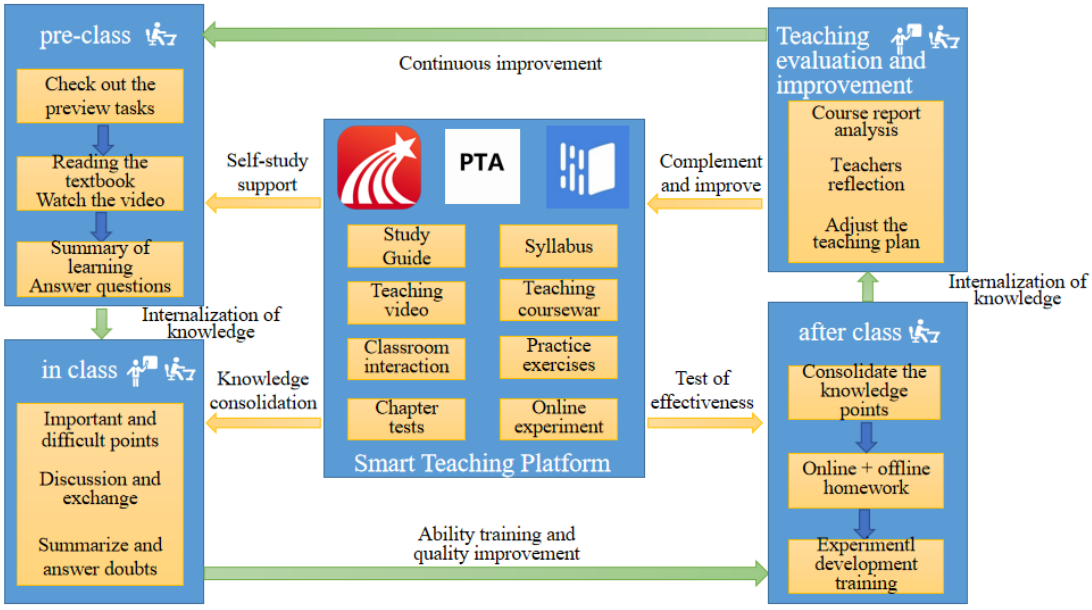

Figure 1. Overall idea of teaching reform

4. Innovating teaching methods and creating a smart teaching platform

4.1. Curriculum resources construction based on a smart teaching platform

Due to the large number of resources and uneven quality of Data Structure courses on the Internet, beginners face challenges in selecting high-quality learning materials. To this end, our teaching team has established a rich and systematic curriculum resource library on the Chaoxing teaching platform, including video textbooks, learning materials, and exercise sets, aiming to help students and teachers learn and teach more effectively. Currently, the course has attracted the participation of 2,232 students, conducted 1,592 class activities, submitted 319 assignments, conducted 18 examinations, and inspired 1,815 discussion topics.

(1) Chapter learning resources: The smart teaching platform provides chapter learning resources, including micro-lecture videos, after-class exercise guidance, competition guidance, final simulation papers, and experimental guidance manuals. These resources are not only helpful for teachers to prepare and teach lessons but also convenient for students to preview before class. Teachers can analyze students' learning behavior data to understand their learning progress and mastery, and then evaluate and improve teaching effect. Students can access the chapter resources on the platform at any time to learn and review by themselves. For difficult knowledge points, they can deepen their understanding and mastery by watching relevant videos or reading text explanations.

(2) Course auxiliary resources: Course auxiliary resources mainly include class courseware, lesson plans, course syllabus, and other materials. The courseware helps students review classroom knowledge points, and the lesson plan guides teachers to carry out teaching activities to ensure the fluency and integrity of teaching content and improve teaching efficiency. The syllabus lists the course name, course code, course type, credits, total class hours, and weekly teaching content

and class hours allocation in detail. This information is helpful in improving teaching quality, maintaining teaching order, enhancing teachers' teaching ability, and strengthening the school's teaching quality monitoring.

(3) Question bank resources: This platform provides a wealth of question bank resources, mainly including chapter exercises, discussion questions, etc. Chapter exercise types include single choice, multiple choice, short answer, fill in the blank, judgment, and other types of questions, students can check the answers and analysis after completing the exercise, and the same teacher can accurately grasp the situation of each student in the background, so as to make an objective and fair evaluation of students; discussion questions also encourage students to discuss in groups. In this way, teachers and students, students and students can interact with each other to discuss and solve problems together.

4.2. Teaching mode reform based on smart teaching platform

4.2.1. The blended theory teaching mode of "one lesson and two platforms"

In view of the characteristics of Data Structure course, such as many knowledge points and abstract content, the traditional teaching methods cannot meet the current teaching needs. Therefore, according to the characteristics of the course, this study designed a blended teaching model combining the two platforms of Learning Access and Rain Classroom. In this teaching mode, teachers use the two platforms to support students' autonomous learning before class, strengthen the consolidation of knowledge points and answer questions in class, and promote the improvement of ability and achievement evaluation after class. This teaching mode aims to guide students' autonomous learning, enhance their independent thinking ability, and implement the teaching concept of student-centered, results-oriented. The specific process and concept of the teaching model are shown in **Figure 2**.

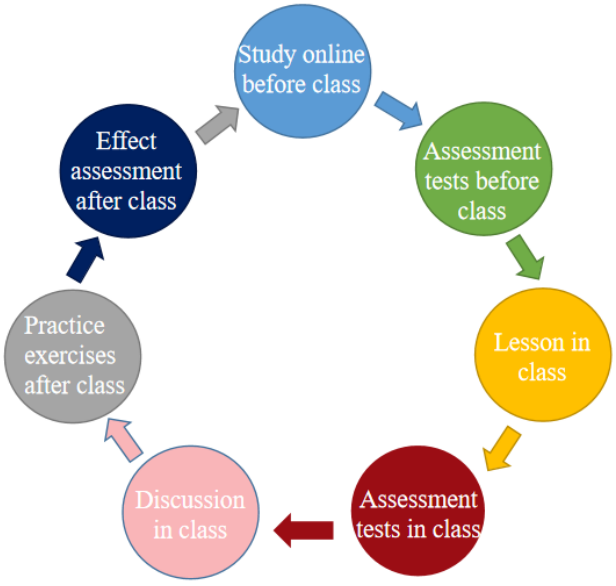

Figure 2. Basic idea of the teaching process

(1) Preparation before class: The smart teaching platform provides a wealth of chapter learning materials. Before class, teachers use the Learning Access platform to publish the learning tasks of the next course and encourage students to preview independently by watching the micro class video or referring to other materials, master the basic concepts, and complete the relevant exercises. At the same time, teachers

can monitor students' previews in real time in the back end, including students' learning progress and learning times to ensure autonomous learning. Students can detect the self-learning effect through exercises after preview, and can immediately find and make up for knowledge loopholes.

(2) Interactive stage in class: In class, teachers adjust the teaching content according to the preview situation of students, focus on explaining the important and difficult points, and briefly repeat the content that students have mastered, so as to truly take students as the center of learning. Through the Rain Classroom smart teaching platform, time-limited answering, group discussion, and other activities are carried out to detect students' learning effects. Students' problem-solving situations can be viewed in real time through statistical data, so as to timely and accurately understand the weaknesses of students' learning, supplement and explain the weak knowledge points of students, and form an effective teaching process driving mode.

In addition, the online scanning code sign-in and random roll call functions of the Rain Classroom smart teaching platform were used to improve students' classroom attendance and participation, activate the classroom atmosphere, and promote the interaction between teachers and students. Students can scan the code to view the teacher's teaching PowerPoint content in real time, and can mark the PowerPoint (including content that they do not understand). At the same time, students sitting in the back can also look at the mobile phone PowerPoint to listen to the teacher, which effectively solves the problem of poor line of sight in large class teaching.

In order to further play the ideological and political education function of the course, the ideological and political elements are fully mined in each chapter of the Data Structure course in the process of teaching reform, innovation, and practice. Through the actual course teaching, the ideological and political elements of the Data Structure course are roughly reflected in the aspects of algorithmic thinking (bubble sorting algorithm, topological sorting algorithm, etc.), craftsman spirit (time complexity, space complexity, etc.), national feelings (Huffman coding, array and generalized list, etc.), and humanistic literacy (stack and queue, compression matrix, etc.), which are combined with the teaching content. It further highlights the organic integration of ideological and political elements and professional content.

(3) After-class consolidation stage: According to the course syllabus, teachers assign diversified and multi-level exercises after class to evaluate the effectiveness. Related assignments and personal tasks, including subjective and objective questions, were published through the Chaoxing or Rain Classroom platform. Objective questions are automatically scored according to the reference answers by the platform, which reduces part of the workload of teachers and improves work efficiency. Subjective questions are carried out by students' mutual evaluation and teachers' manual marking.

In addition, in order to realize phased testing, the smart teaching platform also provides a variety of phased tests and mid-term examinations, teachers can release papers at any time to test students in class. The platform can set up functions such as random selection of questions and anti-plagiarism for each student to prevent students from plagiarism in the examination and ensure the fairness of the examination.

4.2.2. Building a comprehensive and hierarchical practical teaching system

In traditional experimental teaching, teachers usually publish electronic experimental reports, and students only need to complete the experiments and submit reports on an independent compiler. This method mainly verifies the knowledge points of the chapters. However, there are many shortcomings in this experimental teaching mode: the number of experimental topics is limited, and the content is not updated in time. There

is a lack of an effective evaluation mechanism. Without a clear time limit, students easily develop the habit of delaying the completion of tasks, which affects the effectiveness of practical learning. In order to overcome these problems, this study designed a set of comprehensive and hierarchical practical teaching systems, which was based on three levels of basic, comprehensive, and innovative, and constructed multi-level experimental types (including confirmatory experiments, comprehensive experiments, and innovative experiments), aiming to help students understand and apply what they have learned. Its architecture diagram is shown in **Figure 3**. In this system, the verification experiment class mainly verifies the knowledge points learned in each chapter of the class, and students can consolidate the foundation and master the relevant knowledge points through the experiment. The comprehensive experiment mainly examines students' comprehensive application ability, integrates multiple knowledge points, and investigates through different languages. Students can effectively improve their practical skills and independent thinking ability through the experiment. The innovative experiment mainly cultivates students' teamwork and scientific research ability. It adopts the project-driven mode and integrates scientific research practice into classroom teaching. Students solve complex engineering problems through experiments and exercise students' teamwork spirit.

Online practice was used in the whole process of experimental teaching. Teachers selected questions on the PTA practice teaching platform (https://pintia.cn/) and created a question bank for students to use. Students log on to the platform in the experimental class and submit the code according to the topic requirements, and the platform automatically evaluates the quality of the code and feedback on the score. In the process of experimental teaching, the weight of each link is reasonably distributed, and the distribution of experimental scores is: verification experiments account for 60%, comprehensive experiments account for 30%, and innovative experiments account for 10%. According to the progress of theoretical teaching, the corresponding practice content and deadline are reasonably set to prevent students from lagging in the practice process. At the same time, in order to encourage students to actively participate and think, the platform is set up to prohibit copy-and-paste mode in the practice process, which can reduce the plagiarism behavior between students to a certain extent. In addition, teachers can also track the progress of students completing the experiment in real time in the background, which can supervise students and make an objective and fair evaluation. Students can check their own mistakes after submitting the code and correct them, and they can also check the reference answers after the deadline to further improve their independent thinking ability.

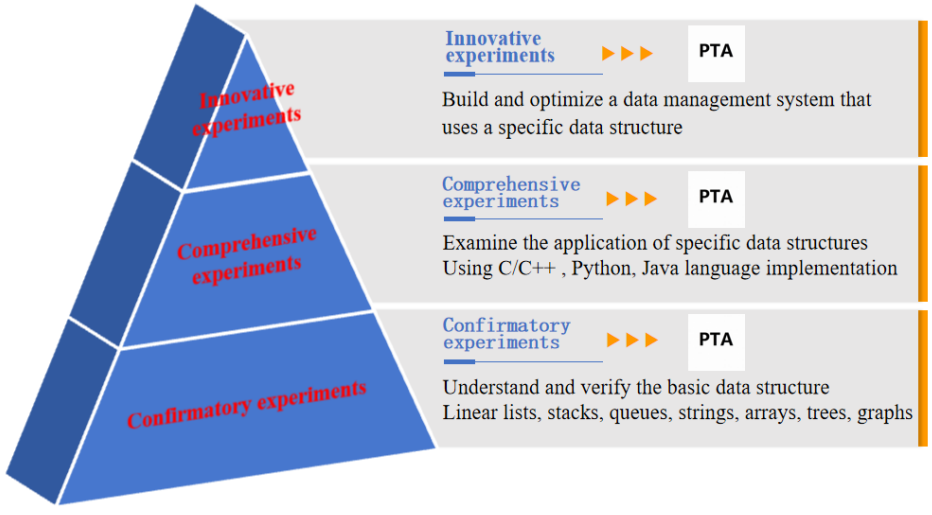

Figure 3. Construction of a comprehensive hierarchical practical teaching system

4.3. Constructing a three-in-one evaluation mechanism

Traditional teaching evaluation mainly relies on students' attendance and final examination scores, which often ignores the comprehensive evaluation of students' learning process and cannot truly reflect students' learning progress and effectiveness. In order to measure students' learning outcomes more comprehensively, this study highlights the whole process of assessment and diversified evaluation standards and methods, and constructs a set of perfect and scientific teaching evaluation systems. Whole-process assessment means that in the entire teaching cycle, whether it is theoretical learning or practical operation, there will be corresponding assessment measures. The diversified evaluation criteria emphasize not only the pursuit of standard answers in the examination but also encourage students to demonstrate personalized thinking and problem-solving skills. The diversified evaluation methods cover the combination of online and offline methods, including but not limited to pre-class preview activities, interactive check-in in class, discussion and communication, in-class exercises, and assignment submission and testing after class, so as to comprehensively investigate students' development in professional knowledge, skill application, emotional attitude, and values. The specific evaluation details of the Data Structure course are shown in **Table 1**.

Through formulating a perfect and scientific evaluation mechanism, it aims to improve students' active learning consciousness and promote the development of their critical thinking and innovation abilities. In addition, the evaluation system also provides teachers with a basis for timely feedback and teaching adjustment, which is helpful to improve the overall teaching quality, and better help teachers to reflect on the teaching process.

Table 1. Data Structure course evaluation details

Evaluation process	Time of assessment	Content of assessment	Percentage of points	Object of evaluation	Evaluation subject
Summary evaluation	In class	Regular testing	5	Individual student	Teacher/Chaoxing/Rain Classroom
	After class	Final exam	60	Individual student	Teacher
Process evaluation	Before class	Course preview	5	Individual student	Chaoxing/Rain Classroom
	In class	Sign in	5	Individual student	Chaoxing/Rain Classroom
	In class	Discussion and exchange	5	Group	Chaoxing/Rain Classroom
	In class	Class exercises	5	Individual student	Chaoxing/Rain Classroom
	After class	Homework after class	5	Individual student	Chaoxing/Rain Classroom
	In class	Experiment	10	Individual student	PTA platform

5. Analysis and reflection on the effect of reform and practice teaching

In recent years, our team has been carrying out the teaching of Data Structure course based on the smart teaching platform. Statistical data of the smart teaching platform show that the online participation rate of students reaches more than 90%, and they actively complete various tasks on time. In order to deeply understand students' satisfaction with the smart teaching platform, a satisfaction survey was conducted on 105 students majoring in Digital Media Technology in class 2022. The contents of the survey were divided into using dual platforms to promote personalized learning, curriculum resources help to understand

knowledge points, smart teaching platform helps to activate the classroom atmosphere, online practical teaching promotes the improvement of practical skills, evaluation mechanism is objective and fair, and smart teaching platform can improve teaching effect.

Table 2. Satisfaction questionnaire of Data Structure course

Survey content	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Learning can be personalized using "dual platforms"	80	19	5	1	0
Course resources contribute to the understanding of knowledge points	82	15	5	3	0
The smart teaching platform helps to liven up the classroom atmosphere	84	17	4	0	0
Online practical teaching promotes the improvement of practical skills	89	12	2	1	1
The evaluation mechanism is objective and fair	70	20	8	3	4
Smart teaching platforms can improve the teaching effect	89	15	1	0	0

As shown in **Table 2**, students are still satisfied with the implementation of a smart teaching platform, and more than 90% of them agree with the above survey contents. However, there is still a lack of objectivity and fairness in the evaluation mechanism, which may be related to the transparency of the evaluation process. In order to analyze the correlation between the test scores of students and the regular scores, the analysis is carried out according to the scores of a certain class of Digital Media Technology in class 2022, and the results are shown in **Figure 4**. In **Figure 4**, there is a positive correlation between test scores and regular scores, which means that regular scores can better predict test scores, which will help to promote student learning and development.

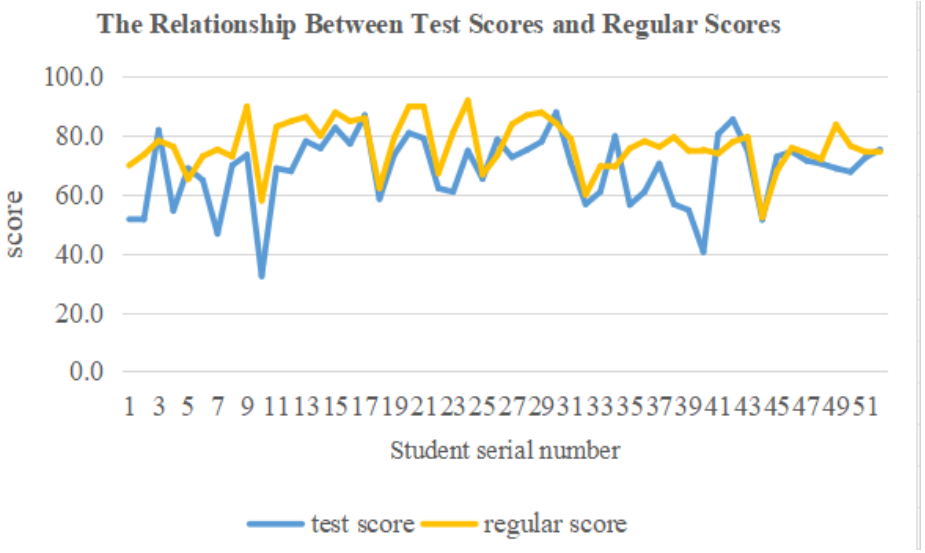

Figure 4. Analysis of the correlation between test scores and regular scores

The team also analyzed the achievement of the course goals according to the evaluation and implementation method of the achievement of the course goals, as shown in **Figure 5**. Through the analysis

of the achievement results, it can be seen that the achievement value of students in the course goal 1 is 0.679, which is higher than the expected target value, indicating that students have a good grasp of the basic concepts and knowledge of data structures. The achievement value of students in course goal 2 was 0.635, which was a little higher than the expected target value, indicating that students were able to master data structures and algorithms. The achievement value of the students in course goal 3 is 0.65, which is 0.05 higher than the expected target value, indicating that the students can solve complex engineering problems, but the ability in this aspect needs to be further strengthened.

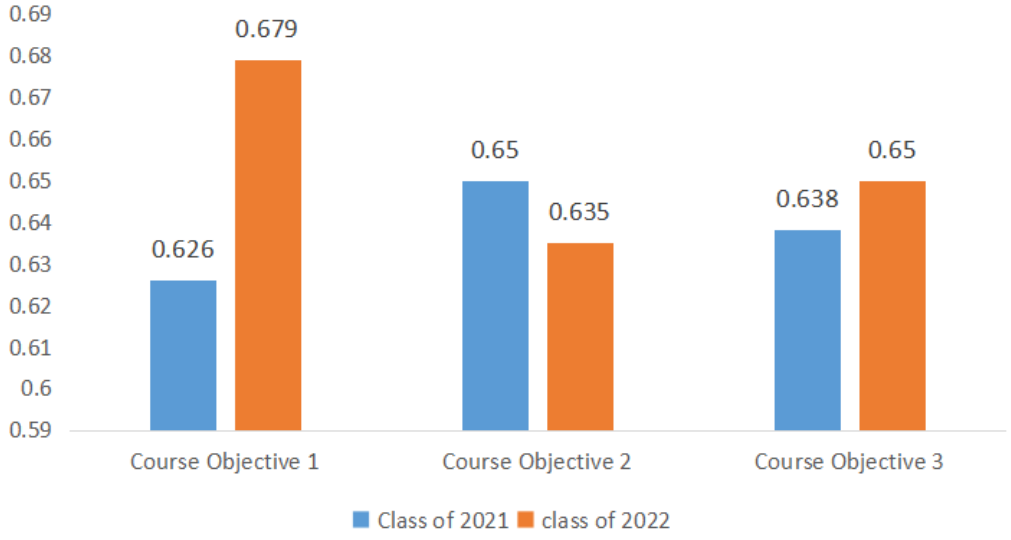

Figure 5. Comparative analysis chart of course goal attainment

Through the comparative analysis of the achievement values of the three course goals between the students of class 2021 and class 2022, the achievement value of the students of class 2022 in course goal 1 increased, indicating that the method of "online + offline combination of theory and practice synchronous teaching" played a certain role. The achievement value of the students of class 2022 in course objective 2 has decreased, which may be due to a lack of full understanding of the overall data structures and algorithms, students may only master some individual data structures and algorithms and cannot relate knowledge points to each other. The achievement value of class 2022 students on course objective 3 has increased, indicating that the adoption of online PTA practice teaching has a certain promotion effect. In summary, the "online + offline" teaching mode adopted in this course can improve students' learning effect.

6. Conclusion

In this study, the four pain points existing in the teaching process of Data Structure course are comprehensively analyzed, and a hybrid theoretical teaching mode of "one lesson and two platforms," a comprehensive and hierarchical practical teaching system, and a trinity evaluation mechanism are constructed. The comprehensive reform and practice of course teaching are carried out, and the teaching effect is reflected. The research data prove that the smart teaching platform has a significant positive impact on improving the teaching effect and students' learning effect of Data Structure course. However, the practice of smart teaching is a process of continuous development, which requires the joint efforts and continuous exploration of teachers, students, and educational technology personnel. The future work

will continue to optimize the function of the teaching platform, deepen the content of teaching reform, and explore more effective teaching methods, so as to realize the long-term development of data structure teaching and the comprehensive improvement of students' ability.

In the future, we will further strengthen the support of scientific research in teaching, realize the teaching concept of promoting research by teaching, and cleverly integrate auxiliary teaching and research to achieve the goal of teaching "innovation." We will constantly update and improve teaching resources to meet the learning needs of students and constantly explore new teaching methods and means to improve the teaching effect. The evaluation criteria and methods should be further improved to reflect the students' learning situation more comprehensively.

Disclosure statement

The authors declare no conflict of interest.

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