A Hybrid Teaching Reform to Enhance Higher Order Thinking and Integrate Ideological and Political Objectives in an Environment for Smart Learning

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Abstract. The idea of "smart teaching" encourages a thorough integration of information technology and education teaching, which transforms the educational system and gradually creates a new model of teaching and learning. In this paper, we use the data structure course as an example and implement hybrid teaching and learning using the China University MOOC platform, the PTA online programming training platform, and the Rain Classroom smart teaching tool to support students' personalized and differentiated learning. Additionally, we create a model for the analysis of learning effectiveness to precisely map student learning through the analysis of the massive amounts of data produced by blended learning, allowing for the prescription of the targeted therapy as well as strong encouragement for teachers to improve their instruction and students' self-learning awareness.

Keywords: higher-order thinking · smart learning · rain classroom · data empowerment · learning effectiveness analysis model

1 Introduction

Data Structures is a critical professional foundation course for computer science students, with complicated educational content and high practical demands. In response to the new era's demand for high-quality classrooms, the teaching reform of data structures has made various advancements in flip classroom [1, 2], split teaching [3], BOPPPS model [4, 5], information technology tools such as rain classroom [6], OBE concept [7], and hybrid teaching [8–10]. A key training objective for university classes nowadays is how to use information technology to develop individualized learning environments and learning models in accordance with the backgrounds, interests, and receptiveness of various students. In the future, online and offline hybrid teaching and practice will be the new standard in higher education, with instructors using a combination of offline classrooms, smart teaching tools, and online teaching resources. Hybrid learning has recently emerged as a major topic of discussion in the realm of educational reform and innovation [11]. In terms of the design of teaching and learning in Data Structures

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Course, this paper's primary focus is on developing the overarching goal of reforming how data structure courses are taught: to "improve higher-order thinking and combine thinking and politics". The second is to use information technology to create a smart learning environment that supports students individualized and differentiated learning. The third step is to create a model for analyzing learning effectiveness to give teachers and students a clearer image of students' learning and to implement individualized learning and guidance based on the model's output to raise the caliber of talent development. The following describes specific procedures.

2 OBE Concepts

OBE's "reverse" design concept first appeared in basic education reform in the United States [12], which emphasized that teaching objectives should come before teaching contents, and reverse teaching design [13] centered on realizing the abilities and requirements that students should achieve when they graduate.

OBE concentrates on four basic issues: what learning objectives do we want our students to reach? Why do we want students to meet these learning objectives? How can we best support students in achieving these learning objectives? How can we tell if students have met these learning objectives? According to OBE's concept of reverse design, the prerequisite is to explain the ultimate learning goals first, to supplement the different and individualized learning requirements, to emphasize the learning process so that each student may achieve self-challenge and gain, and then to enhance teaching and learning based on timely feedback.

3 Overall Design of a Hybrid Teaching Reform

3.1 Teaching Reform Objectives

The study of basic concepts, basic theories, and algorithms is an important part of students' scientific literacy, which lays a solid foundation for them to learn follow-up professional courses and design system programs. In addition, cultivating students' scientific thinking and innovative consciousness, enhancing their abilities of unity and cooperation, analyzing and solving problems, etc., embody scientific thinking, scientific spirit, scientific thinking mode, epistemology, and methodology, and have a fundamental and long-term effect on students' career development and lifelong learning. From the four views of why, what, how, and how effectively we learn, we have created a schematic map of the OBE-based education reform objectives, "a hybrid teaching reform to enhance higher order thinking and integrate ideological and political objectives," as illustrated in Fig. 1.

First, why do you want to learn? From the aspect of ability and quality training, the students we train should have the quality of officers. Therefore, supported by the teaching content of data structure, we train students' computational thinking ability and problem-solving abilities and derive classrooms' ideological and political content, such as ideals, beliefs, and mission responsibility.

Second, what to learn? Teaching is the core, which mainly includes data structure foundation, table structure, tree structure, graph structure, and sorting. Generally speaking, the trinity structure of "data structure-algorithm-problem positioning" is built on the knowledge system of teaching content, and the cognitive depth is enhanced. The teaching material and course objectives have been optimized as a whole, and the ideological and political content of the course has been completely sorted out following the principles of "integration of classical and modern content, penetration of scientific and humanistic spirit, attention to the frontiers of disciplines, adaptation to professional needs, and highlighting military characteristics."

Third, how to learn? The data structures MOOC course, which uses the BOPPPS teaching style and is problem-driven, enables three-dimensional teaching and training, both online and offline. It not only improves students' self-learning abilities, but also increases their motivation and sense of accomplishment in active and interactive learning, allowing for discussion of the higher-level subject. It can cultivate students' self-study ability and enhance students' active and participatory learning interest and sense of accomplishment, leaving room for discussion in learning advanced content. We also use the wisdom teaching tools of Rain Classroom and the PTA program to design an auxiliary teaching system, accurately give feedback on the teaching status, and implement "precision teaching, personalized learning." In addition, in practice, we should pay attention to the integration of in-class experiments and out-of-class practice and make use of the PTA system to ensure the quality of practice teaching.

Fourth, how is learning going? We constructed four sets of questionnaires through the pre-course learning scenario questionnaire, pre-learning satisfaction survey, and the mid-term learning situation questionnaire to implement the whole teaching process. This allowed us to perform instruction better and alter the teaching materials and techniques. A final course satisfaction survey to gauge students' happiness with the course's emphasis on competency development. A varied assessment approach is used in the assessment mode, emphasizing process evaluation. The percentage of the overall grade is as follows.

Overall grade = 40% formative grade + 60% summative grade.

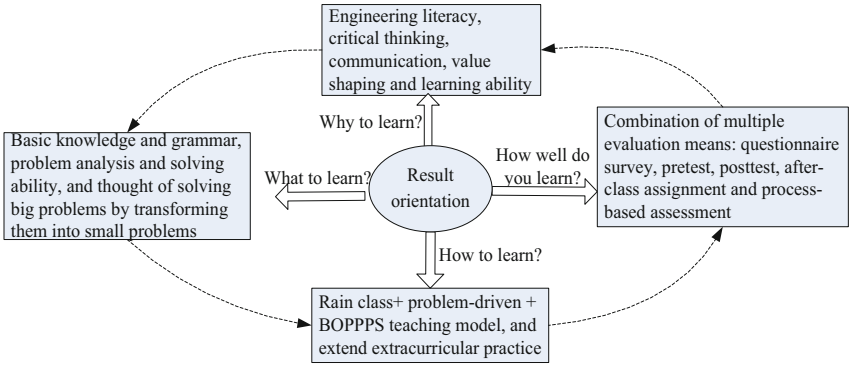


Fig. 1. he schematic diagram of the teaching reform goal based on OBE's "a hybrid teaching reform to enhance higher order thinking and integrate ideological and political objectives" (owner-draw)

Formative grade 40% = SPOC self-study (approx. 10%) + rain classroom (approx. 10%) + PTA assignment (approx. 5%) + PTA quiz (approx. 5%) + project major assignment (approx. 10%).

3.2 Smart Learning Environment

Future university education will focus on how to use information technology to accomplish "precise profiling and individualized learning. Through big data analysis, teachers may keep tabs on each student's learning dynamics and circumstances, provide tailored learning and coaching, and create a learning community with them. The data structure course has developed a pervasive learning environment using digital resources, such as "MOOC/SPOC + Rain Classroom + PTA Online Programming Training Platform," as shown in Fig. 2, to achieve the development and strengthening of learning networks stressed by the associative learning theory. This has increased the accuracy of classroom instruction and satiated the demands of personalized learning for each student.

The MOOC/SPOC platform is primarily used for pre-class self-study and self-assessment, as well as online interaction between teachers and students, and can precisely comprehend each student's online learning level based on the statistical analysis of learning data, as illustrated in Fig. 3. As shown in Fig. 4, the Rain Classroom is primarily used for publishing test questions inside and outside of the classroom. It can obtain real-time answer data, target students' questions, clear up their doubts, and solve problems. It can also adjust the teaching progress in real-time and facilitate effective interaction between teachers and students. The PTA online programming platform is primarily used for gradient-based programming training and tests, with training questions of varying complexity levels released. Students can select the right difficulty level based on their personal background and answer questions online, with the correctness of their answers reviewed and recorded in real time, as showed in Fig. 5. Through mining and analysis, significant insights can be gleaned from the vast quantity of procedural data produced by the combination of the "MOOC/SPOC + Rain Classroom + PTA online programming training platform." This makes it possible to statistically analyze the learning progress or weaknesses of each learner, creating a unique learning data profile for each person.

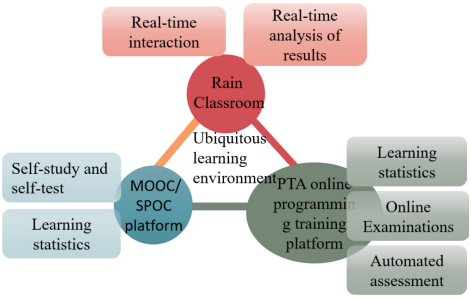


Fig. 2. Smart learning with a clear "learning emphasis"(owner-draw)

Students are grouped	Valid grades	Number of video views	Number of video views	How long the video was watched	The number of discussion board topics	Number of comments + replies to the discussion board
Internet	56.56	39	39	06:00:21	0	3
Big data	54	42	42	06:46:18	0	0
Big data	53	68	68	20:04:08	0	3
Trust	51.16	71	71	05:14:40	0	0
Trust	46.51	19	19	04:14:04	0	4
Trust	41.57	35	35	03:10:40	0	9

Fig. 3. Statistics for the MOOC platform learning(owner-draw)

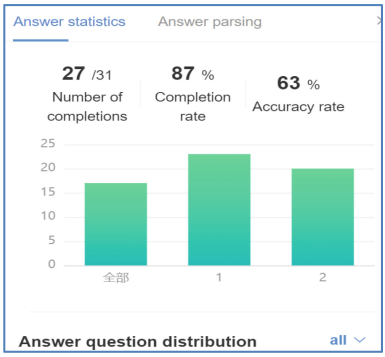


Fig. 4. Single question statistics for Rain Classroom(owner-draw)

3.3 Model for Learning Effectiveness Analysis

Traditional teaching data sources mostly consist of homework, experiment findings, and test results, all of which are manually graded and difficult to analyze. A record of students' learning process and a multidimensional assessment of students' learning from the perspectives of knowledge organization, learning progress, and performance are all necessary components of high-quality teaching. Personalized guidance then enables each student to develop in a unique and varied way.

With the aid of the smart learning environment, Fig. 6 depicts the learning effectiveness analysis model developed using data collected from the "digital space, accurate feedback, and in-depth interaction features" of the smart learning environment provided by Chinese University MOOC, also often called iCourse, Rain Classroom, PTA platform, and Questionnaire Star. The model primarily analyzes the learning data of the

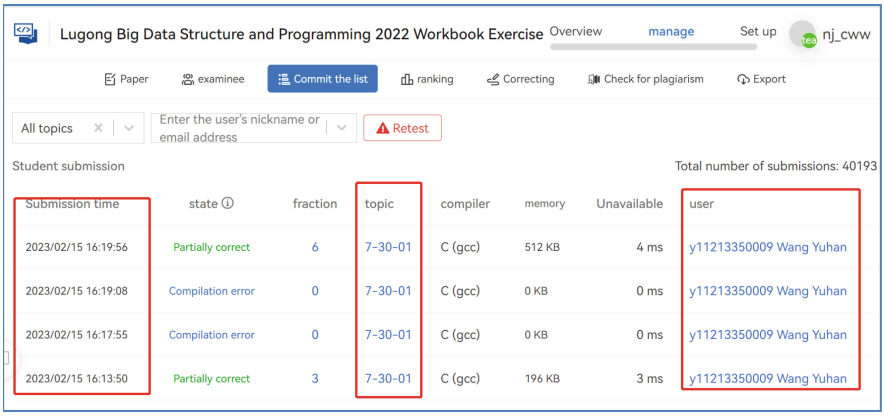


Fig. 5. Real-time interaction function of the PTA platform(owner-draw)

MOOC platform to generate the self-learning portrait and the learning data of the Rain Classroom tool to generate the interactive portrait and accomplishment portrait of Rain Classroom. By analyzing the learning data of the PTA platform, we obtain the portraits of knowledge mastery and PTA test performance; by analyzing the survey data of Questionnaire Star, we obtain the portraits of self-evaluation and teacher satisfaction.

Profile of self-learning. The China University MOOC platform offers information on five dimensions of students' learning, primarily SPOC grades, number of videos watched, frequency of viewing, duration of viewing, and number of comments and responses made in discussion forums. These statistics represent students' prior learning on the MOC platform, involvement and interaction, and learning characteristics, resulting in a self-learning profile. Figure 7 depicts a self-study self-test of the SPOC performed by a student in week five. The student learning data analysis shows that it exceeds the average learning level, but the remark response dimension is still a common shortcoming among students and must be reinforced.

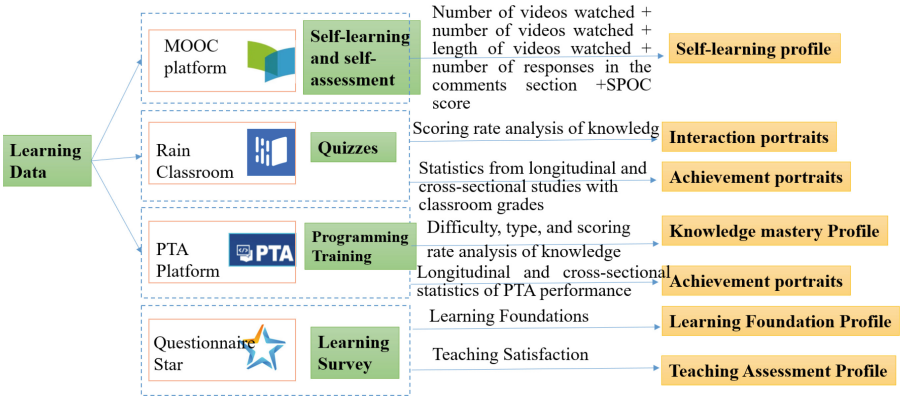


Fig. 6. Learning effectiveness analysis model(owner-draw)

Interactive and achievement portraits from the Rain Classroom. In the pre-class, in-class, and post-class tests, Rain Classroom primarily gives information on the score of each question, as well as the distribution of answers. The interactive portrait and the performance portrait are created by examining each question's scores. Figure 8 displays the Rain Classroom test score tracking, allowing you to monitor exactly how each student's score has changed.

Portraits of performance and knowledge mastery. The PTA platform offers statistics on each question's level of difficulty, the knowledge it falls under, the number of submissions, and the percentage of correct answers. An evaluation of the difficulty, type, and scoring rate of each question results in the creation of a knowledge mastery portrait and a performance portrait. The student's knowledge of the chapter on table structures is demonstrated in Fig. 9(a). Although there was good mastery of stacks, chains, and

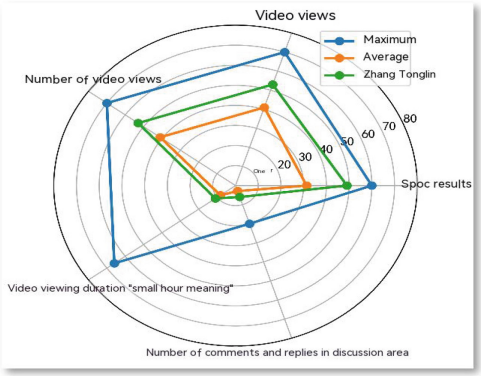


Fig. 7. Self-learning and self-assessment data for a student's fifth week of SPOC learning(owner-draw)

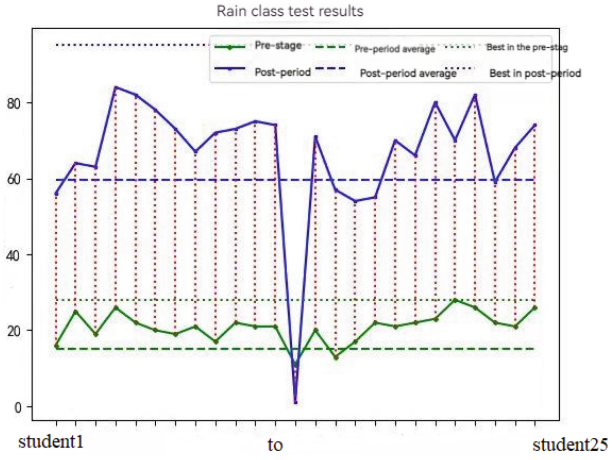


Fig. 8. Progression of exam scores in a rainy classroom(owner-draw)

queues, there was a need for practice in one-dimensional array knowledge. The trajectory of each student's performance on the PTA test is shown in Fig. 9(b).

Portrait of self-satisfaction and teaching satisfaction. As seen in Fig. 10, the Questionnaire Star primarily evaluates students' subjective wishes and feelings, their evaluation of learning content, course progress, and classroom organization throughout the teaching process, generating a portrait of teaching satisfaction.

The study of the learning effectiveness model's results will make students' online and offline learning, in-class engagement, and outside-of-class communication more focused, assisting in the achievement of the teaching objective of the growth and advancement of both teachers and students.

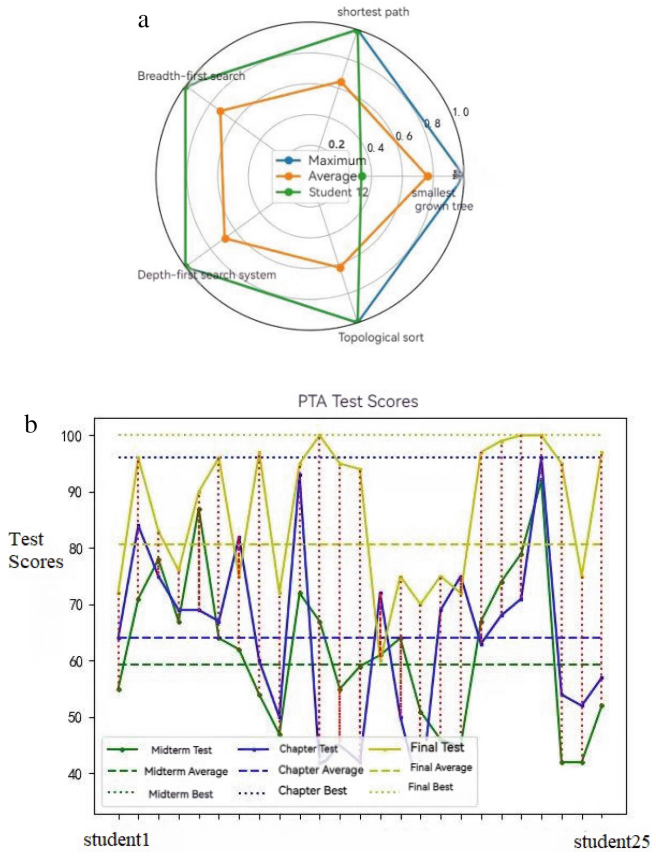
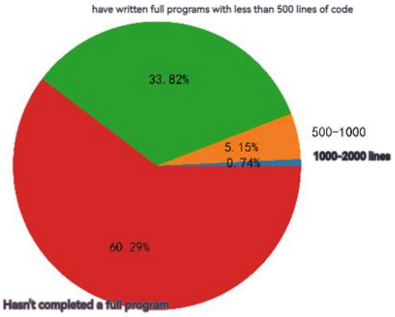
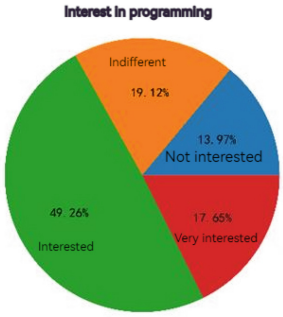


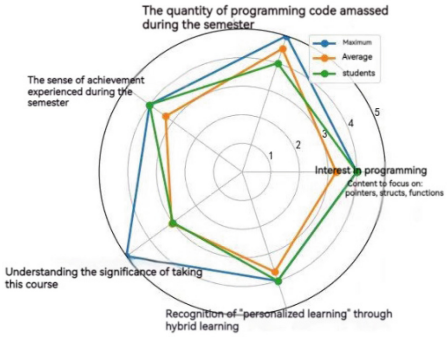
Fig. 9. (a). A student's knowledge of Graph structure points(owner-draw) **(b).** Process of change in PTA test scores(owner-draw)



(a). Programming fundamentals



(b). Programming interests



(c). Learning interests and attitudes

Fig. 10. Data portrait of the Questionnaire Star survey(owner-draw)

4 Implementation Effect Feedback

Since we use multi-level teaching methods and teaching means to achieve the goal of "improving higher order thinking and integrating ideological and political education," the students' learning enthusiasm has been significantly improved. The results of a statistical analysis of the data indicate that the implementation of hybrid learning has

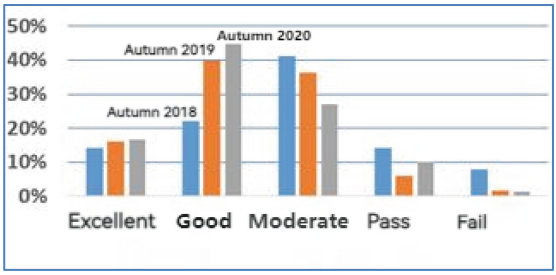


Fig. 11. Comparison of Final Results from 2018 to 2020(owner-draw)

resulted in an annual decline in the final failure rate and an annual rise in the pass rate from 2018 to 2020 (Fig. 11).

5 Conclusion

The "Data Structure" course has developed a model for analyzing the effectiveness of learning and a system for developing progressive competence that includes "digital space, correct feedback, and in-depth interaction." Practice demonstrates that the mixed teaching reform that aims to "promote higher-order thinking and integrate ideological and political goals" has succeeded in both its dual objectives of fostering professional ability and promoting ideological and political education, as well as in producing effective teaching outcomes. The curriculum team will continue to innovate in theory and practice on the foundation of high-quality curriculum design, concentrating on particular tasks, including content design, strategy selection, resource development, and outcome evaluation. The team will concentrate on the problems and make continual changes, effectively removing roadblocks and resolving challenges and promoting high-quality curriculum development indefinitely.

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