Research on Practice of P-PMCP Double Closed-Loop Hybrid Teaching Model—Taking Course of "Big Data Visualization" as an Example

Peipei Gao, Hong Zhao(✉), Sai Liang, and Huiting Xiang

Nankai University, Tianjin 300071, China
watersky@nankai.edu.cn

Abstract. Under the current trend of education reform in China, educational concepts and teaching models are evolving around the "Student-Centered" approach. How to develop a philosophy of education that is in line with this theme and how to design a teaching model that is in line with this philosophy becomes an important issue for teachers to produce innovative results. To address this issue, this paper proposes a P-PMCP hybrid teaching model that incorporates the general laws of human cognition into the design of the learning objectives and activities for each cognitive stage. Taking the course Big Data Visualization as an example, online and offline hybrid teaching was carried out based on the P-PMCP model. The paper illustrates the effectiveness of the method through the comparison of the student's performance and questionnaire analysis.

Keywords: Student-centered · Cognitive Law · P-PMCP · Hybrid Teaching · Big Data Visualization

1 Introduction

World-class universities generally place the quality of undergraduate education in an important position. The current education reform of universities in China should realize "two changes", namely, the change of education concept from "discipline-based" to "student-based" and the teaching model from "teacher-centered" to "student-centered". These "two changes" revolve around a single theme—"student- centeredness" [1, 2]—and are followed by the exploration of new teaching concepts and teaching models.

To achieve a "student-centered" teaching philosophy, the cognitive patterns of learning should be explored. Hu, RP, and Shao, M in 2018 proposed that "Cognitive theory has a subtle influence on the teaching methods. To fully activate students' motivation and initiative, improve the students' learning ability and achieve the harmonious unity of teaching and learning, the teachers should grasp the students' cognitive features and changing regularity. [3]" The general cognitive learning pattern of humans is "Knowing–Exploring–Innovating", and the research and practice in teaching would only be effective when we follow this law.

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In order to achieve the "student-centered" teaching mode, we should study the teaching methods that are suitable for the current teaching trend and that have strong generalization ability. Hybrid teaching [4, 5]—a teaching method that embraces the advantages of both traditional offline learning and online learning—is considered to be a powerful tool to realize the "student-centered" goal and is an important way to produce innovative results in education. Through the dynamic combination of these two strategies, the learners can explore the learning contents gradually and deeply. Some researchers have integrated the method of BOPPPS(Bridge-in, Objective, Pre-assessment, Participatory Learning, Post-assessment, Summary) [6] into online teaching and constructed the teaching model of HBOPPPS. Through comparative study, it is found that "HBOPPPS is likely a more effective teaching model and useful for enhancing the effectiveness of Physiology teaching. This is attributable to the reproducibility and flexibility as well as the increased learning initiatives [7]". However, the exploration of what kind of learning process can fully reflect the students' subjective status and the teacher's leading role is still lacking. Current research also includes the study of the effect of combining the online and offline learning sessions: "Using online in the tenth to fifteenth, twenty-fifth to thirtieth, and fortieth to forty-fifth min of classroom teaching (50 min in total) can effectively increase students' interest and engagement in learning [8]", However, there is still a lack of data to support the impact of fragmented learning time on learning efficiency. Moreover, scholars have proposed the "Prediction—Observation—Quiz—Explanation" (POQE) procedure for the hybrid teaching design [9]. Nevertheless, such studies tend to focus on empirical learning while neglecting the development of students' creative ability as well as the ability to independently identify and solve problems.

Based on these aspects, this paper integrates the general cognitive law of "Knowing–Exploring–Innovating" into hybrid teaching, proposes the P-PMCP teaching model to design corresponding learning objectives and activities for the three cognitive stages of "Knowing", "Exploring" and "Innovating", highlighting the concept of "student-centeredness" in the process, and illustrates the application and effect of the P-PMCP teaching model with the course "Big Data Visualization".

2 P-PMCP Hybrid Teaching

The P-PMCP model consists of five parts (Fig. 1):

Fig. 1. The five parts of P-PMCP model.

P-PMCP has a double closed-loop structure, where each lecture goes through a PMCP process, forming an inner closed loop; "Project" refers to a comprehensive and innovative project that runs through the entire course, forming an outer loop. The form of the P-PMCP model is progressive, and the interconnected links fully reflect the goal progression and the step-by-step implementation of the model.

These five sessions are divided into 3 modules.

The study sessions "Pre-Class Push" and "MOOC Self-Study" happen before class, using the MOOC and SPOC platform, constituting the "Knowing" module;

The study session "Class Participation" takes place during class and the study session "Practice & Exploration" is carried out after class, these two sessions constituting the "Exploring" module using the enterprise practice platform and SPOC platform;

The study session "Project" is carried out throughout the whole semester, where students unlock the "Innovating" module through the practice of integrated innovation projects, using the competition platform.

As illustrated in Fig. 2, the P-PMCP model emphasizes pre-class instructional design by determining the teaching objectives of each session and implementing them step by step, and ultimately reaching the goal of instruction.

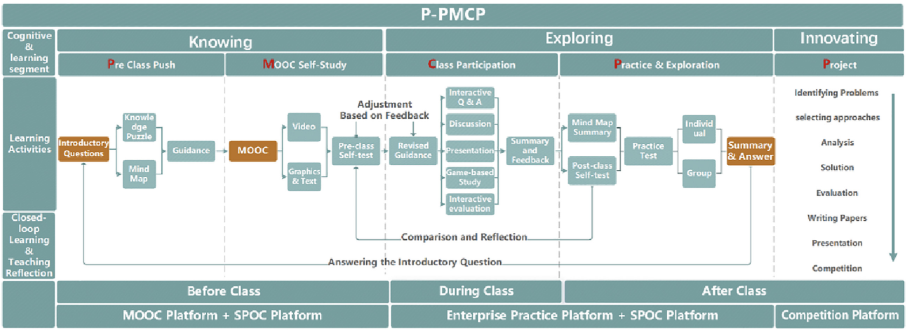

Fig. 2. P-PMCP hybrid teaching model.

2.1 Pre-class

The goal of this part is to ask questions. Before the class, the teacher would push the introductory learning material via the online platform, presenting the problems to be solved and clarifying the role of this module in the overall knowledge system. The teacher assigns the MOOC videos, graphics, and other materials as guidance for students to self-study with questions in mind. Then, students explore and investigate the learning content step by step according to the guidance. This process helps students to stimulate their interests and motivates them to investigate issues related to their own majors.

2.2 Mooc

The goal of this part is to clarify the problem–solving methods. Students work in groups before class to complete the online collaborative learning. Each student learns a part of the MOOC materials and explains the content to other students, increasing their knowledge retention rate and learning rate through this process. Teachers upload the pre-class self-test questions, and students can test themselves to check the result of independent learning. Teachers can also beware of the learning condition of the class in advance. At the same time, teachers can conduct pre-class Q&A session online to address possible problems promptly. Moreover, teachers may review the results of the pre-test to adjust the focus in the class.

2.3 Class

The goal of this part is to solve the problems posed before the class. The course is organized in groups, using offline participatory learning methods. Various forms of participatory learning are carried out step by step according to the level of participation to guide students to get solutions to their problems, making students the main body of independent learning. The first level of interaction is not named, such as pop-ups and posts; the second level of interaction is named, such as online interactive quizzes and group discussions; the third level of interaction is active, such as group presentations, game-based study and interactive evaluation, etc. At the end of the class, the groups are invited to summarize the learning outcomes of the current learning unit.

2.4 Practice

The goal of this part is to submit a problem-solving report and further practice the acquired knowledge in depth. Learning groups answer the pre-class introductory questions, allowing the learning unit to form a closed loop. Teachers assign post-class self-test questions and practices, using real data and cases as much as possible. Students can further practice and consolidate their knowledge of the unit, considering both teaching requirements and workplace needs. Both teachers and students can compare the scores of the post-test with the pre-test to check the effectiveness of learning.

2.5 Project

To achieve the teaching objectives of the course, a group project is carried out throughout the whole semester. The project helps to develop students' awareness and ability to innovatively solve complex problems by implementing the knowledge they have acquired comprehensively. It forms a closed-loop process of identifying problems, selecting approaches, analysis, finding solutions, evaluation, writing papers and presentation. As an effective examination method, the project can be used to determine the student's level of achievement throughout the course. In addition, activities such as "Innovative Project Competition" are organized to promote learning and stimulate students' interest.

3 A Case Study of P-PMCP Hybrid Teaching

3.1 The Knowledge Framework of the Big Data Visualization Course

The course *Big Data Visualization* is designed based on the Outcome-Based Education (OBE) philosophy with three progressive levels of teaching objectives: "Basic Visualization Theory"–"Theory-based Visualization Practice"–"Integrated Visual Analytics Project Development". The course follows the problem-solving logic of visual analytics, implementing the theory of the "knowledge puzzle" [10] when designing the course framework, with each piece of the puzzle solving one problem in visual analytics. The course carries out comprehensive innovation projects according to the bottom-up hierarchy of "Basic Awareness– Data Access–Task Analysis–Visual Mapping–Visual Interface". The framework of the course is shown in Fig. 3.

3.2 P-PMCP Hybrid Teaching in Big Data Visualization

Nankai University's general education course Big Data Visualization is offered to all students and is designed with the P-PMCP double-closed-loop model. Each learning unit is organized according to the model as the inner closed-loop and the integrated innovation project as the outer closed-loop. In the following parts, Lec5 Visualize Frameworks & Graph (Network) in Big Data Visualization is used to illustrate the application of P-PMCP hybrid teaching.

The knowledge objectives of this lecture include: understanding what a data visualization framework is, to be able to describe the relationships among its various components, to be able to use the techniques and tools available, and to comprehend what graph structure (network structure), graph data, and graph attributes are as well as to understand the scope of application of graph structure visualization.

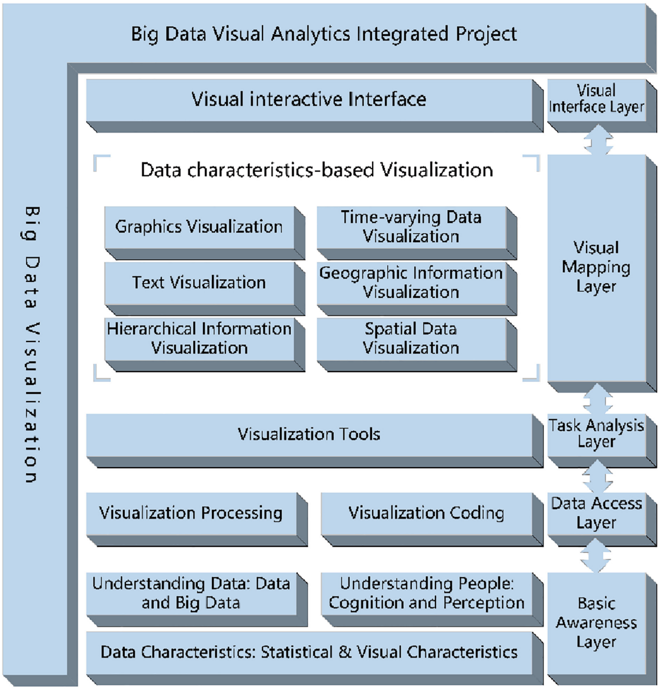

Fig. 3. Big data visualization course framework.

The capacity objectives of this lecture include: being able to use SaCa DataViz, a data analysis (BI) platform, to build model and visualize the social network structure using graphs, and to draw conclusions concerning the characteristics of social relationship by comparing, analyzing and discussing the results.

Pre-class. The question posted previous to this lecture is "How can we visualize and analyze social networks in our 'social circle of friends'?". The teacher presented the knowledge puzzle of the lecture so that students know "what I have already learned", "what I am learning" and "what I will learn". The position and role of this module in the overall knowledge system was also presented according to the puzzle. The knowledge puzzle of Lec5 is shown in Fig. 4.

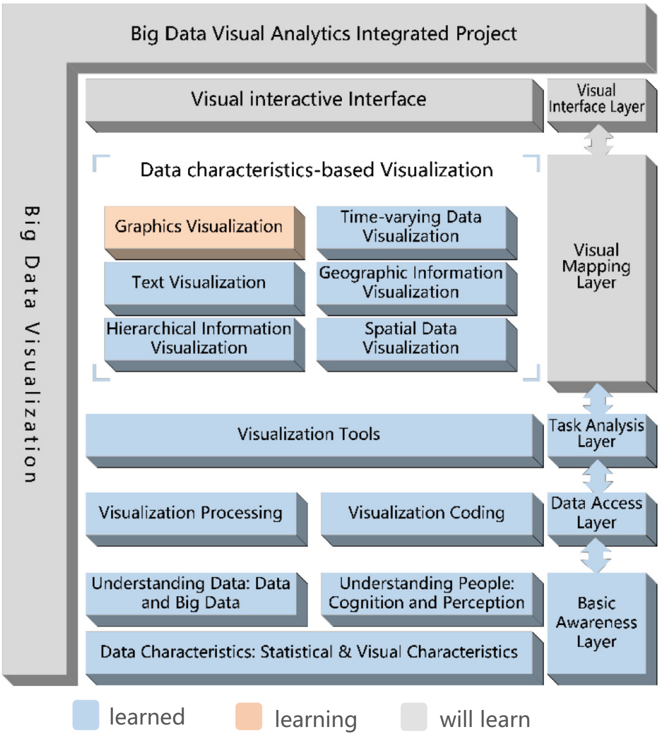

Fig. 4. Knowledge Puzzle of Lec 5.

MOOC Students worked in groups to collaborate online before class and complete the pre-class self-test questions. Students would study the MOOC videos and graphics online using WeChat and complete the self-test questions using “Rain Classroom”, a smart teaching platform that supports posting question and Q&A sessions. The pre-class courseware is shown in Fig. 5.

Class. Classes were conducted offline for participatory learning, with guidance and support from the teacher. Students worked in groups to solve the “social circle of friends” visualization problem, discussed the key points of each step of the social network visual analysis, and proposed a solving plan. The task was approached following the process of “social network data acquisition–data cleansing and organizing–visual mapping–visual analysis–conclusion”. Each group presented a report on their solution and conclusion, which was evaluated by the other groups and the teacher respectively. Eventually, the learning group concluded with a summary of their social network visualization and further expanded to the general process of visualization.

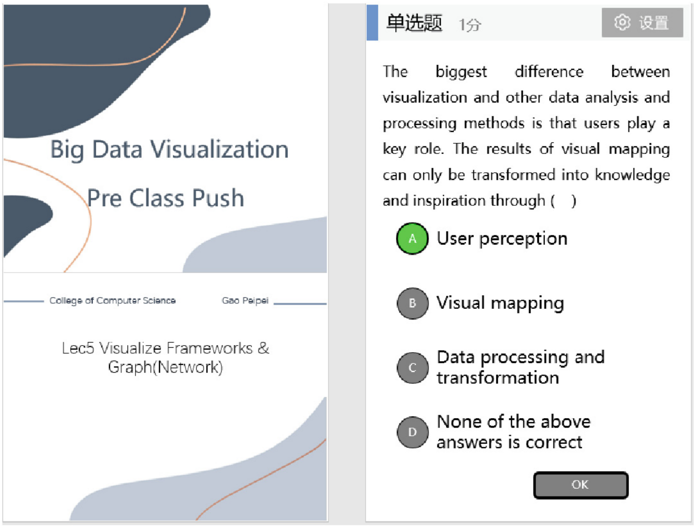

Fig. 5. Pre-class Push (partial).

Practice. After class, practice materials were sent to students, which were authentic data and cases from industry. The course used SaCa DataViz, a visual data analysis platform, to provide students with real-life work experience and online collaborative visual analysis training to consolidate and improve their ability to solve industry problems. A comparison of the post-class self-test and the pre-class self-test is shown in Fig. 6.

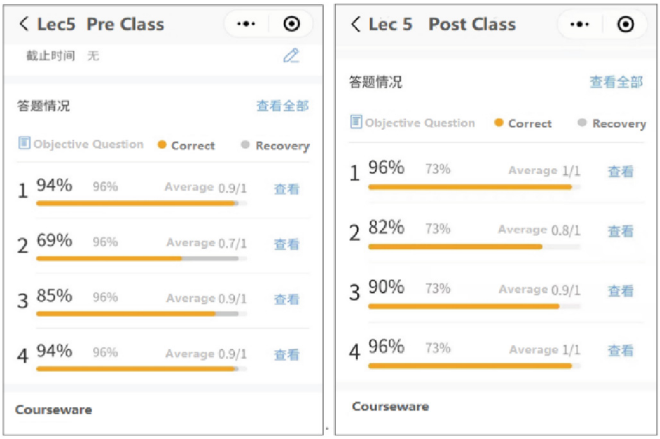

Fig. 6. Comparison of self-test before and after class.

Project. The final assessment for the Big Data Visualization course required students to work in groups to complete a visualization research project. The project had a certain breadth and depth, and required students to synthesize what they have learned throughout the semester to solve a visual data analysis research problem related to their own disciplines.

4 Validity Analysis

To evaluate the effectiveness of the P-PMCP model in hybrid teaching, a comparative study was conducted in this paper. The subjects of the study were two parallel classes taught by the same teacher. Class C1 was the sample class of 96 students with P-PMCP hybrid teaching; Class C2 was the control class of 92 students with the traditional teaching model. The integrated innovation projects submitted by the two classes were assessed using the "Tripartite Evaluation" method, namely self-evaluation, mutual evaluation, and third-party evaluation. Among them, the self-evaluation refers to students' own self-evaluation and group members' evaluation of their group; the mutual evaluation refers to the assessment among peers in the group and among different groups; the third-party evaluation refers to the evaluation by the teachers. There were six dimensions of evaluation, namely project selection (E1), difficulty (E2), completion level (E3), discipline/industry application value (E4), innovation (E5), and presentation performance (E6). The average performance of the sample class and the control classes is shown in Fig. 7, which demonstrates that the sample class has a significant advantage in the dimension of E1, E2, E4, and E5.

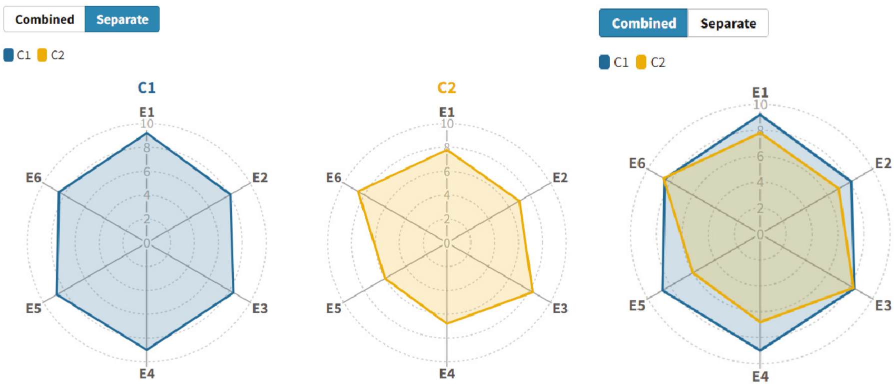

Fig. 7. Radar plot of sample class performance against control class.

Feedback from students in the sample class was collected using the Likert scale [11, 12]. The results showed that 82.29% of students felt that the P-PMCP hybrid teaching helped them to develop awareness and ability to detect professional problems; 78.13% of students felt that they had improved their problem-solving skills through group learning; 92.71% of students felt that the course had stimulated their interest in learning and that they would actively use visual analytics to solve professional problems in the future; 83.34% of the students were satisfied with the learning experience and the outcome of the course. The results of the questionnaire are shown in Fig. 8.

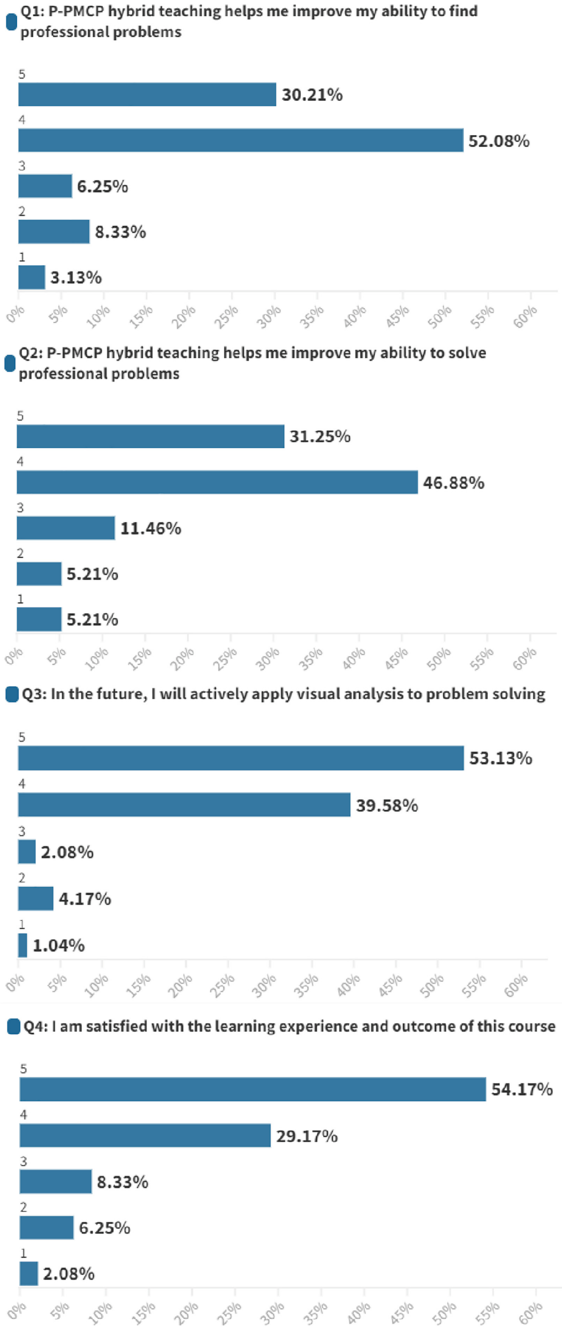

Fig. 8. Results of the questionnaire, the distribution of answers on Q1, Q2, Q3 and Q4.

5 Conclusion

The P-PMCP teaching model does not blindly use smart teaching tools, but conforms to the general cognitive law of "Knowing", "Exploring" and "Innovating", allowing students to be the main subjects of learning. With the assistance of online resources, offline explorations would be carried out more effectively, which in turn leads to the output of high-quality integrated innovation projects. Analysis of the students' performance and the questionnaires validates the effectiveness of this method, which stimulates students' interest in the inquiry process, enhancing their learning autonomy and giving them a sense of achievement and motivation for further study. This method can be better interpreted and more widely used with the support of smart teaching tools and information-based teaching technologies. The P-PMCP model highlights the central role of students in teaching and learning, transforming from "teaching-centered" to "student-centered" in the process, and from "acquiring knowledge" to "having the ability" in the result.

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