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Design and Implementation of Precision Teaching Mode Based on Big Data Technology

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ABSTRACT

Precision teaching refers to the precision and personalization of teaching objectives, teaching processes, and teaching procedures. In the teaching process, teachers use big data technology and artificial intelligence methods to first accurately design and evaluate various aspects of teaching, and then accurately analyze teaching effectiveness. Based on the conclusions drawn from the analysis, continuous adjustment of teaching methods, improvement of teaching plans, and enhancement of teaching efficiency have achieved positive feedback, thereby promoting the precision of classroom teaching. This paper analyzes both the research background and current situation of precision teaching, and explains how to carry out precision teaching in the context of big data. Based on the conditional expectation method in statistics, this paper first constructs the mathematical model of teaching evaluation in precision education; then builds the data processing model, services model and application model of precision teaching respectively. At last, the solution to achieve precision teaching from the perspective of big data is proposed.

1. INTRODUCTION

Teaching activities are the ways for teachers to impart knowledge to students. The teaching activities are usually evaluated through the quality of teaching. The quality of teaching activities has a direct impact on students' achievements and development. Therefore, improving the quality of teaching activities can better enhance students' learning quality.

With the technology progress in the information age, big data has been used more and more widely, and it is no exception in the field of education [1]. The data analysis to assist teaching has entered the classroom. In the future, big data will still be the direction of social development. How to further facilitate teaching results and improve the quality of teaching through big data is very important. The rapid development of big data and Internet technology is driving the teaching model, and the teaching design [2]. The teaching implementation and assessment methods are also shifting to wisdom.

Nowadays, the traditional teaching model can no longer meet the requirements of students' individualized learning. However, with the expansion of enrollment in higher school, most colleges and universities have a large number of students while insufficient teachers [3]. This obviously makes it impossible to implement personalized teaching [4]. In order to meet the needs of modern teaching, the concept of "precision teaching" has emerged. Precision teaching advocates the use of various conditions and environment, with fluency as an important indicator to measure student learning and development [5]. The development of information technology provides strong technical support for the implementation of precision teaching.

Under the help of the big data, teachers make full use of the combination of education and computer technology, such as the Internet and big data [6]. With efficient data collection, processing and analysis, the teaching can be pushed to the precise level. Whether it is a teaching platform or an online practice system, as long as the student implements the submission behavior, the data will be generated in real time, and the traditional processing analysis method cannot effectively process and utilize the massive data. When the collected big data is sorted out and the effective feedback information is obtained, the teachers can implement the teaching activities more specifically. Improving the precision and efficiency of the teaching, and the big data application will become a powerful booster for precision teaching [7].

2. PRECISION TEACHING

In the process of precision teaching, teachers first design teaching objectives and stages, and then use scientific methods to evaluate students' learning effectiveness and teachers' teaching effectiveness; Finally, adjust the teaching plan based on the feedback information.

Precision teaching was first proposed by Lindsley based on Skinner's behavior learning theory in 1960s. Precision teaching was initially geared to primary education [8], and later developed into a framework for evaluating the effectiveness of teaching methods [9]. Precision teaching takes fluency as a measurement index. Students are required to do

daily exercises and measure their learning performance. Teaching intervention is implemented by recording and checking the results [10]. Research shows that precision teaching can significantly improve students' learning performance and learning levels. Early precision teaching required teachers and students to record their learning performance one by one with pens, and then made manual analysis and decision-making accordingly [11].

Skinner was one of the founders of New Behaviorism Psychology in the United States. He believed that human behavior was mainly composed of operational reflexes, which acted on the environment and produced results. Almost all human actions are the result of operational reinforcement, and it is possible for people to change other people's reactions through the influence of reinforcement. In 1954, Skinner introduced this theory into teaching. In the teaching process, teachers first propose teaching objectives and control the teaching process; repeatedly train and correct students to achieve good teaching results [12].

The most important element in precision teaching lies in teaching evaluation. In order to measure whether teaching achieves its goal and whether students really grasp knowledge or skills, the key factor aims to test students' learning behavior and reaction. Based on this theory, precision teaching introduces fluency index to measure students' learning quality. The fluency covers two aspects: "accuracy" and "speed".

In the process of precise teaching, students need to practice daily and take tests. Record the long-term training and generate a Standard Celebration Chart. This table can accurately predict students' levels and determine whether they need to improve and how to improve [13].

The chart can accurately predict when students' knowledge or skills will meet the requirements of fluency, and can determine whether the current students' learning performance has improved significantly over time and whether the intervention measures need to be modified [14].

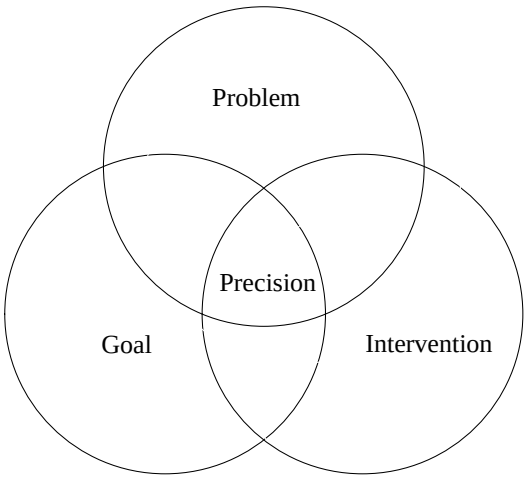

Figure 1. "Tri-Precision" of the precision teaching

The "Precision" of precision teaching includes three items, namely, Goal Precision, Problem Precision and Intervention Precision, referred to as "Tri-Precision". As shown in Figure 1, Goal Precision is the cornerstone of precision teaching, aiming at accurately judging goals that conform to learners' personality characteristics. Problem Precision is the core of precision teaching, aiming at accurately determining the current and potential problems of learners. Intervention Precision is the soul of precision teaching, aiming at providing personalized measures accurately. On the basis of "Tri-Precision", precision teaching can realize the customization of the best teaching strategies, thus serving the teaching work accurately.

3. RESEARCH STATUS OF PRECISION TEACHING

3.1 Research status

Existing studies have shown that precision teaching is an effective strategy to remedy students' lack of academic skills, and can improve their learning efficiency.

Shortly after Linsley proposed precision teaching, he designed a Standard Celeration Chart for recording pupils' behavior. The Standard Celeration Chart is an effective strategy to remedy students' lack of academic skills at the beginning [15]. Later, it has been used by different social groups, and has been proved to have a certain role in promoting the learners.

Lambe et al. [16] studied the effect of precision teaching intervention on reading fluency of children in special period (7-8 years old). The participants were trained for six weeks, using SAFMEDS fluency card and Dolch story, Multiple Baseline Design data (MBD) and Standard Celeration Charts to analyze the fluency scores before and after intervention, and then the results were evaluated.

At present, the application research of precision teaching is not comprehensive, and the research direction and scope have some certain limitations. The research mainly focuses on the teaching mode, the individual courses, and focuses on the evaluation of the effect of precision teaching mainly through teaching experiments.

3.2 Existing problems

Precision teaching has been studied and developed for more than 50 years. Although it is an effective teaching method, its application in traditional teaching environment is not optimistic. The reasons are as follows:

(1) Precision teaching ignores the process of learning behavior and personalized development. Precision teaching can improve students' learning quality by measuring the results of learning behavior and then carrying out intensive exercises according to the results. It is a typical result driven teaching. This teaching method lacks attention to the process of learning behavior and ignores the different personalities of students in this process.

(2) Precision teaching lacks technology support. Precision teaching is based on measuring and recording students' learning performance in operation, and based on analyzing frequency data. Before the popularization of information technology, the measurement and recording of precision teaching were carried out by pen and paper, so the efficiency of data acquisition and data analysis is not high.

(3) Precision teaching is difficult to meet the needs of personnel training in colleges and universities. College teaching is an important position to promote the innovation and practice of teaching methods. There are many kinds of courses. Teaching relies mainly on the system of personnel training and curriculum. The goal of teaching is not only the mastery of knowledge points, but also the acquisition of

thinking methods. In particular, there are some professional courses, for the nature of theoretical inquiry and application innovation, so it is difficult to effectively measure and record students' learning performance [17]. Therefore, the application and promotion of precision teaching in colleges and universities is limited.

4. ROLE OF BIG DATA IN PRECISION TEACHING

The development of big data technology provides powerful technical support for precision teaching [9]. It promotes the development of precision teaching from theory to practical application, and expands the practice space of precision teaching. With the development of big data in the field of education, data mining and learning analysis technology provide technical support for precision teaching. More and more students have the chance to get the "individualized learning" recommendation of the teacher's "differentiated teaching" guidance and application system. This is in line with the development trend of education and teaching in the new era. This kind of teaching practice is called "big data precision teaching", because it relies on big data technology and precision evaluation methods of learning effect, and it can realize differentiated teaching and individualized learning [18].

4.1 Positive effect

Big data analysis is different from traditional data analysis. It uses effective data analysis technology to measure and record the performance of learning behavior in the learning process, reveals the track or law of learning behavior, and presents the track or law visually [19]. On the one hand, big data analysis can help teachers customize personalized learning programs for students and implement the accurate transformation of teaching strategies; on the other hand, it can record learners' learning requirements, learning achievements and learning behaviors systematically and comprehensively, and the learners can perform adaptive learning.

The key of precision teaching is to measure the data of teaching process through big data, and to ensure the accuracy of data effectively. It effectively improves the efficiency of teaching data acquisition, and changes the disadvantages of traditional manual recording and manual computing [20]. Through the application of big data, we can collect classroom information and record useful information in real time without affecting the teaching process of students and teachers.

4.2 Model design

Big data make the teaching method break through the original manual recording mode, make the precision teaching more feasible, and also make teachers accept the acceptance of precision teaching from their own point of view.

Firstly, the teaching goals should be built in precision teaching, and the final teaching effect should be made clear. Only by making clear goals, can we constantly revise the direction and change teaching methods through continuous information feedback. In precision teaching, establishing clear goals is the primary task.

Secondly, the teaching process is designed and implemented through the way of big data. We can build a teaching resource bank, store a large amount of information, and enrich the teaching resource bank. Teachers can use different resources according to the individual differences of different students, thus avoiding the unified mode of traditional precision teaching.

Thirdly, teaching evaluation is based on big data. Through reading and analyzing the teaching resource database, we can analyze the students' learning effect and problems according to the personalized information stored by each student in the big data resource database, and evaluate the students' learning results in many ways. It is no longer limited to the examination results and grade evaluation methods of the traditional teaching.

4.3 Conditions of realization

First, big data collection technology requires a specialized collection and information processing center. Extensive information collection ensures the adequate teaching resources. Secondly, we should standardize the way of data collection and processing. We should not only collect effective data in all directions, but also protect the privacy of data. In addition to the above technical conditions, teachers should also improve their quality. So that teachers can do their job well and take students as the center of the teaching. By this method we can make good use of big data as a teaching tool to achieve precision teaching and teaching effect better.

5. MATHEMATICAL MODEL OF TEACHING EVALUATION

The goal of big data research in education is to improve the teaching effect, which is the core content of big data research in education. Teaching effect is the standard to measure the pros and cons of teaching plan, and is also the key factor to guide the design of teaching plan. In the current study, relevant indicators of teaching effectiveness include student achievement and student satisfaction. For each of these indicators, how to fully mine the data information and evaluate the teaching effect as accurately as possible is a problem worthy of intensive study. In the following, we will build a mathematical model of teaching evaluation in precision teaching based on the conditional expectation method in statistics.

In this mathematical model, the teaching effect is recorded as R, the actual teaching strategies are expressed as S, and the students' characteristics are expressed as F.

The teaching strategy S takes natural number, for example, S = 1, 2, 3, 4, 5 represents 5 different teaching strategies respectively. Student feature $F = (F_1, F_2, F_3, ..., F_n)$ is a vector composed of N characteristic indicators related to students. These indicators include all kinds of information of students, such as basic information such as gender, age, learning behavior information and so on. (F, S, R) constitute the sample space and it is *P*-distribution, that is:

$$(F, S, R) \sim P \tag{1}$$

Under the *P*-distribution, the expectation of teaching effect *R* is *E*. So, the mathematical model of teaching evaluation is:

$$E(R|S, F) \tag{2}$$

The practical significance of this model is to achieve the average teaching effect for students with characteristic *F* after

adopting teaching strategy *S*.

Based on the teaching evaluation model of precision teaching, this paper analyses and studies several problems in precision teaching. It includes the evaluation of the precision teaching plan, the selection of variables affecting the precision teaching plan, the design of the optimal precision teaching plan, and the design of the multi-stage optimal precision teaching plan and so on. Precision teaching is essentially a decision function, which can give corresponding teaching strategies according to the different characteristics of students. If the precision teaching plan is recorded as *d*, then *d* is the map from student characteristic *F* space to teaching strategy *S* space, that is *d (F) = S*.

5.1 Evaluation of precision teaching plan

According to the above teaching evaluation mathematical model, the evaluation of precision teaching plan is to estimate:

$$E(R|S,F) = E(R|d(F),F) \tag{3}$$

In practical application, the joint distribution of teaching effect *R*, teaching strategy *S* and student characteristic *F* is usually unknown, so it is necessary to estimate *E (R| S, F)* with mathematical statistics knowledge. At present, there are many related studies, such as a double robust estimation. The estimator is based on logarithmic density and is an unbiased estimator.

5.2 Selection of variables affecting the precision teaching plan

The teaching process is very complicated, and the teaching effect is affected by many factors, so the design of precision teaching plan needs to consider many factors. Studying the influencing factors of precision teaching plan can deepen the understanding of teaching process and optimize the design of teaching plan, so as to better guide teaching task.

With the rapid development of information technology and the continuous advancement of education informationization, it is possible to obtain a large number of teaching process data and other related data. These data include the basic characteristics of students, such as gender, family status, intelligence level, physical quality, psychological endurance and learning ability. There are also students' behavioral data, such as reading volume, knowledge structure, homework performance, and students' emotional data, such as emotional state, loneliness index and so on. Among the many variables, we need to know which variables will affect the teaching effect and which variables will affect the precision teaching plan design. Therefore, variable selection is needed. Variable selection aims to find out the method that affects the variables of precision teaching plan design from many variables.

Based on regression analysis method, this paper constructs the influencing factors model of precision teaching plan. If the number of variables is n, the variables are F_1, F_2, F_3, ..., F_n. The formula is as follows:

$$E(R|S,F) = \alpha_1 F_1 + \alpha_2 F_2 + \cdots + \alpha_n F_n \tag{4}$$

The $\alpha_1, \alpha_2, \ldots, \alpha_n$ are the regression coefficients corresponding to each variable.

5.3 Design of the optimal precision teaching plan

The design of optimal precision teaching plan is an important issue in the teaching process. In order to improve the teaching effect as much as possible and to really teach students in accordance with their aptitude, we must give different teaching schemes for different students according to their characteristics. There are many researches on teaching strategies, and teachers have accumulated certain teaching strategies in teaching practice. How to find the best teaching strategy and how to put forward the new strategy to improve the teaching effect are important issues to be considered in the teaching process.

If the best precision teaching plan is recorded as *d* (F)*, the formula is as follows:

$$d^*(F) = \arg\max_d E(R|S = d(F), F) \tag{5}$$

This is an optimization problem. The best precision teaching plan is the teaching plan that makes the teaching effect expectation most.

The method of finding the best and precision teaching plan is based on the estimation of $E(R|S = d(F), F)$ and searching for the largest teaching plan among a series of possible teaching plans. Many models can be used to estimate $E(R|S = d(F), F)$, such as linear model, logarithmic regression model, nonparametric model and semi-parametric model.

5.4 Design of the multi-stage optimal precision teaching plan

Teaching process is a long-term process, which has its specific stages. Every month, every semester, every year, every different period is a stage. As the time goes on, the continuous advancement of teaching process, students' ability level, their own needs, learning behavior and other characteristics will also change. Therefore, in different stages, the students' characteristics are different, so the precision teaching plan should be adjusted accordingly. On the other hand, every stage of the teaching process is interrelated, interdependent and interactional, and the corresponding teaching programs of each stage are not isolated. Therefore, the design of relatively long-term precision teaching plan should take into account the phases of the teaching process, which requires the study of the design of multi-stage optimal precision teaching plan. The design of precision teaching plan becomes a dynamic learning problem.

Assuming that there are *M* stages in the teaching process, the corresponding data for each stage is $F_0, S_0, F_1, S_1, \ldots, F_M, S_M, R$. Among them, S_i is the teaching strategy for stage *i* and F_i is the characteristics of students under the influence of teaching strategy ($S_0, S_1, \ldots, S_{i-1}$) before stage *i*. The formula is as follows:

$$F_0 \xrightarrow{S_0} F_1 \xrightarrow{S_1} \cdots \xrightarrow{S_{M-1}} F_M \xrightarrow{S_M} R \tag{6}$$

Then the problem is transformed into how to adjust the optimal individualized teaching plan according to the change of students' behavior, that is, to find the optimal dynamic and precision teaching strategy $d_0^*(H_0), d_1^*(H_1), \cdots, d_M^*(H_M)$. Maximize the following formula.

$$E\left(R\middle|S_0 = d_0^*(H_0), S_1 = d_1^*(H_1), \cdots, S_M = d_M^*(H_M)\right) \tag{7}$$

where, $H_0 = F_0$; $H_i = [F_0, d_0^*(H_0), d_1^*(H_1) \cdots, d_{i-1}^*(H_{i-1}), F_i]$, $i = 1,2, \cdots, M$.

This kind of dynamic optimization problem is usually solved by dynamic programming based on reverse recurrence, such as Q-learning, A-learning and Deep A-learning [21].

6. BIG DATA PROMOTING PRECISION TEACHING

At present, in the background of the new curriculum reform promoted by information technology, big data and cloud computing make it possible for machine labor to replace manual labor. This makes the data statistics and analysis of teaching process more accurate, creates better technical support for the implementation of precision teaching, and effectively promotes the refinement and effectiveness of teaching. The core value of precision teaching supported by big data is to discover the learning rules of learners by mining the data of learners' learning behavior, so as to predict and improve students' learning and teachers' teaching accurately. At the same time, the relevant resource design, teaching activity design and teaching strategies are properly evaluated to improve teaching activities and enhance students' academic performance and core literacy.

6.1 Data processing model

Based on big data analysis of precision teaching, first of all, we need to complete data processing and analysis. It includes the following three aspects: first, the comprehensive data acquisition; second, accurate and scientific data analysis; third, accurate and efficient data application. The three aspects are progressively advancing, and then forming a data processing model for precision teaching. As shown in Figure 2.

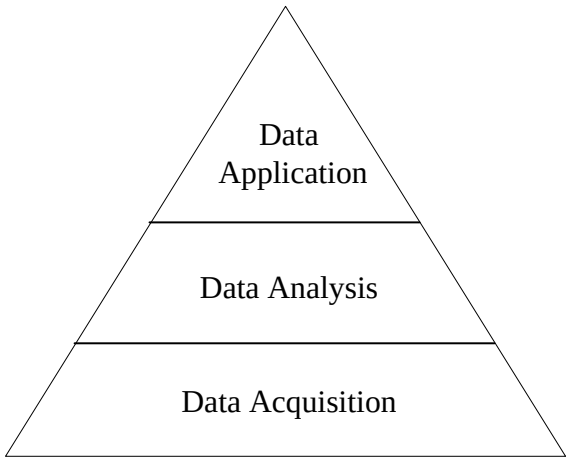

Figure 2. Data processing model for precision teaching

(1) Data Acquisition

Data is the foundation and core. By collecting the massive data normalized in the process of students' learning, teachers can really understand each student, and see the dynamic process of students' development and progress, so as to carry out the objective and rational analysis of students' academic situation and the assessment of students' academic level.

Data acquisition can be combined with on-line data acquisition and off-line data acquisition. The former collects "electronic data" and the latter collects "paper data". Online data acquisition mainly records students' interactive questions, acquisition feedback and online homework in online classroom through digital online classroom teaching platform and learning terminal equipment, and generates relevant learning data. Through data collection, we can get the most vivid and abundant real data in students' learning process.

(2) Data Analysis

On the one hand, the conventional statistics of students' test scores, such as the average class scores and the number of students in each score section, can no longer meet the inner demands of teachers, students and managers under the situation of big data. On the other hand, the normalized data of students' study and examination are massive and fragmentary. Professionals are required to establish mathematical models according to actual needs, and then software developers use mathematical statistics, machine learning, data mining and other technical means to conduct accurate and scientific data analysis to generate valuable information for students' learning, teachers' teaching and management decisions.

(3) Data Application

With the accurate big data analysis, students can better understand themselves, and teachers can better understand each student. Teachers can apply various teaching data to teach students in a purposeful way and teach students in accordance with their aptitude.

6.2 Services model of precision teaching

Under the traditional situation, the application and promotion of precision teaching encounter obstacles in the concept of thinking concept. But the big data technology could promote teachers' acceptance and acceptance of accurate teaching in their thinking concepts. It is of great significance to construct a services model of precision teaching for teachers to learn from, to promote the development of precision teaching and to promote the application of precision teaching. The following constructs a services model of precision teaching based on big data from three dimensions: establishing teaching goals, designing teaching process, teaching evaluation and prediction. The services model is shown in Figure 3.

Clear teaching goals are the logical starting points of teaching task and the important basis for testing the success or failure of teaching task. Accordingly, the most important task of precision teaching is to establish precision teaching goals.

Precision teaching originates from Skinner's procedural teaching, so programming is the core element of precision teaching. Designing a programmed teaching process framework is the key to guarantee the effective implementation of precision teaching.

In the big data environment, sensor technology, face recognition technology, learning and analysis technology and many other advanced technologies are combined and applied. These technologies enable accurate teaching evaluation to accompany the beginning and end of teaching behavior, and to predict the future that has not yet happened accurately.

6.3 Application model of precision teaching

Precision teaching under big data has significant technical advantages, and it has become a new application model different from Lindsley's traditional precision teaching.

The application model of big data precision teaching is shown in Figure 4. Its core content is "automatic recording, multidimensional observation and precision adjustment".

(1) Automatic Recording

This process refers to the data recording of learning behavior in educational information system. It contains behavioral process data, such as raising hands in class, asking questions in class, starting to answer questions, submitting answers and so on. It also contains behavioral result data, such as the result of raising the answer in class, the result of answering questions and so on. It also contains behavioral data, such as classroom audio and video recording, audio-visual recording, etc.

(2) Multidimensional Observation

This process is based on the learning situation analysis tools, observing and analyzing the students' situation reflected by the learning behavior data from multiple dimensions. In the process of practice, the commonly used learning situation analysis tools include "knowledge point distribution map", "achievement trend distribution map", "teacher-student social network map" and "student timeliness matrix", "personal knowledge map" and so on.

(3) Precision Adjustment

This process is based on the analysis of the learning situation and relevant expert experience, and precisely intervenes in class teaching methods and individual learning strategies. In practice, common adjustment measures include adjusting the teaching form, arranging intensive exercises for specific knowledge points, and providing individual guidance for specific students.

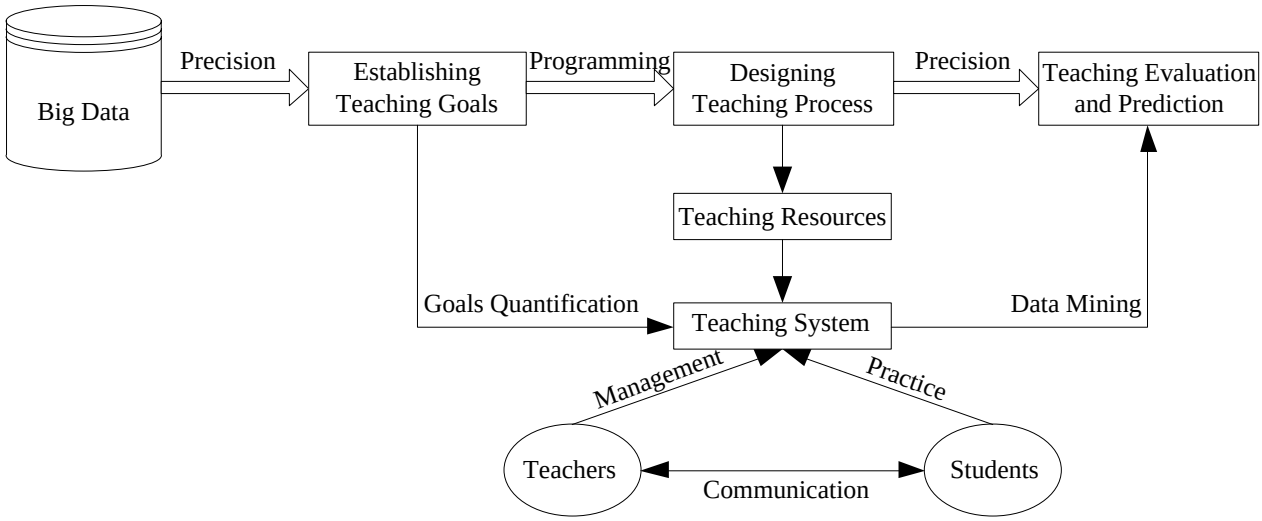

Figure 3. The services model of precision teaching

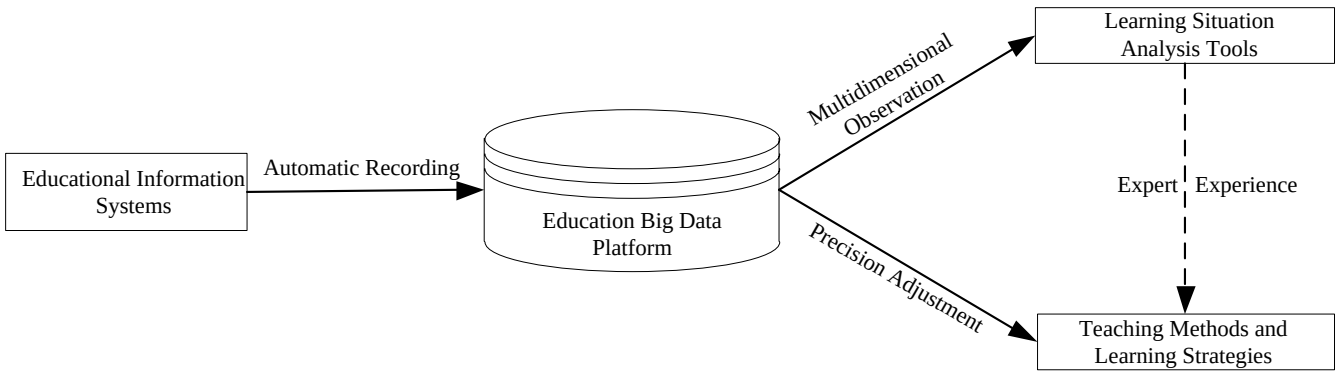

Figure 4. The application model of precision teaching

6.4 Analysis of teaching effectiveness

We examined two groups of students from the E-commerce program, one of which was subjected to a teaching reform plan based on precise teaching concepts, while the other did not receive this plan. The learning outcomes of these two groups were assessed. During the assessment process, five dimensions of teaching objectives were designed as follows:

(1) Fundamental knowledge: Understanding of e-commerce and its planning, design, operation, and other business knowledge and processes;

(2) Various skills: The ability to flexibly apply skills learned in previous courses, such as online store construction and customization, image processing, webpage creation, and network setup;

(3) Team collaboration: Mastery of operating an e-commerce platform through teamwork;

(4) Operational modules: Application of basic operational knowledge for content management, event management, and user engagement;

(5) Innovative capabilities: Possessing certain abilities in information processing, quantitative decision-making, and innovative application.

Based on the various assessment projects and outcomes

designed according to the teaching objectives, and by synthesizing the average scores of each course's assessments, the final achievement level of learning effectiveness for the program is shown in Figure 5.

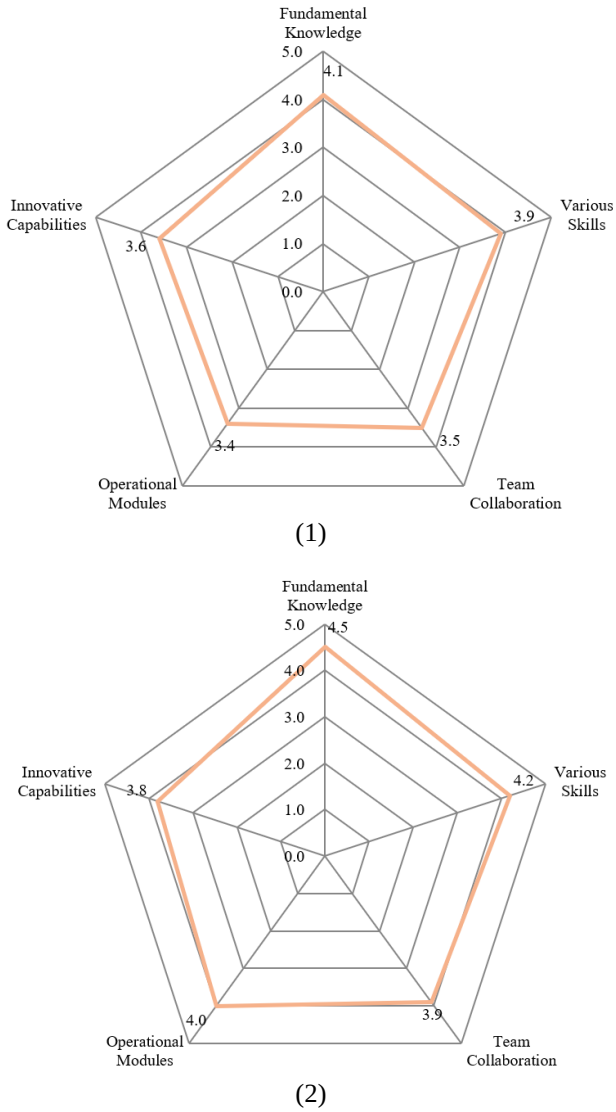

Figure 5. Radar chart of learning effect (1) Students not received this concept; (2) Students received this concept

The radar chart shows that students trained based on the concept of precision teaching have significantly improved in various aspects, while those who did not receive this concept are generally at a lower level.

7. CONCLUSIONS

Under the context of big data, precision teaching has entered a new stage of development. This paper analyses and studies the application of big data in precision teaching. The rise of big data has pushed data value to a new height. Big data makes precision teaching measure data more accurate and feasible, makes precision teaching take into account the personalized development of students, and makes the precision teaching environment more open and efficient.

In a word, the framework of big data precision teaching technology is a set of method system which has been tested by practice and is helpful to improve teaching quality and learning effect. It will be popularized on a large scale with the development of information technology.

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