Portrait-Based Academic Performance Evaluation of College Students from the Perspective of Big Data

Yusong Cao
University, Xuchang, China
`caoyusong1981@126.com`

Abstract—With the advent of the big data era, significant changes have taken place in every aspect of education. To effectively evaluate the academic performance of college students, this paper firstly establishes a scientific evaluation index system for student portrait. Taking the course Object-Oriented Programming as an example, the authors collected various data on the academic performance of college students. The collected data were normalized, and the weight of each evaluation index was determined through analytic hierarchy process (AHP). Next, a fuzzy evaluation model was constructed based on big data, and used to assess each dimension of college students' academic performance. The evaluation reveals the problems of college students in learning and practice, and helps to generate the portrait of each student. The research results promote the realization of personalized education.

Keywords—Big data, student portrait, academic evaluation, fuzzy evaluation model

1 Introduction

Big data and its diverse applications have changed people's life styles and work methods, also brought new opportunities for the innovation in education [1-15]. The Chinese government has attached great importance to education big data; therefore, a series of policies have been issued to promote the construction of education big data, and give guidance to the management and utilization of education big data.

With the advent of the big data era, significant changes have taken place in every aspect of education. Using data mining, learning analysis, data visualization and other technologies, the behavioral data related to the academic performance of college students could be analyzed and integrated to assess the learning situation of college students; moreover, the data obtained via the mentioned techniques also enable college students to discover their problems in the learning and practice process, and the teachers could make use of these data to give targeted and personalized instructions. In the context of big data, the academic performance evaluation of college students has undergone big changes in aspects of ideas, methods and techniques. The totality of big data can give evaluations of college students as a whole; its real-time and dynamic features can realize whole-process evaluation of the academic development process of

college students; the authentic source of big data ensures that the evaluation results are scientific and objective; and the foreseeability of big data can improve the use efficiency of the evaluation results. Scholars Hamad et al. [16] discussed the opportunities and challenges brought by big data to the analysis strategies of university libraries in Jordan. Vora and Rajamani [17] used big data to predict students' academic performance. Castaneda et al. [18] discussed deep learning evaluation models across multiple big data domains. Wibisono and Sarwinda [19] used big data to predict the student evaluation model in the data stream algorithm. In a word, the development of big data, especially the development of education big data, can promote the overall reform of the academic performance evaluation of college students.

After reviewing the research works of Cumming and Miller [20], Hedgcock [21], Fabra-Mata and Mygind [22] and Amundsen and D'Amico [23] concerning the academic performance evaluation of college students, we have summarized the reform measures for the said matter as follows: first, reform the evaluation methods, that is, apply multiple evaluation methods to evaluate multiple subjects; here multiple subjects include teachers, students, and peers; and multiple evaluation methods can be exams, classroom observations, and practice activities, etc. Second, enrich the evaluation content, that is, construct scientific evaluation index system to give comprehensive evaluations to students from various aspects such as their morality, intelligence, and physical fitness, etc. Third, increase the utilization of evaluation results, that is, timely feedback the evaluation results to the students so that they could correct their problems in time. Fourth, carry out studies on student academic performance evaluation using big data technologies.

The literature review we conducted suggested that currently there're very few research papers concerning the evaluation of the academic performance of college students using big data, and a few relevant studies were aimed at designing personalized learning evaluation systems borrowing the idea of big data concept; moreover, the data of such systems were mostly collected from the online learning trajectories of students, offline evaluation factors were less considered. In addition, one-sided learning evaluation can only evaluate a narrow aspect of the academic performance of college students, for this reason, this study comprehensively considers both the online learning and offline learning of students and constructs a comprehensive evaluation index system; then, the paper conducts an empirical research on the proposed system and achieves personalized and dynamic evaluation of college students' academic performance.

As mentioned above, now there're very few studies directing at the academic performance of college students, and the existing ones mostly centered on the field of basic education; as for studies that have truly applied big data technologies to the evaluation of college students' academic performance, no case has been reported yet. The Ministry of Education has requested to improve the teaching quality of undergraduate education and target at cultivating all-round talents, in this context, it becomes a development trend in the field of education to reform the evaluation concept and content, and make full use of big data, AI and other new-generation information technologies to construct a comprehensive system for the evaluation of college students' academic performance [24-33].

2 Introduction to the Profiling Technique

As big data have been accumulated continuously and new techniques are being innovated, Recommendation Engines (EO) have become an important starting point for researchers to process information. The deepening understanding of analysis objects has brought out a new concept: the user portraits. A user portrait is a profile that can better describe the user, it makes the information of the user (namely the analysis object) more vivid and alive, and can be processed by computers more easily; it is also the reason for some big companies to employ the big data theories.

The student portraits are used to identify students, and the profiling technique can draw the portraits by analyzing the students: such as what behaviors and habits they have, and their status in the class, etc., it can also reflect their studies through their behaviors. In short, user information tagging. After the learning situations of students have been analyzed, their portraits could be drawn, and an important work in this process is to tag the students, then through the tags on the students, their academic performance could be analyzed more objectively and comprehensively; and the tags make the information processing even easier.

The purpose of student profiling is to give real-time evaluations to the learning process of students. Once the student portraits are drawn, teachers and administrators can have a more accurate and intuitive understanding of the students, and this could serve as a focus for teachers to evaluate the students. When disagreement arises, the portraits of students can always provide a reasonable balance point. Previous academic performance evaluation usually focuses on exam scores, the evaluation results are one-sided and cannot reflect the real ability or potential of the students, that is to say, the traditional GPA (Grade Point Average) evaluation method cannot measure students' development, and such exam-oriented evaluation method is detached from the actual development requirements of the students, resulting in that students attach undue importance to exam scores, students learn for exams, teachers teach for tests, and ultimately, all of them will give negative response to the evaluations.

2.1 Student portrait index system

During portrait profiling, a theme runs through the process is how to truly reflect the status of students using the data, and this means that we need to extract registration data, browsing and collection history, feedback information, as well as some text data of students to better evaluate them. For this purpose, we need to find a method to collect all these fragmentary and scattered data and convert into useful and complete information, and this process is just the design and generation of student portraits. According to the actual requirements of the evaluation of college students' academic performance, this paper designed a student portrait index system, which includes the following 20 indexes: average viewing time of teaching videos (video time), number of uploads and downloads of learning resources (resource upload/download), number of borrows of related library books (book borrow), number of times of classroom attendance (classroom attendance), number of questions answered by the student (questions answered), number of valid comments on learning resources (resource

comment), daily test grades (daily grades), final exam scores, grades of personal works (personal works), time takes to obtain correct experimental results (experiment time), number of times of punctual homework submissions (homework submission), number of questions proposed by the student to teachers (questions proposed), ability to discover problems independently (problem discover), ability to analyze problems independently (problem analysis), classroom notes, team work, experimental reports, accurate analysis of experimental results (experiment analysis), proper data processing method (data processing method) , and detailed data processing process explanation (data processing process). In the following texts, these indexes (referred to by the names in the brackets) are employed to analyze the student portraits.

3   Construction of College Student Portrait Model Based on Big Data

Education big data is generated from various activities, including both school activities and life activities. Using student portrait model, their learning status could be described and expressed from multiple aspects. For this purpose, we need to study the personalized expression of student portrait model, analyze and normalize the parameters, and construct a personalized student portrait model. Then, based on the full-sided student data obtained, for the complete teaching scenarios, we need to set learning status and result information from different angles and cycles, realize the data-driven portrait model, profile specific and personalized student portraits, and quantify their characteristics from multiple dimensions such as regularity, effort level, and learning skills, etc., in this way, we could provide an important basis for the schools to give comprehensive, scientific and objective evaluations for students.

Table 1. Quantitative learning data of students

Index	Student 1	Student 2	Student 3	Student 4
Video time	25.22	8.15	27.23	22.22
Resource upload/download	10	6	8	9
Book borrow	1	1	0	3
Classroom attendance	8	8	6	6
Questions answered	5	6	5	6
Resource comment	2	3	0	3
Daily grades	85	60	82	75
Final exam scores	75	72	78	72
Personal works	82	81	85	76
Experiment time	11.23	31	12.31	25.12
Homework submission	8	7	8	6
Questions proposed	12	6	7	6
Index	Student 5	Student 6	Student 7	Student 8
Video time	23.06	25.08	29.12	28.34
Resource upload/download	8	9	8	5
Book borrow	2	3	2	2
Classroom attendance	8	8	8	5

Questions answered	2	3	4	3
Resource comment	1	0	2	2
Daily grades	65	68	72	75
Final exam scores	70	66	65	70
Personal works	70	61	62	62
Experiment time	20.35	27.56	15.23	22.31
Homework submission	6	5	7	7
Questions proposed	8	8	8	7

3.1 Data collection

In this study, the course "Object-oriented programming" was taken as the example, 10-times performance data of 8 students in this course were extracted, and some of the learning process data were recorded on the excellent course website. Table 1 shows the quantitative learning data of students in this course. Table 2 shows the qualitative learning data of student 1 for this course.

3.2 Data processing

Since the student data came from different aspects, it needs to be normalized. First, based on the automatically generated data on the network platform, the data was divided into five levels: excellent, good, average, poor and very poor. Table 3 shows the evaluation levels of the quantitative data.

Table 2. Qualitative learning data of student 1

Index	Excellent	Good	Average	Poor	Very poor
Problem discover	0.8	0.2	0	0	0
Problem analysis	0.5	0.3	0.2	0	0
Classroom notes	0.4	0.2	0.4	0	0
Team work	0.7	0.3	0	0	0
Experimental reports	0.2	0.3	0.5	0	0
Experiment analysis	0.5	0.4	0.1	0	0
Data processing method	0.5	0.2	0.2	0.1	0
Data processing process	0.4	0.6	0	0	0

Table 3. Evaluation levels of quantitative data

Index	Excellent	Good	Average	Poor	Very poor
Video time	25-30	20-25	15-20	10-15	0-10
Resource upload/download	8-10	6-8	4-6	2-4	0-2
Book borrow	Above 4 times	3-4	2	1	0
Classroom attendance	9-10	8	6-7	4-5	0-3
Questions answered	Above 5 times	3-4	2-3	1	0
Resource comment	Above 5 times	3-4	2-3	1	0
Daily grades	90-100	80-90	60-75	50-60	Below 50
Final exam scores	90-100	80-90	60-75	50-60	Below 50
Personal works	90-100	80-90	60-75	50-60	Below 50

Experiment time	10-15	16-20	21-25	25-30	Above 30
Homework submission	9-10	7-8	5-6	3-4	0-2
Questions proposed	Above 10 times	8-9	6-4	1-3	0

3.3 Fuzzy evaluation model based on big data

According to the 20 evaluation indexes and 5 evaluation levels {excellent, good, average, poor, very poor} given, a fuzzy relationship evaluation matrix had been constructed in the paper. Based on the big data results on the network platform and the qualitative evaluation data of students, the established fuzzy matrix is as follows:

$$M1 = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \\ 0.8 & 0.2 & 0 & 0 & 0 \\ 0.5 & 0.3 & 0.2 & 0 & 0 \\ 0.4 & 0.2 & 0.4 & 0 & 0 \\ 0.7 & 0.3 & 0 & 0 & 0 \\ 0.2 & 0.3 & 0.5 & 0 & 0 \\ 0.5 & 0.4 & 0.1 & 0 & 0 \\ 0.5 & 0.2 & 0.2 & 0.1 & 0 \\ 0.4 & 0.6 & 0 & 0 & 0 \end{pmatrix}$$

Then, the weight values of each evaluation index were determined by AHP, n experts were invited to give the importance judgment matrix A, each judgment matrix was subject to the consistency test. If it fails to pass the test, it is fed back to the scorer to modify the results. Using eigenvector method, the eigenvector corresponding to the largest eigenvalue of the judgment matrix was obtained, and the obtained eigenvector was the weight values of the indexes. By calculating the largest eigenvalue and conducting the consistency check, the weight vector of the indexes was obtained to be:

$$A1 = (0.0378, 0.0215, 0.0217, 0.0637, 0.0138, 0.0105, 0.319,$$

$$0.0835, 0.0651, 0.0367, 0.0256, 0.0187, 0.0587, 0.0871, 0.0322,$$

$$0.0316, 0.0111, 0.02, 0.0308, 0.0109)$$

The weighted fuzzy evaluation matrix is:

$$A1 * M1 = \{0.28599, 0.55122, 0.13801, 0.02478, 0\}$$

In order to obtain the comprehensive evaluation results of college students' academic performance, the evaluation levels should be quantified, as shown in Table 4.

Table 4. Coefficients of evaluation levels

Level	Excellent	Good	Average	Poor	Very poor
Score	90-100	80-90	70-80	60-70	60以下
Coefficient	95	85	75	65	50

According to fuzzy evaluation method, the final evaluation result of student 1 in the course "Object-oriented programming" was 95*0.28599+85*0.55122+75*0.13801+65*0.02478+50*0=86.27019, the result indicated that the performance of the student in this course was "Good", although his/her exam score was 75 and the evaluation level of the score was average. This shows that students shouldn't be evaluated solely based on one-time exam scores, and the evaluation based on final exam scores cannot objectively reflect the overall learning attitude, learning status, and the learning process and effects of the students. Then, the scores of each index of the student were subject to quantitative analysis, and the specific index scores of student 1 are listed in Table 5 below.

Table 5. Index scores of student 1

Index	Full score	Actual score	Percentage of score
Video time	3.591	3.591	1
Resource upload/download	2.0425	2.0425	1
Book borrow	2.0615	1.4105	0.684211
Classroom attendance	6.0515	5.4145	0.894737
Questions answered	1.311	1.311	1
Resource comment	0.9975	0.7875	0.789474
Daily grades	30.305	27.115	0.894737
Final exam scores	7.9325	6.2625	0.789474
Personal works	6.1845	5.5335	0.894737
Experiment time	3.4865	3.4865	1
Homework submission	2.432	2.176	0.894737
Questions proposed	1.7765	1.7765	1
Problem discover	5.5765	5.4591	0.978947
Problem analysis	8.2745	7.6648	0.926316
Classroom notes	3.059	2.737	0.894737
Team work	3.002	2.9072	0.968421
Experimental reports	1.0545	0.9102	0.863158
Experiment analysis	1.9	1.78	0.936842
Data processing method	2.926	2.6488	0.905263
Data processing process	1.0355	0.9701	0.936842

According to fuzzy evaluation method, the final fuzzy evaluation matrix of student 2 is:

$$M2 = \begin{pmatrix} 0 & 0 & 0 & 0 & 1 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0.2 & 0 & 0.2 & 0.6 & 0 \\ 0.5 & 0.3 & 0.2 & 0 & 0 \\ 0.4 & 0.2 & 0.4 & 0 & 0 \\ 0.7 & 0.3 & 0 & 0 & 0 \\ 0.2 & 0.3 & 0.5 & 0 & 0 \\ 0.5 & 0.4 & 0.1 & 0 & 0 \\ 0.5 & 0.2 & 0.2 & 0.1 & 0 \\ 0.4 & 0.6 & 0 & 0 & 0 \end{pmatrix}$$

$$A2 * M2 = \{0.136070，0.241980,0.168450,0.3790,0.0745\}$$

The evaluation result of student 2 in the course "Object-oriented programming" was: 95*0.13607+85*0.241980+75*0.168450+65*0.3790+50*0.0745=74.4887. This student's performance in the course was "Average", although the evaluation level of his/her exam score was "Poor". Then, the scores of each index of the student were subject to quantitative analysis, and the specific index scores of student 2 are listed in Table 6 below.

Table 6. Index scores of student 2

Index	Full score	Actual score	Percentage of score
Video time	3.591	1.89	0.526316
Resource upload/download	2.0425	1.8275	0.894737
Book borrow	2.0615	1.4105	0.684211
Classroom attendance	6.0515	5.4145	0.894737
Questions answered	1.311	1.311	1
Resource comment	0.9975	0.7875	0.789474
Daily grades	30.305	20.735	0.684211
Final exam scores	7.9325	6.2625	0.789474
Personal works	6.1845	5.5335	0.894737
Experiment time	3.4865	1.835	0.526316
Homework submission	2.432	2.176	0.894737
Question proposed	1.7765	1.4025	0.789474
Problem discover	5.5765	4.2851	0.768421
Problem analysis	8.2745	7.6648	0.926316
Classroom notes	3.059	2.737	0.894737
Team work	3.002	2.9072	0.968421
Experimental reports	1.0545	0.9102	0.863158
Experiment analysis	1.9	1.78	0.936842
Data processing method	2.926	2.6488	0.905263
Data processing process	1.0355	0.9701	0.936842

In terms of the percentage of score, the portrait tags of student 2 should be: answer questions actively, analyze experimental results accurately, and good team work ability; however, student 2 needs to work on aspects of the viewing time of teaching videos, and obtaining correct experimental results.

4 Conclusion

Based on a constructed student portrait model, this paper established a college student academic performance evaluation model, which laid a good basis for data analysis. Then, through a few selected data analysis methods, a fuzzy evaluation model integrated structured, semi-structured, and unstructured data was proposed, studied, and applied to restore the big data analysis results and express them as specific questions, also, the root of these questions was analysis in the paper. The evaluation suggestions made through data analysis and research could be fed back to the administration departments to assist decision-making. With the established data comparison samples, we can write academic performance reports for individual students and write development evaluation report for the entire student group according to the analysis results, and then give reasonable development suggestions, and build a college student development evaluation mechanism in the context of big data; the analysis results can be used to issue early warnings for the academic progress of college students and predict their academic development level.

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6 References

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7 Author

Yusong Cao, associate professor, School of Food and Pharmacy, Xuchang Univesity, has been engaged in higher education teaching for a long time. She has presided over six teaching reform projects and published more than fifteen papers on education and teaching reform.