Construction and Adjustment Methods for Teacher-Student Relationship in College Student Management Based on Big Data Analysis

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Abstract—Building a harmonious Teacher-Student Relationship (TSR) is a necessary work for college student management, because different TSRs can result in different effects in student management and cultivation. However, in existing studies, the definitions of harmonious TSR given by different scholars are dimensionless, the understandings of the nature of TSR is not thorough enough, and the analysis of the influencing factors of TSR often lacks the support of theoretical evidences. To overcome these shortcomings, this paper aims to study the construction and adjustment methods for the TSR in college student management based on big data analysis. At first, the paper investigated the daily behavioral features of college students on online management platforms; then, with the help big data analysis and data processing techniques, this paper calculated the fitness degree of harmonious TSR between college students and the counselors and other administrators who engaged in student management works and have interacted with them. After that, based on the calculation results of the said fitness degree, this paper built a basic interactive network for college student management works, and gave the method for dividing student management groups. At last, experimental results verified the effectiveness of the proposed algorithm.

Keywords—big data analysis, college student management, teacher-student relationship (TSR), counselor

1 Introduction

College student management is a cumbersome but important work that requires circumspection and patience, and it is closely linked to other types of works [1–8]. In the course of social progress, students' values and life outlook are greatly affected by the

social environment, as a consequence of the one child policy that had been carried out for decades in China, the numbers of only child and special group students are growing, brining many new challenges for the student management works in colleges and universities [9–13]. Building a harmonious TSR is a necessary work for college student management, because different TSRs can result in different effects in student management and cultivation [14–19]. The student management works should center on college students and take student development as the goal, in this way, when students encounter problems, they could get instructions from counselors and other administrators, and the counselors and administrators would receive respect and affection from students.

As we enter the era of big data, student management is no longer a repetitive and procedural job. Field scholars have conducted relevant studies on college student management based on big data, for instance, scholar Wang [20] adopted big data analysis techniques and principles to build a system structure for the college student information management platforms in the big data environment, which contained a user layer, a service layer, an application layer, a persistence layer, and a data layer; the writer also proposed a path for building such platforms based on big data so as to make the management works more scientific and effective. Scholar Zou [21] devised and implemented a comprehensive university management system platform which involves various student-related tasks such as enrollment, accommodation, fee collection, and employment, aiming at improving the decision-making, management level and student training quality of colleges and universities, the writer also designed a student management system platform, the system requirements were analyzed at first, then the function modules of the system were summarized, at last, the design details of each function module were given. Hershkovitz et al. [22] used the mobile app WhatsApp to study the primary and secondary school students' perception of classroom environment, the TSR, and their out-of-class communication, and they identified the special roles of WhatsApp in promoting good TSR and active classroom environments. Tang et al. [23] took high school students as subjects to discuss the influencing factors of their autonomous learning, they selected 306 high school students in Yunnan Province and Xiamen City of China, and studied the relationship between parenting style and TSR of the students and their autonomous learning via questionnaire survey; the authors also explored the mediating role of core self-evaluation and used SPSS22.0 and AMOS22.0 for data analysis. A growing number of studies suggest that TSR is negatively correlated with the Internet addiction of adolescents, Jia et al. [24] investigated the problem of whether psychological safety and abnormal peer relationship play a mediating role between TSR and Internet addiction, and used questionnaires to survey related aspects including demographics, TSR, psychological safety, abnormal peer relationship, and Internet addiction.

Regarding TSR and college student management, existing studies have proposed rich research contents and methods, however, after carefully reviewing relevant literatures, it's found that the definitions of harmonious TSR given by different scholars are dimensionless, the understandings of the nature of TSR is not thorough enough, and the analysis of the influencing factors of TSR often lacks the support of theoretical evidences. To overcome these shortcomings, this paper aims to study the construction

and adjustment methods for TSR in college student management based on big data analysis. In the second chapter, this paper investigated the daily behavioral features of college students on online management platforms, then, with the help big data analysis and data processing techniques, the fitness degree of harmonious TSR between college students and the counselors and other administrators who engaged in student management works and have interacted with them was calculated. In the third chapter, based on the calculation results of the said fitness degree, this paper built a basic interactive network for college student management, and gave the method for dividing student management groups. At last, experimental results verified the effectiveness of the proposed algorithm.

2 Modelling of the influencing factors of TSR

A harmonious TSR should be a positive companion relationship that promotes the joint development and growth of both teachers and students. College students would encounter various problems, so the instructions provided by teachers should be flexible. Due to the diversity of actual situations, the building of TSR often seems difficult and fragile, so it's necessary to study the construction and adjustment of TSR and its influencing factors and analyze them from multiple perspectives, so as to update the ideas of teacher management, build scientific and standardized management systems, and formulate humanized and personalized application standards. In order to rationally build TSR in college student management, this paper combined with the daily behavioral features of college students on online management platforms and employed big data analysis and data processing techniques to propose methods for building TSR in college student management.

Colleges and universities often use online management platforms to carry out student management works smoothly and collect the data of students' daily and learning behaviors in real time. This paper selected several factors in these behaviors as key factors for building TSR and constructed a model for the said matter.

The gender difference between students and counselors/administrators is a key factor that can affect TSR, this factor is so important that it determines whether students would seek help from counselors or administrators, open their heart, and carry out verbal or emotional communications constantly. Therefore, if samples of students' daily behavior features are to be taken, the gender difference is the first thing to be considered, and the gender difference model *GE* is given by the following formula:

$$GE = \begin{cases} 0, Male \\ 1, Female \\ 2, Others \end{cases} \tag{1}$$

Students in different grades have certain differences in terms of basic cognition, comprehension ability, and communication skills; and they would encounter different types of problems, such as freshmen would have difficulties during enrollment, while students in higher grades have to face employment problems. This paper built a grade difference model *NJ* for it, which could be expressed as:

$$NJ = \begin{cases} 0, Freshman \\ 1, Sophomore \\ 2, Junior\ year \\ 3, Senior\ year \end{cases} \tag{2}$$

When matching suitable counselors or administrators for students to give proper instructions, the students' daily behavioral habits and preferences are an important similarity factor. The behavioral habits of students during their daily life and learning would show certain regularities and periodic characteristics, so when calculating students' daily behavioral habits and preferences, this study investigated multiple time spans, and the specific calculation methods for the features of the behavioral habits and preferences of college students are given below. At first, according to the regularities and features of behaviors, this paper divided the students into different groups, the specific mathematical model is:

$$TI = \begin{cases} 0, Live\ regularly \\ 1, Work\ and\ rest\ irregularly \\ 2, Dine\ irregularly \\ 3, Recreate\ irregularly \\ 4, Without\ fit-keeping\ awareness \end{cases} \tag{3}$$

The click on in-class and after-class learning resources *PVS*, and the level of repeated clicks *AVR* can describe students' interest and attention in different types of educational training or psychological instructions currently provided in the school; moreover, assuming *PE* represents the percentage; *SP* represents the click frequency of learning resources; *TOW* represents the number of repeated clicks; *TOV* represents the total number of resources being clicked repeatedly; x_1 represents the set of different training programs that students participate; then the specific mathematical model is:

$$PVS = \sum_l PE(l) * SP(l) \tag{4}$$

$$AVR = \frac{1}{x_1} \sum_i^{x_1} \frac{TOW_i}{TOV_i} \tag{5}$$

The attendance level *PEO* can represent students' learning involvement degree, it can measure fluctuations in students' psychological state and the changes in their daily behavioral habits; also, assuming *WHW* represents the number of class hours that students should complete; *WRW* represents the number of class hours that students actually

complete; x_2 represents the set of different offline classes that students participate, then the specific mathematical model is:

$$PEO = \frac{1}{x_2}\sum_i^{x_2}\frac{WRW_i}{WHW_i} \tag{6}$$

The messages, discussions, and interactions left and conducted by college students in the message boards or forums of online management platforms can intuitively reflect their real thoughts and willingness and determination to solve current problems, and this information is very helpful for counselors and administrators to figure out the key issues and apply targeted adjustment measures when dealing with student management works. Assuming: *NMA* represents the total number of posts; *NPO* represents the total number of replies; *NUH* represents the total number of likes; x_3 represents the set of different discussions that students participate, then the corresponding mathematical models of *PEO* (level of post numbers), *PAO* (level of reply numbers), and *PEH* (level of like numbers) are:

$$PEO = \frac{1}{x_3}\sum_i^{x_3} NMA_i \tag{7}$$

$$PAO = \frac{1}{x_3}\sum_i^{x_3} NPO_i \tag{8}$$

$$PEH = \frac{1}{x_4}\sum_i^{x_4} NUH_i \tag{9}$$

In the management process of large-scale student groups, the various features of students' daily behavioral habits and preferences often exhibit a normal distribution. To better process these features, this paper further divided the students being managed as:

$$\lambda = \frac{1}{M}\sum_i^{M} c_i \tag{10}$$

$$\xi = \frac{1}{M}\sum_i^{M}\sqrt{\left(c_i - \lambda\right)^2} \tag{11}$$

$$c = \frac{c-\lambda}{\xi} \tag{12}$$

The *c*-value in above formula is the value on the standard normal distribution corresponding to the eigenvalue of students' daily behavioral habits and preferences, by comparing this value with the quantile value of the standard normal distribution, the categories of students could be judged. Figure 1 gives the diagram for judging students' categories and building TSR, blue blocks in the figure represent counselors and other student management administrators.

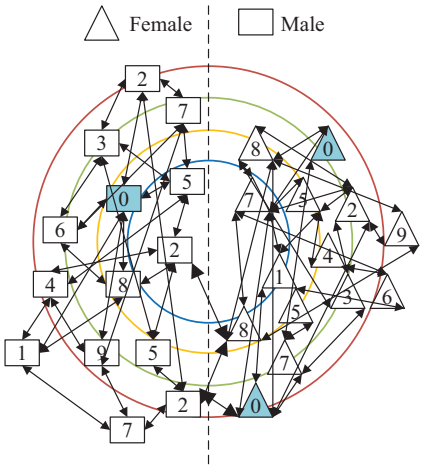

Fig. 1. Diagram for judging students' categories and building TSR

During harmonious TSR building, the history communication experiences are also a very important influencing factor. If a student has positive conversations, discussions, or interactions with a counselor recommend by the proposed TSR building method in the past, such as in the message boards or forums on the online management platforms, then, it's more likely to build a harmonious TSR between them, therefore, it's very necessary to analyze the contents of such conversations, discussions, or interactions.

Assuming: *REC* represents the text sentiment analysis value of each piece of interactive information between students and counselors/administrators; M_e represents the set of positive sentiment words extracted after the interactive information is processed by word segmentation tools; M_m represents the set of negative sentiment words; q represents the weight value attained from calculations; S represents the set of interactive information; *FIC* represents the fitness distance of harmonious TSR; then the following formula calculates the fitness degree of TSR between a student and the counselors/administrators he/she has interacted with:

$$REC = \frac{\sum_{i=1}^{M_e} qe_i + \sum_{j=1}^{M_m} qm_j}{M_e + M_m} \tag{13}$$

$$EMC = \frac{1}{S}\sum_{i}^{s} \frac{REC_i}{T_N - T_P} \tag{14}$$

$$EMC = \begin{cases} \dfrac{EMC}{max(EMC)}, if \quad EMC > 0 \\ \dfrac{EMC}{-min(EMC)}, if \quad EMC < 0 \end{cases} \tag{15}$$

$$FIC = \frac{1}{EMC + 1 + e^{-10}} \tag{16}$$

3 Large-scale student group management based on basic interactive network

Based on the calculation results of the fitness degree of harmonious TSR, a basic interactive network could be constructed for the student management works in colleges and universities. During the management of large-scale student groups, in order to help counselors/administrators achieve better communication effects and find out students who need help, this paper further divided the student management groups.

Assuming: B_{uq} represents the network adjacency matrix; l_u and l_q represent the degrees of nodes u and q in the network; $\xi(x_u, x_q)$ represents the binary function describing whether two nodes have been classified into a same community, this paper used the modularity to divide the student management groups, and its mathematical definition is given by the formula below:

$$W = \frac{1}{2n}\left[B_{uq} - \frac{l_u l_q}{2n}\right]\xi(x_u, x_q) \tag{17}$$

The division of student management groups is a basic clustering problem, this paper adopted the *k-Means* method as the clustering method. Since the distance calculation method in conventional *k-Means* method cannot accurately determine the importance degree of each influencing factor of harmonious TSR in the calculation of fitness degree, this paper used the *Jaccard* distance based on graph structure to represent the distance between nodes in the basic interactive network of college student management in the graph, assuming $M(u_i)$ represents the adjacency vector of node u_i, $M(u_j)$ represents the adjacency vector of node u_j, then the specific formulas are:

$$JD = \frac{\left|M(u_i) \cap M(u_j)\right|}{\left|M(u_i) \cup M(u_j)\right|} \tag{18}$$

$$JD = JD + 10^{-5} \tag{19}$$

$$JD = \frac{1}{JD} \tag{20}$$

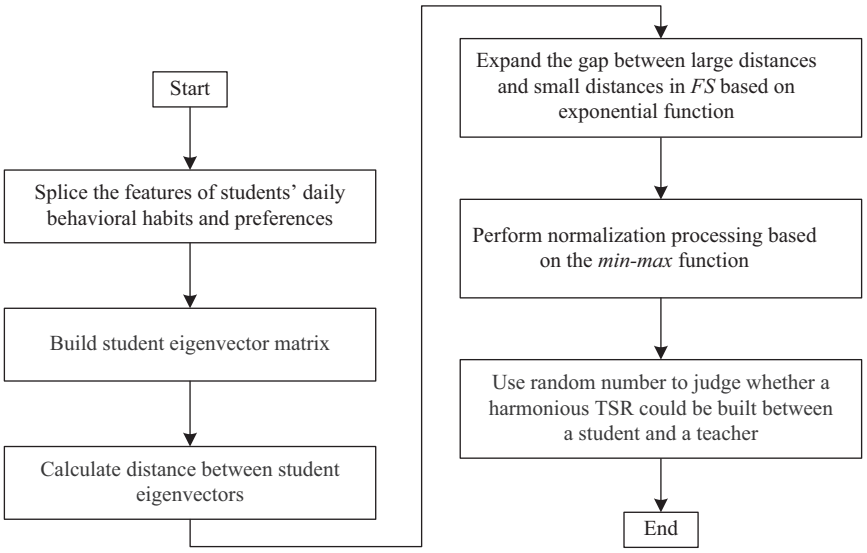

Fig. 2. Flow of the harmonious TSR labeling algorithm

Figure 2 gives the flow of the labeling algorithm for harmonious TSR. As shown in the figure, by splicing the features of students' daily behavioral habits and preferences, a student eigenvector matrix could be attained, denoted as *FS*. The greater the distance between *FS* and *FD*, the lower the probability that two will be classified into a same student management group. Therefore, this paper used an exponential function to expand the gap between the large values and the small values in *FS*, then, normalization was performed using the min-max function, among the fitted teachers who have already built TSR with the student, those with a smaller similarity distance have a greater probability to build a harmonious TSR with this student. At last, this paper used the random number to judge whether a harmonious TSR could be built between a student and a teacher, the relevant formulas are:

$$FD = \left[\sum \left(\nabla FS_{i,j} \right)^2 \right]_{m \neq m} \tag{21}$$

$$FD = exp\left(FD \right) \tag{22}$$

$$FD = min\_max\left(FD \right) \tag{23}$$

$$FAD_{i,j} = \left[RAND\left(\ \right) > FD \right] \tag{24}$$

Combining with the features of students in their daily behavioral habits and preferences during TSR building, this paper adopted the neural network training method to recommend students whose similarity and complementary factors of daily behavioral habits and preferences both meet requirements to teachers, so as to build harmonious TSR for student management works, the structure of the neural network is given by the Figure 3 below.

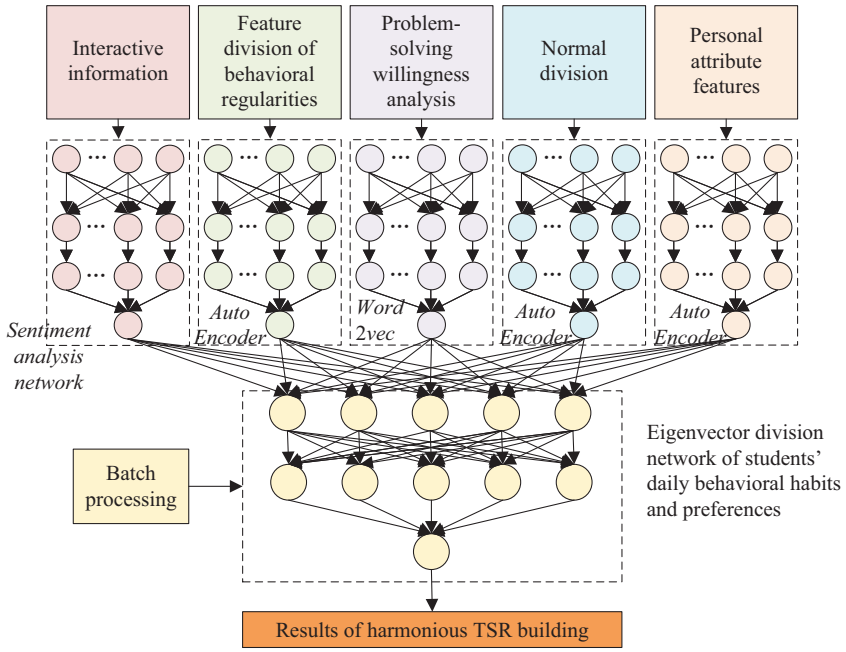

Fig. 3. Structure of neural network of harmonious TSR building

4 Experimental results and analysis

After the basic interactive network for college student management was constructed, based on the advantages of big data analysis, the information data in the network could be shared, which had increased the probability of successfully building harmonious TSR. In this research, five scenarios were simulated, and the results of fitness degree of different TSR samples are summarized in the following Table 1. Figure 4 shows the variations of the fitness degree of TSR in different scenarios.

Table 1. Fitness degree of TSR in different scenarios

Sample No.	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
1	325.14	526.39	569.37	695.38	825.41
2	113.62	125.48	162.37	251.47	262.38
3	15.28	16.37	158.24	162.38	157.19
4	469.35	528.42	639.28	625.31	695.38
5	45.17	52.61	314.27	352.94	417.25
6	162.35	152.49	125.48	158.24	252.19
7	25.41	24.51	23.59	23.16	25.37
8	–13.62	–16.35	–37.48	–46.21	125.62
9	–9.638	–142.58	–152.96	–185.62	–224.15
10	–142.58	–169.35	–128.37	–114.27	–169.37
11	–263.95	–258.36	–362.95	–362.95	–451.25

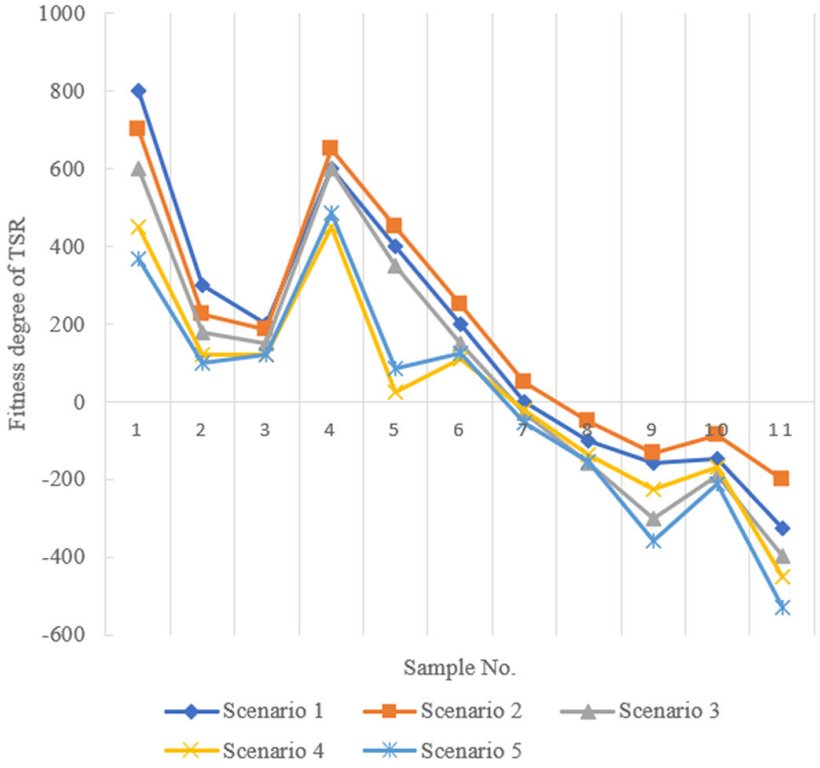

Fig. 4. Variations of fitness degree of TSR in different scenarios

According to above experimental results, there're not much difference in the calculation results of the fitness degree of TSR of different samples in different TSR building requirement scenarios. Samples No.4 and No.1 had higher TSR fitness; and the calculation results of samples No.7, No.8, No.9, No.10, and No.11 were less than 0, indicating that the TSRs built for these samples were not fitted at all, and the fitness of sample No. 11 was the worst.

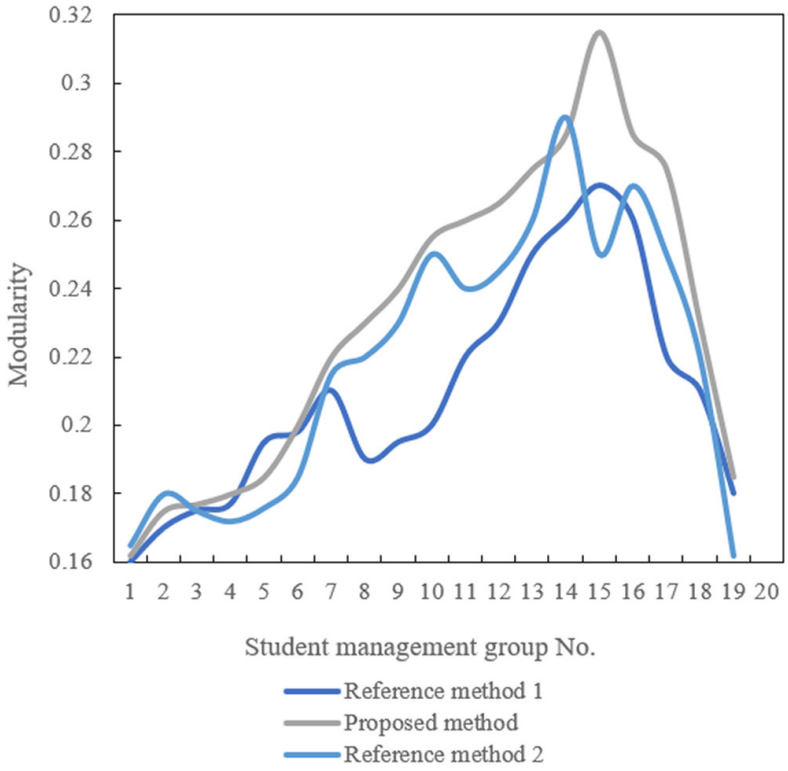

Fig. 5. The modularity of student management groups of different algorithms

To solve the problem of student management group division, this research conducted experiments on three algorithms including the proposed method, and took modularity as the index for evaluating the quality of division results. Figure 5 gives the modularity of student management groups of different algorithms. The reference algorithms were the GN community discovery algorithm and the community detection algorithm.

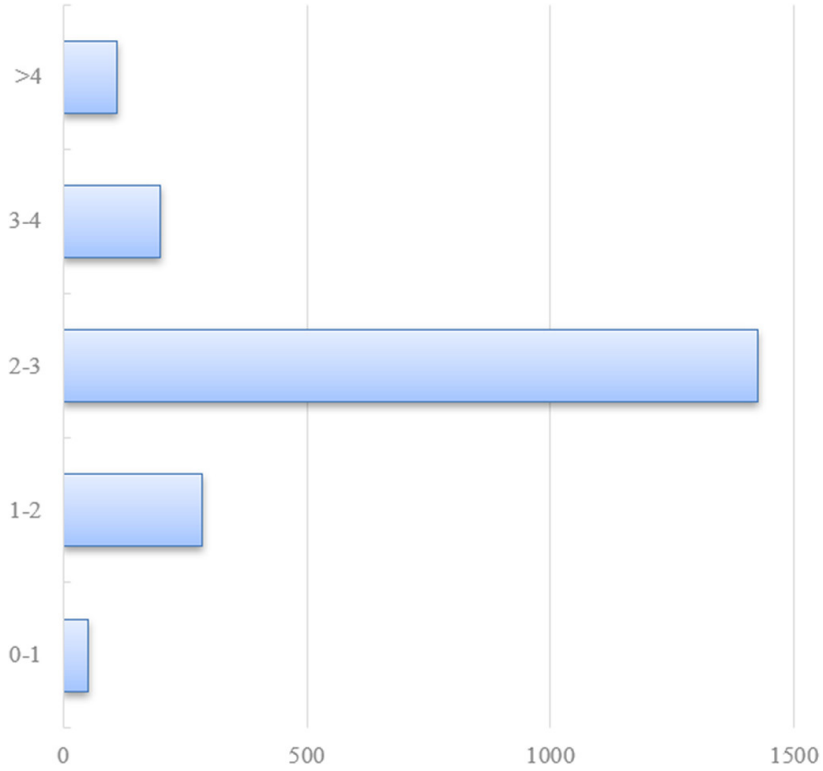

Fig. 6. Statistics of partnership labeling results of samples

According to the figure, with the increase of the total number of preset student management groups, the modularity values of the three algorithms increased as well, indicating that obviously there're dividable student management groups on the online management platforms. By comparing the experimental results of the three algorithms, it can be seen that the optimized *k-Means* method adopted in this paper attained the largest modularity value, and the main reason was that this optimized method had considered the importance degree of various influencing factors of harmonious TSR to the calculation of fitness distance of harmonious TSR, judging from a global perspective, the division effect was better, because it can more accurately determine the shortest path of nodes in the basic interactive network of college students, and the situation of unstable performance occurred to it less likely than other methods.

Table 2. Statistics of TSR labelling

Dependent Variable	TSR Fitness					Teacher-Student Interaction Situation				
Scenario No.	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Mean difference	0.325	3.025	–0.315	2.015	–3.601	0.362	–0.615	–0.363	–0.915	0.625
Standard deviation	0.715	1.625	0.748	1.302	1.528	0.263	0.518	0.215	0.415	0.596
Significance	0.651	0.025	0.692	0.027	0.015	0.247	0.058	0.039	0.027	0.241
Lower limit of 95% confidence interval	–1.528	–0.285	–1.629	–0.385	–6.251	–0.085	–1.236	–0.847	–1.625	–0.415
Upper limit of 95% confidence interval	1.258	6.512	1.629	6.021	0.261	0.815	0.4362	0.084	–0.051	1.748

Since there're more than 1 million pieces of teacher and student behavior information on the online management platform, so it's impossible to label TSR for all teachers and students within a short time during the experiments, therefore, this paper selected 1,000 teachers and students with relatively complete data information and higher teacher-student interaction frequency to conduct the experiments. Table 2 gives the statistics of the TSR labeling. According to the data in the table, on the whole, the distribution of TSR conformed to a normal distribution that meets the large-scale student group behavioral features, which had verified the scientificity and rationality of the harmonious TSR labeling algorithm proposed in this paper; also, in the dimension of TSR fitness, the TSR building was not significant under different TSR building requirement scenarios.

5 Conclusion

This paper studied the construction and adjustment of TSR based on big data analysis. At first, combining with the features of college students' daily behaviors on online management platforms, this paper employed big data analysis and data processing techniques to calculate the fitness degree of the harmonious TSR between college students and the counselors/administrators. Then, based on the calculation results of fitness degree, a basic interactive network was initially constructed for college student management, and the division method of student management groups was given. After that, experiments simulated five scenarios and calculated the fitness degree of different TSR samples, and the calculation results were not very different; moreover, the modularity values of student management groups of different algorithms were given as well, which indicated that the optimized *k-Means* method adopted in this paper attained the maximum modularity. At last, this paper gave the statistics of TSR labelling, and verified the scientificity and rationality of the harmonious TSR labeling algorithm proposed in this paper.

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